The Pharma Innovation Journal 2023; 12(8): 2801-2804

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(8): 2801-2804

www.thepharmajournal.com
Received: 02-05-2023
Accepted: 05-06-2023

Pratap A Divekar
ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India

Sarvesh Mishra
ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India

Suhas Karkute
ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India

Shailesh K Tiwari
ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India

Corresponding Author:
Shailesh K Tiwari
ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India

Screening of brinjal genotypes for resistance against shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae)

Pratap A Divekar, Sarvesh Mishra, Suhas Karkute and Shailesh K Tiwari

Abstract
Brinjal shoot and fruit borer (BSFB) *Leucinodes orbonalis* Guenee is a major pest of brinjal which primarily attacks the shoot and fruits of brinjal. An experiment was undertaken to screen the different brinjal genotypes at Varanasi against BSFB and to observe their relative level of resistance under natural field conditions in during 2017 and 2018. The parameters like percent shoot and fruit infestation caused by BSFB and the further damage scale reported was selected for screening the different brinjal genotypes. The genotypes selection-10 showed least shoot (20.1 and 29.8%) and fruit (12.7 and 6.4%) infestation. The genotype CHBR-2 showed higher shoot infestation (38.4 and 32.2%) but lower fruit infestation (18.7 and 21.4%). The higher shoot and fruit infestation was observed in the genotypes Punjab Sadabahar, Kashi Taru, Kashi Sandesh, Pant Rituraj and Kashi Uttam. The genotype Selection-10 can be deployed in the resistance breeding programme against BSFB, *Leucinodes orbonalis*.

Keywords: Brinjal, genotypes screening, *Leucinodes orbonalis*, shoot and fruit infestation

Introduction
Brinjal or eggplant (*Solanum melongena* L. (Solanaceae) is one of the major solanaceous crop of tropics and sub-tropics acclimatized to different agro-climatic zones grown in South East Asia. It is rich in minerals, vitamins and is a great source of total water-soluble sugars, amide proteins and free reducing sugars among other nutrients (Alam *et al*., 2003) [1]. India is the second largest producer of brinjal worldwide, after China. Brinjal is the fourth largest crop after potato, onion and tomato in terms of consumption in Indian scenario. In India, it is cultivated on 0.730 million hectares with an annual production of 12.8 million tonnes and a productivity of almost 17.5 tonnes ha-11 (IHD, 2018) [13]. More than 70 species of insects attack brinjal (Subbarathnam and Butani, 1982) [26], the fruit and shoot borer (FSB) being the most destructive insect pest not only responsible for a substantial yield loss (85-90 percent) (Patnaik 2000) [23], but it also decreases the value of the product, making the product less lucrative.

For the management of insect pests, farmers primarily depend on the application of chemical pesticides (Divekar *et al*., 2022a) [7]. Considerable side effects are produced by the concurrent, unseemly and indiscriminate use of chemical pesticides, including exposing of agricultural workers and end users to pesticide residues, raised crop production costs, degradation of the environment, destruction of natural insect enemies, resurgence of insect pest, etc. (Narayana *et al*., 2022, Aarya *et al*., 2022; Divekar *et al*., 2022 b,c; Sant Kumar, 2011) [21,2,8,9,15]. The natural environment is adversely affected by the excessive and unjustified use of synthetic chemicals to improve plant protection and productivity. The biological control of phytopathogens involves the utilisation of microbes from several taxonomic groups of bacteria, viruses, and fungi. Such bioagents can more efficiently grow, survive and proliferate in several agro-horticultural ecosystems (Dukare *et al*., 2021) [10]. A combination of the Entomopathogenic fungi like *Beauveria bassiana*, *Metarhizium anisopliae*, and *Lecanicillium lecanii* with neem oil at half of their recommended concentrations could be a viable eco-friendly option in the management of the sucking pests of okra, along with the conservation of natural enemies (Halder *et al*., 2021) [12]. Biocontrol agents like entomopathogenic nematodes are effective biological control agents for a variety of economically important insect pests and considered as potential alternatives to chemical insecticides (Gowda *et al*., 2020) [20].

One of the most significant, suitable, and cost-effective management strategies for insect pests is host plant resistance (HPR), which has negative impacts on the survival and other biological parameters of insect pests (Divekar *et al.*, 2019 a and b) [5, 6]. The key component of Integrated Pest Management (IPM) is resistant and tolerant cultivars, on top of which additional elements need to be layered. It helps IPM in two ways: by lowering the amount of pesticides used and by enhancing the effectiveness of insect natural enemies in plants. Even a low level of tolerance in plants has a dramatic effect, which in fact reduces the need of insecticides (Panda, 1971) [22]. With the aforementioned information in mind, the present investigation was carried out to screen the brinjal genotypes in order to find out the elite source of resistance.

Materials and Methods

The study was conducted at the experimental farm of ICAR-Indian Institute of Vegetable Research (IIVR), Varanasi (82.52 0 E longitude; 68 25.10 0 N latitude), Uttar Pradesh, India during 2017 and 2018. Seeds of seven brinjal genotypes *viz*., Kashi Taru, Selection 10 (a derivative line from Uttara), Punjab Sadabahar, CHBR-2, Pant Rituraj, Kashi Uttam and Kashi Sandesh were collected from genebank at ICAR-IIVR, Varanasi. The brinjal genotypes and their physical characteristics are listed in Table 1.

Table 1: Brinjal genotypes with their physical characteristics

Genotypes	Calyx colour	Fruit colour	Fruit shape
Kashi Taru	Green	Dark Purple	Long
Selection-10	Purple	Light Purple	Long
Punjab Sadabahar	Green	Black Purple	Long
CHBR-2	Green	Light Purple	Round
Pant Rituraj	Green	Dark Purple	Round
Kashi Uttam	Green	Light Purple	Round
Kashi Sandesh	Green	Dark Purple	Round

A randomized complete block design (RCBD) with three replications was used to set up the experimental plots. The unit plot size was 3.0 m x 3.0 m. Plots and blocks were 1.5 m and 2.0 m apart, respectively. The brinjal genotypes were grown following all the standard agronomic practices except plant protection measures. Brinjal plants were transplanted at a row distance of 75 cm (3 rows in each plot) and plant spacing of 60 cm (5 plants in each row). Ten different brinjal genotypes' seeds were planted in separate, small nursery seedbeds (3.0 m × 1.0 m). In the experimental plots, 35-day-old plants were randomly transplanted.

Incidence of the shoot and fruit borer on each brinjal genotype's was monitored weekly, from transplanting to harvest, on five plants per treatment that were randomly selected. Starting on the seventh day after transplanting (DAT), the pest population/damage was assessed at weekly intervals. On five randomly chosen plants, the number of healthy and damaged shoots by *L. orbonalis* was recorded, and the percentage of damage was calculated. Every assessment was followed by the removal of the damaged shoots. Fruit infestation was determined by counting the amount of healthy and damaged fruits and calculated the percentage of damage as per scale given by Mishra *et al.* 1988; Kavishetty and Rani, 2018 [19, 28] (Table 2).

Table 2: Scale used for brinjal genotypes categorization based on the percentage shoot and fruit damage

Category	Shoot damage	Fruit damage	Scale
Immune	0%	0%	1
Highly resistant	1-10%	1-10%	2
Moderately resistant	11-20%	11-20%	3
Tolerant	21-30%	21-30%	4
Susceptible	31-40%	31-40%	5
Highly susceptible	above 40%	above 40%	6

The screening parameters like percent shoot and fruit infestation were studied using one-way analysis of variance (ANOVA) through SPSS 22.0 software. Duncan's Multiple Range Test ($p<0.05$) was performed for the comparison of means between the treatments (Gomez and Gomez 1984) [11].

Result and Discussion

Shoot and fruit infestation of different brinjal genotypes is presented in Tables 1 and 2 for Season 1 and Season 2. Significant differences were obtained among the percent shoot infestation among the different brinjal genotypes during season 1 ($F = 20.3$, $p <0.001$) and season 2 ($F = 10.2$, $p <0.001$). During season-1, the least shoot infestation was found in the genotype Selection-10 (20.1%). However, the higher shoot infestation was recorded in the genotype Punjab Sadabahar (43.0%), followed by Kashi Taru (42.7%), followed by CHBR-2 (38.4%), Pant Rituraj (37.4%), Kashi Uttam (36.5%) and Kashi Sandesh (36. 0%).On the basis of the screening scale, brinjal genotypes were Selection 10 genotypes was found moderately resistant based on the percent shoots infested. Kashi Taru and Punjab Sadabahar were observed as highly susceptible. The genotypes CHBR-2, Pant Rituraj, Kashi Uttam and Kashi Sandesh were found as susceptible during season 1. In Season 2, Selection-10 was found in the tolerant category whereas rest all the genotypes were found in the susceptible category.

Significant differences were obtained among the percent fruit infestation among the different brinjal genotypes during season 1 ($F = 176.52$, $p <0.001$) and season 2($F = 784.67$, $p <0.001$). During season1, the lower fruit infestation was found in the genotype Selection-10(12.7%) followed by CHBR-2 (18.7%). However, the higher shoot infestation was recorded in the genotype Punjab Sadabahar (85.7%), followed by Kashi Sandesh (85.6%), Pant Rituraj (83.5%) and Kashi Taru (70.8%) during season 1. During season 2, lower fruit infestation was observed in the genotype selection-10 (6.4%) followed by CHBR-2 (21.4%) followed by Kashi Uttam (36.2%). Higher fruit infestation was recorded in the genotypes Kashi Sandesh (83.3%) followed by Pant Rituraj (80.8%), Punjab Sadabahar (78.5%), followed by Kashi Taru (70.2%) in season 2. On the basis of the screening scale, brinjal genotypes were Selection-10 and CHBR-2 genotypes were found moderately resistant based on the percent fruits infested. Kashi Uttam was recorded as susceptible genotype and genotypes Kashi Taru, Punjab Sadabahar, Pant Rituraj, Kashi Sandesh were observed as highly susceptible. The genotypes CHBR-2, Pant Rituraj, Kashi Uttam and Kashi Sandesh were found as susceptible during season 1. In Season 2, selection-10 was found in the highly resistant category, CHBR-2 in the tolerant category, Kashi Uttam in the susceptible category and the genotypes Kashi Taru, Punjab Sadabahar, Pant Rituraj, Kashi Sandesh were found in the highly susceptible category.

Earlier researchers Jat *et al*., (2003) [14] reported a comparable range of fruit infestation was 20.23 to 45.61% though they used different set of varieties/cultivars. Malik *et al*., (2013) [18] 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, Devi *et al*., (2015) [4] found 5.21% to 28.27% fruit infestation in diverse eggplant varieties. Screening of brinjal genotypes against shoot and fruit borer infestation has been done by Mishra *et al*., (1988), Lit *et al*., (2002), Singh *et al*., (2016) and Vethamoni *et al*., (2016) [19, 17, 25, 27]. Kavishetty and Rani, 2018[28] used the shoot and fruit percentage scale and found that the brinjal hybrids Wardha local × Palakurthi local, Swetha × Vellayani local and Neelima recorded minimum infestation of shoot and fruit borer during both kharif and summer seasons at Trivendrum.

Highly susceptible reaction on the basis of percentage fruit damage was exhibited by genotypes namely, Kashi Taru, Punjab Sadabahar, Pant Rituraj and Kashi Sandesh. The possible reasons for high susceptibility of genotypes may be due to the round shaped fruit with less number of seeds and soft and smooth surface, as reported by (Sharma *et al*., 1985; Lal *et al*., 1976) [24,16].

However, none of the genotypes examined in the present investigation were resistant to *L. orbonalis*. The resistance reaction of the genotype selection-10 to *L. orbonalis* may be caused by the 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. According to reports, Pusa Purple Cluster and Black Beauty were resistant because they had purple-colored leaves (Panda *et al*., 1971) [22]. The moderately resistant / tolerant reactions in the hybrid brinjals may be brought on by the presence of extensively lignified sclerenchymous hypodermis and densely packed vascular bundles.

Table 3: Percentage of shoots fruits damaged by shoot and fruit borer (*L. orbanalis*) in different brinjal genotypes

Brinjal Genotypes	Season 1				Season 2			
	Healthy shoots	Infested shoots	Total shoots	Percent shoots infested	Healthy shoots	Infested shoots	Total shoots	Percent shoots infested
Kashi Taru	9.7ab	7.3b	17.0ab	42.7cd	14.4ab	9.1b	23.5b	38.9d
Selection-10	12.7c	3.8a	18.9d	20.1a	15.9bc	7.1a	22.9b	29.8a
Punjab Sadabahar	9.5a	7.2b	16.7a	43.0d	17.8cde	9.9bc	27.7c	35.8bc
CHBR-2	11.1ab	6.9b	18.1cd	38.4bcd	13.1a	6.7a	19.8a	32.2b
Pant Rituraj	10.9ab	6.5b	17.5abc	37.4bc	19.3e	9.7bc	29.0c	33.6b
Kashi Uttam	11.0ab	6.3b	17.3abc	36.5b	18.1de	10.7c	28.9c	36.1cd
Kashi Sandesh	11.4b	6.4b	17.8bc	36.0b	16.9cd	9.9bc	26.9c	35.8cd
F	7.4	10.5	5.0	20.3	10.8	18.8	14.1	10.2
P	<0.001	<0.001	<0.006	<0.001	<0.001	<0.001	<0.001	<0.001

Table 4: Percentage of fruits fruits damaged by shoot and fruit borer (*L. orbanalis*) in different brinjal genotypes

Brinjal genotypes	Season 1				Season 2			
	Healthy fruits	Infested fruits	Total fruits	Percent fruits infested	Healthy fruits	Infested fruits	Total fruits	Percent fruits infested
Kashi Taru	27.7c	67.2c	94.6b	70.8c	24.3c	57.7d	82.0c	70.2c
Selection-10	84.7d	12.3ab	97.4b	12.7a	82.7d	5.7ab	88.4d	6.4d
Punjab Sadabahar	16.5b	76.3c	89.3b	85.7d	22.4c	81.7e	104.1e	78.5e
CHBR-2	16.0b	3.7a	19.7a	18.7a	14.1b	3.9a	18.0a	21.4a
Pant Rituraj	3.1a	16.0b	19.1a	83.5d	4.4a	18.2c	22.6b	80.8b
Kashi Uttam	15.1b	7.7ab	22.7a	34.4b	13.5b	7.5b	21.1ab	36.2ab
Kashi Sandesh	3.5a	16.4b	19.2a	85.6d	3.4a	17.0c	20.4ab	83.3ab
F	368.39	83.29	102.63	176.52	1742.04	916.64	784.67	784.67
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Conclusion

The screening parameters like percentage shoot and fruit infestation by BSFB, *Leucinodes orbonalis* on different brinjal genotypes were giving an indication about the germplasm susceptibility level. The brinjal genotypes like Selection-10 showed resistant reaction to BSFB infestation and attack. The genotypes *viz*., Kashi Taru, Kashi Sandesh showed susceptible reaction. Due to the synthesis of certain biochemical and secondary metabolites as a result of an insect feeding on the plant, which confers resistance against the insect. The germplasm selection-10 showed least shoot and fruit infestation which can be further utilized in the breeding programme for imparting resistance against BSFB, *L. orbonalis*.

Authors' Contributions

PAD, SKT, SM- conceptualized the experiment and performed the experiment; PAD, SM, SGK did the statistical analysis; PAD and SGK prepared the draft of the manuscript; SKT revised and edited the manuscript. All the authors have read the manuscript.

Acknowledgments

The authors would like to acknowledge the Director, ICAR-Indian Institute of Vegetable Research, Varanasi and Head, Division of Vegetable Improvement for providing the necessary facilities required for the research during the experimentation.

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