Research Article

Appraisal of Different Commercially Available Brinjal Genotypes Against Brinjal Shoot and Fruit, *Leucinodes orbonalis* Guenne (Crambidae: Lepidoptera) Infestation in Khyber Pakhtunkhwa, Pakistan

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Abstract | Screening of brinjal genotypes were conducted to devise an integrated pest management strategy against brinjal fruit borer, *Leucinodes orbonalis*. For this purpose, seven commercially available brinjal genotypes *viz.* Nutech Seeds, Durga Seeds, F_1 Hybrid Brinjal, Brinjal Malni, Bharat Kaveri F1, Advanta 303 and Black long were tested for resistance/ susceptibility against *L. orbonalis* in spring and autumn brinjal crop under natural field conditions during 2020, Experiment was carried out under randomized complete block design with three replications. Results revealed that none of the tested genotype was free from *L. orbonalis* infestation. However, larval counts, shoot and fruit infestation, and yield varied among the genotypes. Based on grade index, Baharat kaveri F1 was the only genotype categorized as resistant, with shoot and fruit infestations of 1.45% and 10.1%, respectively followed by genotypes Durga seed and Nutech seeds, with moderate resistant. Where F1 Hybrid brinjal, Brinjal malni and Advanta 303 were categorized as susceptible genotypes while Black long was declared a highly susceptible genotype with 8.9% shoot and 41.4% fruit infestation. *L. orbonalis* incidence was higher on the spring crop as compared that on the fall brinjal crop. Furthermore, Baharat Kaveri F1 yielded significantly higher (9539 kg $ha^{-1)}$ followed by Durga Seeds and Nutech Seeds while Advanta 303 and Black Long yielded lower 1992 kg ha^{-1} and 2350 kg ha^{-1}, respectively. Results further revealed the host plant susceptibility indices (HPSI) values was lower for resistant and higher for susceptible genotype. Over all, Baharat kaveri F1 gave better results as it was resistant to *L. orbonalis* as well as high yielding than other tested genotypes is recommended to incorporate in IPM program for the management of *L. orbonalis*.

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Introduction

In Pakistan, brinjal farmers do not achieve the required brinjal production mainly due the attack of insect pest particularly brinjal fruit borer (*Lucinodes orbonalis*). It is one of the major threats to brinjal crop in Asian Countries (CABI, 2007) particularly in India, Pakistan, Sri Lanka, Nepal, Bangladesh, Thailand, Philippines and Cambodia (CABI, 2021). According to an estimate, losses by *L. orbonalis* to the brinjal crop in Pakistan was about 50-70% (Dhankar, 1988; Alam *et al*., 2003).

L. orbonalis remain active throughout the year with many overlapping generations. The pest may damage 85-90% of shoots and fruits, if not controlled on time (Patnaik, 2000; Mishra, 2008). Adult moth lays off-white or yellowish, flat and oval shaped eggs on the lower side of leaf near midrib (Onekutu *et al*., 2013). Small creamy color larvae after hatching bores into the brinjal shoots and fruits (Prasad *et al*., 2017). At early stages of the plant, the small larvae bores into petiole and tender shoots, sealing entry points with their frass, and feed inside causing withering of the attacked parts, which result in wilting of the whole plant (Alam *et al*., 2006). At the arrival of flowers and fruits, the mature larvae bores into the buds and fruit calyx through a very small hole, and making them ultimately unfit for human consumption (Gautam *et al*., 2019).

The lack of awareness and unavailability of genotypes resistant to insect pests has led to the haphazard and injudicious use of pesticide (Divekar *et al*., 2022). Due to environmental and health problems caused by pesticides (Aarya *et al*., 2022; Narayana *et al*., 2022), alternative control measures that are ecologically safe and economically acceptable, should be focused.

Host plant resistance is regarded as an important component of IPM because it is compatible with other existing pest management tactics. The use of resistant genotypes alone or in conjunction with other control strategies has been observed to reduce pest infestation to an acceptable level (Leuschner *et al*., 1985). However, there has been a scarcity of data on resistance to brinal genotypes commercially present in Pakistan, mainly in Khyber Pakhtunkhwa Province. The climatic condition of the Khyber Pakhtunkhwa Province is ideal for growing all types of vegetables. This sector plays an important role in socio-economic development of the farming community. Vegetable cultivation is becoming popular among the farmers of this province as these are short-duration, has higher yield potential, has low cost of production and fetch higher returns. The present study was therefore, aimed to evaluate the response of available brinjal genotypes against *L. orbonalis in* the field conditions for identifying most resistant genotype.

Materials and Methods

Location and site attributes

The field screening trail of Brinjal genotypes against *L. orbonalis* was conducted at New Developmental Farm (NDF) of The University of Agriculture Peshawar Pakistan (34°1′10″N 71°27′50″E) at 331m above sea level for two growing seasons, i.e., Spring and Autumn 2020.

Raising of brinjal nursery, land preparation and seedlings transplantation

Seeds of seven commercially available Brinjal genotypes (Table 1) were purchased from Seed and Pesticide Markert at Gur Mandi, Peshawar. Healthy seeds of each genotype were sown separately in the sterilized potting mixture in 30cm earthen pots, at the nursery of the Department of Horticulture, The University of Agriculture Peshawar. Pots of each genotype were covered with polythene sheets to protect from severe cold. All pots were regularly inspected for germination and watered when required. The plastic cover was removed a week before transplantation.

Table 1: *Brinjal genotypes used in the experiment.*

Genotype	Trade name	Manufacturer
1	Nutech Seeds	Agroimpex corporation
2	Durga Seeds	Durga seed farm CRGD
3	F_1 Hybrid Brinjal	Kalash seeds Pvt. Ltd.
4	Brinjal Malni	Polo seeds
5	Bharat Kaveri F1	Bharat Kaveri overseas India
6	Advanta 303	ICI Pakistan Limited
7	Black long	Agri Labh Seeds, India

Transplantation was done early in the morning in 2nd week of March. A healthy brinjal seedling (five weeks old) of each genotype was transplanted in the assigned plots. The experiment was arranged in randomized Complete Block Design (RCBD), with three replications. A distance of one meter was maintained between each replication. The total area of the experimental trial was 97.02m^2. Each experimental plot size was 2.4 m^2. In all there were (7 x 3) i.e. 21 experimental plots. (12.6m X 7.7m). A total of 15 plants (in three rows each having 5 plants) were transplanted in each experimental plot. A space of 35 cm and 60 cm was maintained between Plants to plant and row to row, respectively. The field was irrigated just after transplantation and subsequent irrigations were given once or twice a week, depending upon weather conditions. Standard agronomic practices such as fertilizer, hoeing and weeding were applied uniformly to all experimental units. The spring brinjal crop was left un harvested in the field for autumn season data. Brinjal crop was regularly inspected for pest arrival and data were recorded on the following parameters.

Mean number of larvae plant^{-1}

Number of larvae per plant was recorded by randomly selected five plants in each genotype in each replication at a fortnightly basis starting from the first appearance of larvae till end of shoot and fruit borer infestation in both spring and autumn brinjal crops. Then mean larval population was calculated (Javed *et al*., 2011).

Shoot infestation (%)

Data on shoot damage was recorded by counting the number of dried shoot or infested shoots by *L. ordonalis* in randomly selected five plants from each replication at forthnight basis till the end of shoot infestation in both seasons. The percent shoot infestation was calculated by following formula adopted by Adiroubane and Raghuraman (2008).

$$\text{\% Shoot infestation} = \frac{\text{Number of damaged shoots}}{\text{Total number of shoots}} \times 100$$

Fruit infestation (%)

To record the percent fruit damage, mature brinjal fruits were harvested on weekly basis from randomly selected five plants of each genotype. The harvested fruits were kept in a polythene bag and tagged with genotype names and replication numbers. After every harvest, the number of infested fruit (presence of holes) and sound fruits were counted from each genotype. The percent damaged fruits were calculated according to the following formula adopted by Adiroubane and Raghuraman (2008).

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

Based on the *L. orbonalis* the mean infestation throughout growing seasons, the brinjal genotypes were categorized as per the grade index of Subbaratnam and Butani (1981).

Yield (kg ha^{-1})

For yield assessment, at the onset of fruiting, mature fruits were picked on weekly basis from each genotype, weighed and the total yield of all the pickings of each genotype was transformed into yield kg per hectare with the following formula:

$$\text{Yield (kgh}^{-1}) = \frac{\text{Obtained yield plot}^{-1}}{\text{Plot size } (m^2)} \times 10000$$

Host plant susceptibility indices (HPSI)

The HPSI based on shoot and fruit infestation by *L. orbonalis* for each genotype was calculated according to the methods outlined by (Farooq, 2007), to determine the level of susceptibility in the tested brinjal genotypes.

$$HPSI\ (\%) = \frac{A}{B} \times 100$$

A= average shoot infestation and fruit infestation in individual genotype. B= average shoot infestation and fruit infestation in all genotypes.

Statistical analysis

The data were subjected to ANOVA through computer software Statistix 8.1. The means were compared by LSD test at 0.05% of significance.

Table 2: *Grade index for shoot and fruit damage by L. orbonalis.*

Grade index	Damage (%)	
	Shoot	**Fruit**
Resistant	< 2.0	< 15
Moderately resistant	2.1-3.0	16-25
Susceptible	3.1-5.0	26-40
Highly susceptible	> 5.0	> 40

Results and Discussion

Screening on the basis of larval population of L. orbonalis

Results shows significant difference in larval population in all brinjal genotypes during Summer (F=1351.28, P=0.0) and Autumn (F=995.0, P=0.0) crops. Significantly more larvae were found in genotype Black long 8.7 and 8.1 larvae plant^{-1} in spring and autumn respectively, while significantly fewer larvae were found in genotype Baharat kaveri F1 2.8 and 2.1 larvae plant^{-1} in spring and autumn respectively. Mean larval population was significantly high in genotype Black long 8.4 larvae plant^{-1}, while low was reported in genotype Baharat kaveri F1: 2.4 larvae plant^{-1}. Results further showed that generally spring crop has more larvae than autumn (Table 3).

Table 3: *Mean L. orbonalis larval population on brinjal genotypes during spring and autumn of 2020.*

Genotypes	Mean larval population plant^{-1}		
	Spring	Autumn	Mean
Nutech seeds	3.76 e	2.58 e	3.17 e
Durga seeds	3.58 e	2.22 f	2.90 e
F 1 Hybrid Brinjal	4.41 d	3.29 d	3.85 d
Brinjal Malni	4.70 c	3.84 c	4.27 c
Baharat Kaveri F1	2.80 f	2.10 f	2.45 f
Advanta 303	5.18 b	4.21 b	4.70 b
Black Long	8.72 a	8.12 a	8.42 a
Mean	4.73 a	3.76 b	

Mean in columns with similar letters are non significantly different at 0.05% level of significance.

Table 4: *Mean percent shoot damage by L. orbonalis to brinjal genotypes during spring and autumn of 2020.*

Genotypes	Mean percent shoot damage plant^{-1}			Grade index
	Spring	Autumn	Mean	
Nutech seeds	5.40 d	4.50 d	4.95 d	***
Durga seeds	2.70 e	2.20 e	2.45 e	**
F1 Hybrid Brinjal	6.00 c	5.10 c	5.55 c	****
Brinjal Malni	6.30 c	5.40 c	5.85 c	****
Baharat Kaveri F1	1.80 f	1.00 f	1.45 f	*
Advanta 303	7.70 b	6.20 b	6.95 b	****
Black Long	9.30 a	8.50 a	8.90 a	****
Means	5.60 a	4.70 b		

Mean in columns with similar letters are non significantly different at 0.05% level of significance. Resistant, Moderately resistant**, Susceptible***, Highly susceptible*****

Screening on the basis of percent shoot damage by L. orbonalis larvae

Results pertaining shoot damage by *L. orbonalis* to different brinjal genotypes are shown in Table 4. Results revealed that none of the tested genotype was free from *L. orbonalis* infestation. However, significant difference in shoot infestation was observed in spring (F=282.99, P=0.0) brinjal crop and autumn (F=207.88, P=0.0) brinjal crop. Shoot infestation was lowest (1.8% and 1%) in genotype Baharat Kaveri FI followed by Durga Seed with shoot infestation of 2.7% and 2.2% in both the spring and autumn crops respectively. While shoot infestation was highest in Black long 9.3 and 8.5% in spring and autumn, respectively. Mean fruit damage of both seasons showed that among the tested genotypes only Bahrat kaveri F1 was decleared resistant with lowest fruit damage 1.4%, while Dhugra seed with shoot infestation of 2.4% was decleared moderalely resistant. Nutech Seed with fruit infestation of 4.95 % fell in susceptible category. While the remaining four genotypes Black long, Advanta 303, Brinjal malni and Hybrid Brinjal were categorized as highly susceptible genotypes with highest fruit infestation ranging from (5.55% to 8.9%). Results further revealed that shoot damage was higher in spring crop (5.6%) than autumn brinjal crop (4.7%).

Table 5: *Mean percent fruit damage by L. orbinalis larvae to brinjal genotypes during the Spring and Autumn of 2020.*

Genotypes	Mean percent fruit damage			Grade index
	Spring	Autumn	Mean	
Nutech seeds	22.60 e	17.30 e	19.950 e	**
Durga seeds	15.60 f	11.50 f	13.550 f	**
F1 Hybrid Brinjal	28.00 d	23.40 d	25.70 d	***
Brinjal Malni	33.40 c	27.60 c	30.50 c	****
Baharat Kaveri F1	11.50 g	8.70 g	10.10 g	*
Advanta 303	40.20 b	36.20 b	38.20 b	**
Black Long	43.50 a	39.30 a	41.40 a	****
	27.8 a	23.4 b		

Mean in columns with similar letters are non significantly different at 0.05% level of significance. Resistant, moderately resistant**, Susceptible***, Highly susceptible*****

Screening on the basis of percent fruit damage by L. orbonalis larvae

Table 5 represents fruit damage in different brinjal genotypes by *L. orbonalis* larvae. Significant variation in fruit damage was observed in the tested genotypes in both spring (F=360.62, P=0.0) and autumn (F=4534.66, P=0.0) crops. None of the tested brinjal genotype was free from the *L. orbonalis* infestation in both spring and autumn season. In spring crop, highest fruit damage was recorded in black long (43.5%) followed by Advanta 303 (40.2%) while the lowest fruit damage was recorded in Baharat Kaveri followed by Durga seeds with fruit damage of 11.5 % and 15.6%, respectively. Similar in autumn crop, significantly more fruit damage was recorded in Black long (39.3%) followed by Advanta 303 (36.2%) while the lowest damaged fruits were recorded in Baharat Kaveri F1 (8.7%) followed by Durga seeds (11.5%). Based of grade index, mean fruit damage in spring and autumn showed that only Bahrat Kaveri F1 was found the most resistant with lowest fruit damage of 10.1%, followed by Dhugra seed and Nutech Seed with moderately resistant to *L. orbonalis.* Genotype Hybrid Brinjal, Brinjal malni and Advanta 303 fall in the grade index of susceptible with infestation level of (25.7-38.2%), whereas genotype Black long with highest fruit infestation 41.4% was catagerized the most susceptible genotype. Season-wise data shows that significantly more fruit damage by *L. orbonalis* larvae was recorded in spring (27.8%) than in autumn crop (23.4%).

Screening on the basis of yield (kg ha^{-1})

Significant variation in brinjal yield was recorded in both spring (F=209.04, P=0.0) and autumn (F=517.73, P=0.0) crop (Table 6). However, in spring crop, Genotype Baharat Kaveri yielded significantly higher (8563.0 kg ha^{-1}) followed by Durga Seed (7230 kg ha^{-1}) while genotype Advanta 303 yielded significantly lower (1590 kg ha^{-1}) followed by Black long (1861 kg ha^{-1}). In autumn crop, the highest yield was recorded for genotype Baharat kaveri F1 (10515 kg ha^{-1}) followed by Durga Seeds (8770 kg ha^{-1}) while the lowest yield was recorded for genotype Advanta 303 (2395 kg ha^{-1}). Mean yield of both the crops, shows genotype Baharat kaveri F1 yielded the highest 9539.0 kg ha^{-1} and Advanta 303 yielded the lowest 1992.5 kg ha^{-1}. Generally, yield was significantly higher in the autumn (6087.8 kh ha^{-1}) than the spring crop (4562.6 kg ha^{-1}).

Table 6: *Mean yield (kg ha^{-1}) of brinjal genotypes during Spring and Autumn crops of 2020.*

Genotypes	Mean yield (kg ha^{-1})		Mean
	Spring	Autumn	
Nutech seeds	6034 c	7450 c	6742 c
Durga seeds	7230 b	8770 b	8000 b
F1 hybrid brinjal	3869 d	6100 d	4984 d
Brinjal Malni	2791 e	4544 e	3667 e
Baharat Kaveri F1	8563 a	10515 a	9539 a
Advanta 303	1590 f	2395 g	1992 f
Black long	1861 f	2840 f	2350 f
Mean seasonal yield	4562 .6 b	6087.8 a	

Mean in columns with similar letters are non significantly different at 0.05% level of significance.

Host plant susceptibility indices (HPSI)

The host plant susceptibility of different brinjal genotypes based on shoot damage by *L. arbonalis* is demonstrated in Figure 1. In the spring season, Black long was found the most susceptible genotype with highest HPSI value of 23.72%, while Baharat kaveri F1 was found the most resistant with lowest HPSI value of 4.59%. Similarly in autumn season, Black long again found the most susceptible, with the highest HPSI value (25.83%), while Baharat kaveri F1 has the lowest HPSI value (3.04%) was the most resistant genotype. The mean HPSI of spring and autumn brinjal crop showed the highest HPSI 24.78% for Black long followed by Advanta 03 (19.24%), Brinjal malni (16.24%) and the lowest HPSI (3.82%) for Baharat kaveri F1 thus decleared the most resistant genotype.

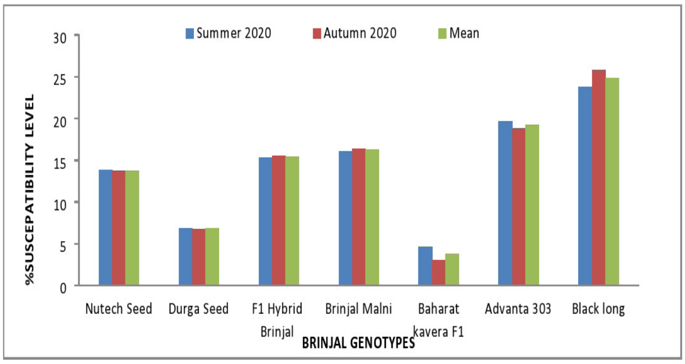

Figure 1: *Host plant susceptibility indices (HPSI) of brinjal genotypes on the basis of shoot damage (%) by L. orbonalis during Spring and Autumn 2020.*

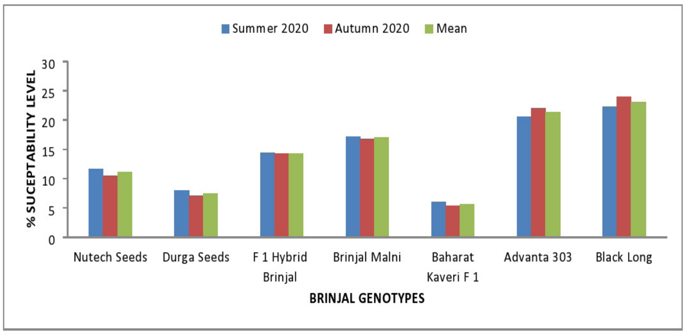

Figure 2: *Host plant susceptibility indices (HPSI) of brinjal genotypes on the basis of fruit damage (%) by L. orbonalis during Spring and Autumn 2020.*

HPSI based on percent fruit damage (Figure 2), shows that the genotype Black long showed highest HPSI value 22.3% and 24% in spring and autumn crop, respectively, while the genotype Baharat kaveri F1 had lowest HPSI of 6% and 5.3% in Summer and autumn crop respectively. The mean HPSI of spring and autumn , showed that susceptibility level on the basis of fruit damage was highest (23%) for genotype Black long, and was proved to be the most susceptible while the HPSI value was lowest (5.6%) for Baharat kaveri F1, and hence termed as the most resistant genotype

Results of the present study demonstrated that none of the tested brinjal genotypes was free from the attack of *L. orbonalis*, However, the shoot and fruit infestation were in the range of 1.45 to 8.90% and 10.10% - 41.40%, respectively. It was also found that genotype Baharat Kaveri F1 was found the most resistant followed by Durga Seeds and Nutech Seeds with intermediate resistant while Black Long and Brinjal Malni were declared the most susceptible. Divekar *et al*. (2023) found significant variation in the response of brinjal genotypes. They reported shoot and fruit infestation of 29 % and 10% respective, in resistant genotype. A study conducted by (Krishna *et al*., 2001) revealed that variety rainy round purple had 43% fruit infestation categorized as the most susceptible, while SM-02 had 10% fruit infestation was categorized as comparatively the resistant variety. Malik and Pal (2013) reported that shoot infestation varied from 0 to 20% but fruit infestation range was comparatively higher (14.18 to 53.19%) among the different brinjal germplasms. Similarly, Sharma *et al*. (2017) they found that none of cultivar was found to be resistant to the pest. However, the infestation was minimum on cultivars: DS-407 and Ganesh (6.66% to 46.63%) and maximum on the cultivars: Prapti, Pusa Purple Long and Neelkanth. Our findings are not strictly be comparable with some earlier researchers, due to difference in genotypes used in the experiment and differences in ecological conditions.

Physical and biochemical plant features such as shaped fruit, presence of tough fruit skin, a thin pericarp, extra-long fruits that are light purple in colour, a smaller area where seeds are present, and a smaller peripheral ring may contribute to the genotype's resistance/ susceptibility as reported by (Sharma *et al*., 1985). Another putative plant component that influences resistance is shoot softness, sparse pubescence, and spherical and oblong fruit with soft skin and loosely scattered seeds. Brinjal's tolerance may be ascribed to the firmness of the fruit skin and flesh. Kumar and Shukla (2002) and hard to semi-hard shoot and medium to dense pubescence (Senapat, 2003). Present study revealed high larval infestation, shoot and fruit damage in spring crop as compared to autumn; this might be due to optimum environmental conditions for insect survival in spring season. Variation in brinjal yield was observed among the tested genotypes. Although such variation may be due the genetic yield traits, but response of these genotypes to *L. orbonalis* attack may also be responsible. In the present study, the genotypes with lower pest infestation gave higher yield.

Host plant susceptibility of shoot and fruit infestation were lowest for Baharat kavera F1 (resistant one) and maximum for Black long (susceptible). Some earlier researchers had also reported minimum HPSI value for resistant and maximum value for susceptible genotypes (Sajjad *et al*., 2011; Wakil, 2004).

Conclusions and Recommendations

None of the tested brinjal genotype was free from the attack of *L. orbonalis* in both spring and autumn crop. Genotype Baharat kaveri F1 was found to be the most resistant having the lowest shoot and fruit infestation with highest brinjal yield followed by Durga seeds and Nutech seeds (Moderately resistant) while genotype Black long and was found the most susceptible with highest shoot and damaged fruits with lowest brinjal yield in both spring and autumn crop. The genotypes performed better in the field and need to be further explored. In this context, investigating the physical and biochemical plant characters of the studied genotypes from a viewpoint of host plant resistance to *L. orbonalis* would be useful contribution towards development of a resistant variety that can be incorporated into an IPM strategy.

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Novelty Statement

These commercially available genotypes have never been tested together against *L. orbonalis* under the agro-climatic conditions of Peshawar. So, the present study would contribute to develop an integrated pest management program for the management of *L. orbonalis*.

Author's Contribution

Saboor Naeem: Conducted research and data analysis and prepared initial draft of the manuscript.
Amjad Usman: Supervised the whole research and proof read the manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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