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Ardhendu Chakraborty
Department of Agricultural Entomology, Institute of Agriculture (PSB), Visva-Bharati, Sriniketan, West Bengal, India

Swarnali Bhattacharya
Department of Agricultural Entomology, Institute of Agriculture (PSB), Visva-Bharati, Sriniketan, West Bengal, India

Biswajit Das
Division of Horticulture, ICAR RC for NEHR, Lembucherra, Tripura, India

Corresponding Author:
Ardhendu Chakraborty
Department of Agricultural Entomology, Institute of Agriculture (PSB), Visva-Bharati, Sriniketan, West Bengal, India

Screening of certain brinjal germplasms for resistance to brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen.

Ardhendu Chakraborty, Swarnali Bhattacharya and Biswajit Das

Abstract
An experiment was carried out with eight brinjal germplasms *viz*; Shinghnath, Tripura Brinjal 10, Bholanath, Tripura Brinjal 17, Tripura Brinjal 8, Tripura Brinjal 21, Tripura Brinjal 4, Tripura Brinjal 18 at Krishi Vigyan Kendra, Khowai, Tripura to find out the suitable resistant germplasms against brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guen. The data on fruit damage revealed that significantly lowest fruit damage (17.34%) was recorded in the germplasm Shingnath, in comparison to Tripura Brinjal 18 which recorded the highest mean infestation value (45.38%) of *L. orbonalis* on number basis. Similarly, significant lowest fruit damage on weight basis was recorded in the germplasm Shingnath (14.08%) which was at par with Tripura Brinjal 10 (17.73%) and the highest fruit damage was observed in the germplasm Tripura Brinjal 18 (42.40%). The descending order of fruit infestation of *L. orbonalis* to different brinjal germplasms was Shingnath< Tripura Brinjal 10< Tripura Brinjal 17< Bholanath< Tripura Brinjal 8< Tripura Brinjal 21< Tripura Brinjal 4< Tripura Brinjal 18. Significantly highest fruit yield (19.46 tonnes/ha) was recorded in germplasm Shingnath and lowest (5.47 tonnes/ha) fruit yield was obtained in highly susceptible germplasms Tripura Brinjal 18.

Keywords: Brinjal, *Leucinodes orbonalis*, screening, germplasm

Introduction
Brinjal (*Solanum melongena* L.) is widely cultivated as one of the most important vegetables in both subtropical and tropical regions of India. In India, eggplant is cultivated over an area of 7.49 lakh hectares and production of 128.74 lakh tonnes with productivity of 18.6 tonnes/ha (Anon., 2018) [1]. India ranks second after China in area and production of brinjal at global level. It is also grown almost in all the districts of Tripura and extensively in Khowai, Sepahijala, South Tripura and North Tripura districts. Owing to its popularity and versatile nature, it is widely used in Indian cuisine not only everyday but also in festive occasions. Thus brinjal (baingan) is also often described as the "King of vegetables". Brinjal fruits are widely used in various culinary preparations *viz*., sliced bhaji, stuffed curry, bertha, chutney, vangnibath, and pickles etc. Commercially grown brinjal fruit can vary in taste, colour (purple, green, white, yellow and striated shades), size (small to large) and shape (pendulous, cylindrical, egg-shaped and oblong to round) with smooth and glossy skin (Herbst, 2001) [13].
Eggplants are attacked by several insect pests and mites right from the nursery stage till harvesting including *L. orbonalis* (Guenee); whitefly, *Bemicia tabaci* (Gennadius); Leafhopper, *Amrasca biguttula biguttula* (Ishida); Hadda beetle, *Henosepilachna vigintioctopunctata* (Fab.); Blister beetle, *Mylabris pustulata;* Thrips, *Thrips palmi* (Karny); Leafroller, *Eublemma olivacea* (Walker) and non insect pest like red spider mite, *Tetranychus macfarlanei* (Baker and Pritchard) and *Tetranychus urticae* (Koch) (Muhammad *et al.*, 2018) [19].
Among the major pests infesting the crop, brinjal shoot and fruit borer (BSFB) is the most limiting factor distributed all over India, causing heavy yield loss upto 70 percent (Jat and Pareek, 2003) [15]. The newly hatched larvae bore into the petioles and midribs of large leaves and young tender shoots during the vegetative phase. They feed on the internal tissue causing the shoot drooped down and withered at the reproductive phase. The larva prefers to bore into flower buds and also enter into the tender fruits through the calyx. Observing the bored holes, the infested fruits can easily be identified. Besides, the dark coloured excreta, can easily be seen on the holes of infested fruits. Secondary infestations by certain microorganisms may cause further deterioration of the fruits (Islam and Karim, 1994) [14] and make them unfit for

human consumption. Economic threshold level of brinjal for shoot and fruit borer is 0.5% shoot, 5% fruit damage and 8-10 moths/ day/ trap (Dhaliwal *et al.*, 2003) [8].

Chemical control is widely used means of managing the pest. Repeated use of broad spectrum synthetic chemicals results in environmental contamination, pesticide residue in the produce and destruction of beneficial insects. Farmers are presently using countless insecticide nearly 140 times or more in one cropping season, during 6-7 months and 32% of total cost is contributed to crop production (Alam *et al.*, 2006) [3]. Heavily sprayed and freshly harvested brinjal can be dangerous to our health.

Many farmers thus hesitate to grow brinjal because of heavy infestation of this borer and lower returns. The losses in reduction of crop yield caused by the pest varies from season to season and from location to location because of moderate temperature and high humidity favoring the population build-up thereby causing heavy losses during hot and humid conditions (Gautam *et al.*, 2019) [10].

There are numerous brinjal varieties available in the subcontinent including India. But none has been found to be immune to BSFB with an appreciable level. Hence, there is an urgent need to look for alternate and safer methods for BSFB management. Host plant resistance (HPR) is the economically sound technique for effective pest management (Nagappan *et al.*, 2017) [20]. Developing brinjal hybrids/varieties with natural resistance to BSFB is one of the effective and eco friendly alternate methods for combating the pest (Nirmala and Vethamoni, 2016) [21]. Use of local resistant cultivars can be the most productive and cheapest way to manage the pest which is environmentally safe (Kayani and Mukhtar, 2018) [16]. Therefore, in the present study, different local brinjal germplasms have been assessed for their comparative response to *L. orbonalis* on the basis of shoot and fruit infestation.

Materials and Methods

The present investigation on screening of certain brinjal germplasms for resistance to brinjal shoot and fruit borer was carried out in the upland of Krishi Vigyan Kendra, Khowai, Tripura during 2018-19 and 2019-20 which is situated at 24.022° N latitude and 91.632° E longitude. The experimental materials for the present study consisted of eight germplasms (Shinghnath, Tripura Brinjal 10, Bholanath, Tripura Brinjal 17, Tripura Brinjal 8, Tripura Brinjal 21, Tripura Brinjal 4, Tripura Brinjal 18) locally collected from different district of Tripura and evaluated in a randomized block design with three replications.

Forty five days old seedlings were transplanted on the ridges adopting a spacing of 45 cm (row to row) x 60 cm (plant to plant). The land was prepared by ploughing and laddering and fertilized with organic manure such as cowdung @ 10 t ha^{-1} 7 days before final land preparation. The doses of chemical fertilizers were NPK- 100:50:50 kg/ha (Basal- 50:50:50 and Split- 50:00:00 at 30 days after transplanting). Irrigation and other cultural operations were done as and when necessary. However, crop was kept free from insecticidal spray during entire crop growth period. Observations were recorded at weekly interval starting from incidence of the pest. The observations were recorded in each germplasm from ten selected and tagged plants for screening of brinjal genotypes for their relative resistance/susceptibility against *L. orbonalis.* The observations were recorded on number and weight of healthy and damaged fruit at the time of each picking. Whereas, percentage of fruit damage was recorded from total number of damaged and healthy fruits by using following formula (Rahman *et al.*, 2008) [2].

Percent fruit infestation (Number basis) = Number of infested fruits / Total number of fruits X 100

Percent fruit infestation (Weight basis) = Weight of infested fruits / Total weight of fruits X 100

The Marketable yield per plant was measured by deducting the yield of infested fruits from the total yield per plant. The data regarding infestation percentage of brinjal shoot and fruit borer on 8 selected brinjal cultivars were recorded during screening trial and was subjected to analysis of variance (ANOVA). The statistical analysis for mean performance was followed as suggested by Panse and Sukhetme (1989) [22]. Least significant difference (LSD) was used to separate the treatment mean at 0.05% level of probability as described by Gomez and Gomez (1984) [12].

Results and Discussion

Based on categorization for relative resistance (Lal *et al.*, 1976) [18], different brinjal germplasms were graded relative resistance/susceptibility. None of the germplasms were found to be immune.

Percent fruit infestation by shoot and fruit borer on number basis

The percent shoot and fruit borer infestation varied significantly among the germplasms. The data presented in Table 1 (Pooled data of 2018-19 & 2019-20) revealed that the peak infestation period was observed between the sixth to eleventh weeks of harvesting. On ninth week, the germplasms Tripura Brinjal 18 (59.01%) and Tripura Brinjal 4 (53.90%) had registered peak fruit damage. In most of the germplasms the fruit infestation was at peak upto ninth week then gradually started declining. The infestation level was same in the twelfth week as well. The susceptibility of brinjal germplasms to shoot and fruit borer in both years was more or less similar. The overall pooled data on fruit damage revealed that significantly lowest fruit damage was recorded in germplasm Shingnath at 17.34%, and the highest mean infestation value in germplasm Tripura Brinjal 18 (45.38%) to *L. orbonalis* on number basis.

Percent fruit infestation by shoot and fruit borer on weight basis

The relative susceptibility of brinjal germplasms to *L. orbonalis* (Table 2) on weight basis (Pooled data of 2018-19 & 2019-20) depicted that the mean value of infestation of fruit borer increased upto tenth week then gradually decreased till twelfth week. The fruit infestation of different brinjal germplasms varied from 5.34 to 17.25 percent. Significantly the lowest fruit infestation on weight basis was observed in Shingnath (5.34%) which was at par with Tripura Brinjal 10 (7.56%). However, the highest fruit infestation was recorded in germplasms Tripura Brinjal 21 (17.25%). Perusal of data on fruit infestation presented in the table revealed that the peak period of infestation was observed between seventh to tenth picking of brinjal fruits. The data revealed a significant difference among all the germplasms screened.

The sequence of susceptibility of brinjal germplasms to shoot and fruit borer in both the years were similar. The overall pooled data of fruit infestation on weight basis revealed that significantly lowest fruit damage was recorded in germplasms Shingnath (14.08%) which was at par with Tripura Brinjal 10 (17.73%). The intermediate percent fruit damage was observed in germplasms *viz*., Bholanath, Tripura Brinjal 17, Tripura Brinjal 8, Tripura Brinjal 21 and Tripura Brinjal 4 with 27.29, 26.40, 33.66, 35.04, 38.28 percent fruit damage respectively. However, significantly the highest fruit damage was exhibited by germplasm Tripura Brinjal 18 (42.40%). The descending order of fruit infestation of *L. orbonalis* to different brinjal germplasms was Shingnath< Tripura Brinjal 10< Tripura Brinjal 17< Bholanath< Tripura Brinjal 8< Tripura Brinjal 21< Tripura Brinjal 4< Tripura Brinjal 18.

Based on the result of percent fruit infestation the different germplasms screened were categorized as Shinghnath and Tripura Brinjal 10 (moderately resistant); Bholanath and Tripura Brinjal 17 (Tolerant); Tripura Brinjal 8 and Tripura Brinjal 21 (Susceptible); Tripura Brinjal 4 and Tripura Brinjal 18 (Highly Susceptible)**.**

Shingnath has emerged out to be moderately tolerant to Brinjal shoot and fruit borer infestation from our present study. Ahmed *et al.*, 2008 has also resulted with a similar finding where the varieties/lines Amjuri, Borka, Dharola, Deembegun, ISD 006, Kajla, Khatkhatia BAU, Laffa S, Singnath, Thamba, and Uttara were moderately tolerant, with shoot infestations ranging from 2.03 to 3. Whereas, the susceptible varieties were BL-118, Eye Red, Islampuri BADC, Irribegun, and Nayantara.

Krishnaiah and Vijay (2003) [17] screened 37 brinjal varieties including indigenous and exotic collection against shoot and fruit borer, out of which, two varieties Bekwai and Husk brinjal were found to possess moderate degree of resistance recording 15.8 and 20 percent damaged fruit, respectively. Darekar *et al.* (1991) [5] evaluated 9 varieties of brinjal against shoot and fruit borer under field condition in Maharashtra and found that varieties Arka Kusumkar, PBR-129-5 and Wild Brinjal were resistant to *L. orbonalis*. The results of the present study were more or less same with the findings of Prasad *et al.*, 2014 [23], Devi *et al.* (2015) [7], Sharma and Swaroop (2000) [24], Taher *et al.* (2020) [25] and Cieśla *et al.* (2021) [4].

Yield performance of different brinjal germplasms

The pooled data of two years (2018-19 and 2019-20) on fruit yield of brinjal germplasms (Table 3/ Figure 1) revealed significantly highest fruit yield (19.46 tonnes/ha and 14.08% fruit infestation) in germplasm Shingnath which was at par with Tripura Brinjal 10 (17.42 tonnes/ha and 17.73% fruit infestation). The significantly lowest (5.47 tonnes/ha and 42.40% fruit infestation) fruit yield was obtained in highly susceptible germplasms Tripura Brinjal 18 which was at par with Tripura Brinjal 4 (6.63 tonnes/ha and 38.28% fruit infestation). The remaining germplasms Bholanath, Tripura Brinjal 17, Tripura Brinjal 8 and Tripura Brinjal 21 also revealed fruit yield ranging from 9.25 to 16.53 tonnes/ha. The results of the findings are in accordance with Ghosh and Senapati (2001) [11] who stated that higher yields were obtained in hybrid brinjal (27.02 to 33.54 tonnes/ha) than in open-pollinated varieties (13.41 to 22.00 tonnes/ha). Similar results were also obtained by Jat and Pareek, 2003 [15].

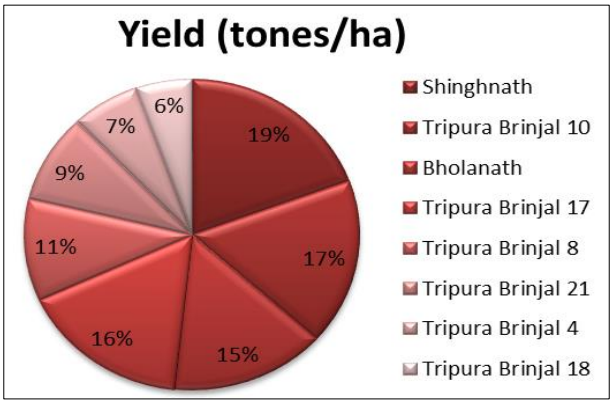

Fig 1: Yield performance of different brinjal genotypes

Table 1: Relative susceptibility of brinjal genotypes to *L. orbonalis* on number basis (Pooled data of 2018-19 & 2019-20)

Sl. No.	Genotypes	Mean percent infestation of fruits at each picking #												
		1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	9th week	10th week	11th week	12th week	Overall Mean
1	Shinghnath	9.43 (17.88)	10.82 (19.20)	13.43 (21.49)	15.65 (23.30)	16.68 (24.11)	18.20 (25.25)	19.80 (26.42)	20.89 (27.20)	19.98 (26.55)	21.86 (27.87)	21.83 (27.85)	19.51 (26.21)	17.34 (24.61)
2	Tripura Brinjal 10	13.70 (21.72)	14.69 (22.54)	16.41 (23.90)	17.79 (24.95)	19.47 (26.18)	20.66 (27.03)	20.94 (27.23)	22.52 (28.33)	22.68 (28.44)	22.57 (28.36)	21.29 (27.48)	19.19 (25.98)	19.32 (26.08)
3	Bholanath	17.49 (24.72)	19.52 (26.22)	22.72 (28.46)	25.40 (30.26)	28.06 (31.98)	29.41 (32.84)	30.59 (33.58)	33.49 (35.36)	33.37 (35.29)	31.98 (34.44)	30.38 (33.44)	29.59 (32.95)	27.66 (31.73)
4	Tripura Brinjal 17	13.59 (21.63)	17.57 (24.78)	21.82 (27.85)	25.34 (30.22)	28.41 (32.21)	30.76 (33.68)	33.43 (35.32)	34.51 (35.98)	36.59 (37.22)	34.85 (36.18)	32.40 (34.70)	31.14 (33.92)	28.37 (32.18)
5	Tripura Brinjal 8	22.70 (28.45)	25.13 (30.09)	33.49 (35.36)	35.04 (36.29)	37.23 (37.60)	37.56 (37.80)	39.38 (38.87)	38.72 (38.48)	39.63 (39.01)	41.47 (40.09)	42.86 (40.90)	44.44 (41.80)	36.47 (37.15)
6	Tripura Brinjal 21	23.14 (28.75)	24.62 (29.75)	27.00 (31.30)	29.19 (32.70)	30.82 (33.72)	34.69 (36.08)	37.41 (37.71)	43.55 (41.29)	45.20 (42.25)	47.59 (43.62)	47.87 (43.78)	50.45 (45.25)	36.79 (37.34)
7	Tripura Brinjal 4	14.28 (22.20)	20.64 (27.02)	25.61 (30.40)	30.92 (33.78)	38.58 (38.40)	43.33 (41.16)	47.05 (43.31)	50.48 (45.28)	53.90 (47.24)	56.50 (48.73)	60.56 (51.09)	63.83 (53.03)	42.14 (40.48)
8	Tripura Brinjal 18	18.46 (25.45)	21.77 (27.81)	25.86 (30.57)	30.70 (33.64)	38.50 (38.35)	41.67 (40.20)	48.78 (44.30)	56.75 (48.88)	59.01 (50.19)	62.73 (52.37)	67.13 (55.02)	73.19 (58.81)	45.38 (42.35)
	S.Em	1.31	1.30	1.54	1.59	1.92	2.05	2.35	2.68	2.94	3.17	3.62	3.89	2.28
	CD (P=0.05)	4.38	4.35	5.16	5.32	6.42	6.84	7.85	8.96	9.82	10.59	12.11	13.35	7.64
	CV	15.55	14.19	15.22	14.68	16.55	16.90	18.52	20.16	21.70	23.00	26.09	28.55	19.01

* Figures on parentheses are original values while those outside are arcsine transformed values

\# - Mean of 10 plants & mean of 3 replications

Table 2: Relative susceptibility of brinjal genotypes to *L. orbonalis* on weight basis (Pooled data of 2018-19 & 2019-20)

Sl. No.	Genotypes	Mean percent infestation of fruits at each picking #												
		1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	9th week	10th week	11th week	12th week	Overall Mean
1	Shinghnath	5.34 (13.35)	7.77 (16.19)	9.76 (18.20)	10.65 (19.05)	11.71 (20.01)	13.64 (21.67)	15.87 (23.47)	17.27 (24.56)	19.91 (26.50)	20.86 (27.18)	18.65 (25.58)	17.54 (24.76)	14.08 (22.04)
2	Tripura Brinjal 10	7.56 (15.96)	9.36 (17.81)	11.42 (19.75)	14.60 (22.46)	16.65 (24.08)	17.98 (25.09)	20.61 (27.00)	21.72 (27.77)	23.36 (28.90)	24.65 (29.77)	23.17 (28.77)	21.65 (27.73)	17.73 (24.90)
3	Bholanath	11.34 (19.67)	13.40 (21.47)	19.35 (26.09)	23.63 (29.08)	26.35 (30.89)	28.74 (32.42)	29.80 (33.09)	32.65 (34.85)	36.00 (36.87)	37.22 (37.59)	34.74 (36.11)	34.29 (35.84)	27.29 (31.49)
4	Tripura Brinjal 17	9.23 (17.69)	10.71 (19.10)	14.46 (22.35)	18.78 (25.68)	24.79 (29.86)	28.87 (32.50)	31.29 (34.01)	32.61 (34.82)	34.68 (36.08)	36.38 (37.10)	38.63 (38.43)	36.42 (37.12)	26.40 (30.92)
5	Tripura Brinjal 8	16.42 (23.90)	19.62 (26.29)	24.45 (29.63)	29.55 (32.93)	32.37 (34.68)	33.79 (35.54)	35.48 (36.56)	38.18 (38.16)	40.60 (39.58)	42.33 (40.59)	43.58 (41.31)	47.55 (43.60)	33.66 (35.46)
6	Tripura Brinjal 21	17.25 (24.54)	22.55 (28.35)	24.95 (29.96)	26.25 (30.82)	28.40 (32.20)	31.33 (34.04)	35.81 (36.76)	42.06 (40.43)	44.53 (41.86)	46.50 (42.99)	49.19 (44.54)	51.72 (45.99)	35.04 (36.30)
7	Tripura Brinjal 4	12.83 (20.99)	19.54 (26.23)	21.71 (27.77)	25.49 (30.32)	31.31 (34.02)	38.73 (38.49)	42.50 (40.69)	46.23 (42.84)	49.56 (44.75)	52.58 (46.48)	57.66 (49.41)	61.29 (51.52)	38.28 (38.22)
8	Tripura Brinjal 18	16.98 (24.33)	20.74 (27.09)	26.99 (31.30)	30.75 (33.68)	37.37 (37.68)	41.59 (40.16)	48.37 (44.07)	51.25 (45.72)	54.16 (47.38)	56.51 (48.74)	59.86 (50.69)	64.25 (53.28)	42.40 (40.63)
	S.Em	1.47	1.68	1.75	1.83	2.05	2.23	2.39	2.56	2.57	2.67	3.20	3.70	2.29
	CD (P=0.05)	4.92	5.60	5.86	6.11	6.86	7.45	7.98	8.56	8.60	8.93	10.70	12.37	7.64
	CV	20.77	20.77	19.36	18.47	19.08	19.41	19.60	20.02	19.27	19.47	22.99	26.17	19.90

* Figures on parentheses are original values while those outside are arcsine transformed values
\# - Mean of 10 plants & mean of 3 replications

Table 3: Yield performance of different brinjal germplasms during 2018-19, 2019-20 & pooled data

Sl. No.	Genotypes	Yield (tones/ha)#		
		2018	2019	Pooled
1	Shinghnath	19.68	19.24	19.46
2	Tripura Brinjal 10	17.96	16.88	17.42
3	Bholanath	15.42	14.81	15.11
4	Tripura Brinjal 17	16.76	16.31	16.53
5	Tripura Brinjal 8	11.68	9.68	10.68
6	Tripura Brinjal 21	9.74	8.76	9.25
7	Tripura Brinjal 4	6.81	6.45	6.63
8	Tripura Brinjal 18	6.20	4.74	5.47
	S.Em	1.61	1.74	1.67
	CD (P=0.05)	5.39**	5.82**	5.59**
	CV	21.94	24.74	23.23

\# - Mean of 10 plants & mean of 3 replications
** - Significant at P=0.01

Conclusions

It is concluded from the present findings that Shingnath and Tripura Brinjal 10 suffered less damage by the borer and therefore, is recommended for cultivation in the state. The germplasms can also be employed as a component of integrated pest management along with other control strategies. The cultivar will have comparatively better crop yield as compared to other cultivars. The above germplasms could be used as parents for shoot and fruit borer resistance breeding programmes while selecting suitable varieties or hybrids.

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