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Biophysical and biochemical basis of resistance to fruit and shoot borer (*Leucinodes orbonalis* Guennee) in eggplant

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ABSTRACT

Host plant resistance is an important component for minimizing the yield losses in eggplant due to fruit and shoot borer (EFSB) (*Leucinodes orbonalis*). Present study was taken up with 23 eggplant accessions comprising eight resistant, eleven susceptible to fruit and shoot borer, and four cultivated varieties (Pusa Shyamla, Pusa Ankur, KS331 and Punjab Sadabahar) to investigate the influence of biophysical and biochemical factors conferring pest resistance. Results indicated that five germplasm accessions, *viz.* IC280954, IC099723, IC111013, IC111033 and EC038474 were found resistant as the infestation levels were less than 15% on number basis. Green coloured, oblong and round shaped fruits with high number of seeds had less infestation. Protein (r = 0.48), sugars (r = 0.65) and moisture content (r = 0.97) of fruits showed significant positive correlation, while phenols (r = -0.89), flavonols (r = -0.83), dietary fibre (r = -0.92), ash (r = -0.83) and starch (r = -0.88) contents showed significantly negative correlation with per cent fruit infestation. The eggplant accessions of with green colour, oblong and round shaped fruits, low sugar and high polyphenols could be used in breeding programmes for developing resistant cultivars to fruit and shoot borer.

Key words: Eggplant, *Leucinodes orbonalis*, resistance, biophysical, biochemical factors.

INTRODUCTION

The eggplant, *Solanum melongena* Linn. is the most common, popular and major vegetable grown in India and other parts of the world. Among various insect pests of eggplant, eggplant fruit and shoot borer (EFSB), *Leucinodes orbonalis* Guennee (Pyralidae: Lepidoptera) alone is a serious menace causing yield losses ranging from 40.79 to 71.84 per cent (Pareek and Bhargava, 9). For the management of this pest, farmers usually resort to spray of synthetic pesticides. This practice of indiscriminate use of pesticides leads to build up of pesticide residues in the produce, destruction of beneficial insects, pest resurgence, pesticide exposure to farm workers and environmental pollution. Host plant resistance (HPR) is the economically sound technique to reduce pest-linked damage in eggplant as well as to protect the environment from adverse effects of pesticides. In many cases it is obvious that the morphological characters of the host plant and biochemical constituents such as phenols, flavonols, sugars, protein, and starch or combined factors are important in conferring resistance to fruit borer. Varieties with round shape, less number of seeds and smooth fruit surface are more susceptible than those with long fruits and hard surface (Gupta and Kauntey, 4). Biochemical characters, such as total sugars and free amino acids, were positively correlated with fruit infestation, whereas, polyphenols content was negatively correlated with fruit borer attack. An understanding of different biophysical and biochemical components of resistance is essential for developing strategies to breed for resistance to insect pests. Hence, the present investigation was carried out to identify the eggplant genotypes for resistance against EFSB and to understand the biophysical and biochemical basis of resistance.

MATERIALS AND METHODS

Field experiments were carried out during rainy seasons of 2009 and 2010 at National Bureau of Plant Genetic Resources (NBPGR), Experimental Farm, Pusa Campus, New Delhi (77.15°E longitude and 28.64°N latitude) in semi-arid type of climate with temperatures ranging from 20° to 40°C, average RH of 50% and rainfall ranging from 550 to 850 mm. The experiment was laid-out in randomized block design (RBD) with three replications. A total of 23 accessions (comprising of eight resistant and eleven susceptible eggplant germplasm accessions against EFSB along with four cultivated varieties, selected from four hundred accessions, based on the previous year's preliminary screening) were evaluated for resistance to EFSB. The cultivated varieties included Pusa Shyamla, Pusa Ankur, KS331 and Punjab Sadabahar. The seeds were treated with Captan {cis-N [(trichloromethyl) thio]-4 cyclo hexane-1, 2-dicarboximide} to prevent

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soil-borne fungal diseases, and sown in nursery beds. One-month-old seedlings (about 15 cm in height) of each accession was transplanted in two rows of 6 m length with 90 cm spacing between rows and 60 cm between plants. A basal dose of 100 kg N, 80 kg P_2O_5, and 60 kg K_2O ha^{-1} was applied and top dressing with 40 kg N ha^{-1} was done at 45 days after transplanting. Irrigation and hand weeding operations were performed whenever necessary. The infestation per cent of eggplant fruits against EFSB was recorded both on number and weight basis at each picking of fruits at marketable maturity, starting from 60 days after transplanting till the last picking. The per cent infestation of fruits on number basis was calculated by counting the infested and healthy fruits separately from all the plants in each accession. The weight of both healthy and infested fruits was taken separately and level of percent infestation was calculated. At the time of harvesting, five fruits of marketable maturity from each genotype/variety were selected and length and width of fruit was recorded using Vernier calipers. Fruit length-width ratio was calculated as ratio of fruit length to fruit width. The shape and colour of fruit was recorded visually at marketable maturity stage as per the minimum descriptors list (Srivastava *et al.*, 13). The seediness of the fruit was visually recorded at marketable stage by cutting the fruit longitudinally. Weight of five fruits at marketable maturity stage was recorded in each accession using digital weighing balance and averaged.

For biochemical analysis, five fruits per plant were harvested at marketable maturity stage. One replicate was constituted by compositing five fruits, three replicates of each genotype were analyzed and each replicate was processed independently. The maturity stage was assessed based on fruit colour, firmness and glossiness. Cleaned and surface-dried fruits were sliced longitudinally into small pieces representing the whole sample, and fresh weight (FW) was recorded. All the 23 genotypes were analyzed for following biochemical parameters, *viz*., total proteins (AOAC 976.06), dietary fibre (AOAC 992.16), starch (AOAC 996.11), moisture (AOAC 935.29) and ash (AOAC 942.05) by AOAC (1) method and total soluble sugars (Roe, 10), total phenols and flavonols (Oomah *et al*., 8) to understand the biochemical basis of resistance. Statistical analyses were performed using Statistical Analysis Software, Version 9.2 (SAS, 11). Analysis of variance was carried out using PROC GLM to determine significant differences in percentage infestation among the eggplant germplasm studied. Simple linear correlation analysis was performed to indicate the measure of correlation and strength of relationship between biophysical and biochemical variables with percentage of EFSB infestation.

RESULTS AND DISCUSSION

Significant differences ($P<0.05$) were observed among 23 eggplant accessions with respect to the per cent of infestation, both in number basis and weight basis. Results revealed that the infestation of ESFB ranged from 3.03 to 72.00% on number basis and 3.39 to 66.19% on weight basis. Five accessions, namely, IC280954, IC099723, IC111013, IC111033 and EC038474 were found resistant against ESFB as the infestation level was less than 15% on number basis. Three accessions IC090910, IC112747 and IC090093 were found highly susceptible against ESFB, as the infestation level was more than 60% on number basis.

Plants defend themselves against herbivores using their biophysical and structural features. In many cases, it is obvious that the biophysical characters of the host plant play an important role in conferring resistance to fruit borer. Major biophysical characters of eggplant fruits in relation to EFSB infestation is given in Table 1. In the present study, the fruit colour varied from green through light purple to black purple. Fruits which were green in colour had less infestation (7.89 to 16.32% damage). The present result gets support from the earlier works of Jat and Pareek (5) who reported that the light green coloured fruits were not preferred by the borer. Although, Naqvi *et al.* (7) reported that the shape and colour of the fruits had no clear cut impact on the infestation of fruit borer. Accessions such as IC280954, IC099723, IC111013, IC111033 and EC038474 had green, oblong and round shaped fruits and high number of seeds, were resistant. The varieties having closely arranged seeds in mesocarp were less infested (Subbaratnam, 14). Although, Gupta and Kauntey (4) reported that varieties with round shape, and less number of seeds are more susceptible to borer than those with long fruits.

The mean length of the fruits of the accessions were ranged from 6.55 to 22.07 cm and there was no significant correlation found for EFSB infestation with length of fruits, fruit width, fruit length-width ratio and fruit weight. Our results are in conformity with previous reports of no impact of length (Jat and Pareek, 5; Gupta and Kauntey, 4) and fruit length and diameter (Shukla *et al.*, 12) on the infestation, whereas, Naqvi *et al.* (7) reported that length of fruits had significant negative correlation and diameter of fruits had significant positive correlation. Many biochemical factors are known to be associated with insect pest resistance in crop plants. In many cases, it is obvious that the biochemical constituents like, total phenols, flavonols and enzymes are more important than other morphological and physiological factors, in conferring non-preference and antibiosis. Some biochemical constituents may also act as feeding stimuli for insects.

Table 1. Biophysical characters of eggplant fruits in relation to fruit and shoot borer infestation.

Accession	Fruit colour	Shape	Seediness	Fruit length (cm)	Fruit width (cm)	Fruit length width ratio	Fruit wt. (kg)	% infestation (No. basis)	% infestation (wt. basis)
Pusa Shyamla	Purple black	Long	Less	17.22	4.38	3.93	0.11	3.39	3.39
IC280954	Green	Oblong	High	9.00	4.55	2.00	0.55	7.89	11.97
IC099723	Green	Round	High	11.86	3.96	2.99	0.45	10.00	6.25
IC111013	Green	Oblong	High	12.06	3.96	3.05	0.30	11.76	15.70
IC111033	Green	Round	High	6.57	5.55	1.18	0.75	13.33	28.24
EC038474	Green	Long	High	13.94	2.46	5.66	0.40	15.00	19.14
KS331	Green	Oblong	High	11.21	4.24	2.64	0.50	16.32	14.36
IC112726	Purple	Round	High	7.15	6.15	1.16	0.40	17.69	26.19
IC383102	Light purple	Oblong	Medium	14.83	6.26	2.37	0.71	19.04	31.60
IC420590	Purple black	Oval	High	10.12	5.16	1.96	0.75	22.22	22.48
Punjab Sadabahar	Purple black	Long	Low	22.07	3.25	6.79	0.5	26.31	26.00
Pusa Ankur	Purple black	Round	Medium	8.0	7.08	1.13	0.17	20.51	32.70
IC374852	Purple	Oblong	Medium	8.22	4.82	1.71	0.15	37.50	35.02
IC089886	Purple black	Oval	Low	11.6	5.56	2.11	0.90	38.46	29.14
IC215020	Purple black	Long	Medium	12.50	3.96	3.16	0.40	42.85	39.17
IC415084	Light purple	Long	Medium	12.42	5.97	2.08	0.94	44.00	48.33
IC316258	Purple	Long	High	17.8	2.46	7.25	0.45	45.24	51.42
IC545854	Light purple	Oblong	Medium	11.36	4.83	2.35	0.4	50.00	40.9
IC354721	Purple	Round	Medium	6.55	5.18	1.26	0.35	51.35	49.82
IC320865	Purple	Round	Medium	10.63	4.56	2.33	0.40	57.78	61.39
IC090910	Purple	Oval	Medium	7.31	4.32	1.69	0.25	64.29	60.00
IC112747	Purple	Long	Medium	16.63	3.93	4.23	0.50	66.66	54.54
IC090093	Light purple	Long	Medium	12.06	4.33	2.81	0.50	72.00	63.63
Correlation coefficient (*r*)	-	-	-	-0.02	-0.09	0.02	0.01	-	-

Occurrence at lower concentration or total absence of such biochemical constituents leads to non preference, a form of insect resistance. Among the biochemical factors studied, phenol content varied from 1.67 to 5.17 mg/g FW. The lowest phenol content (1.67 mg/g FW) was recorded in the accession IC090093, which was highly susceptible to EFSB (72% infestation on number basis). The phenol content was high in resistant check, Pusa Shyamala (5.17 mg/g) followed by IC280954 (4.66 mg/g), which were resistant to EFSB infestation recording 3.03 and 7.89% infestation on number basis respectively. Phenols are the most abundant plant alleo-chemicals, often associated with feeding deterrence or growth inhibition of herbivores. Phenols in fairly large concentration could ward off insects pests because of their direct toxicity (Mohan *et al.*, 6). The accessions with high phenols content showed low percentage infestation, while the susceptible accessions with low phenol content showed high infestation, indicating that phenols plays an important role in imparting resistance against this pest. Total phenols showed a significantly inverse correlation with per cent fruit borer infestation (r = -0.89). The present results are in good agreement with the earlier reports of Jat and Parrek (5), Chandrashekhar (2), and Elanchezhyan *et al.* (3) who reported that higher phenol contents increased resistance to fruit borer. Ash content of the fruits was found to negatively correlated (r = -0.83) with fruit borer infestation. Warade *et al.* (15), and Elanchezhyan *et al.* (3) also reported the same type of observation. Similarly, flavonols (r = -0.83) and starch (r = -0.88) exerted a significant negative correlation with per cent fruit borer infestation indicating that these constituents might have influenced the biology and establishment of fruit borer by playing an important role in the antibiosis mechanism.

In the present study, dietary fibre content was highest (3.63 g/100 g) in resistant check, Pusa Shyamala followed by IC280954 (3.53 g/100 g) and IC099723 (3.39 g/100 g) in contrast to the susceptible accession IC090093, which contained 1.77 g dietary fibre per 100 g. FFSB infestation had significant negative correlation with dietary fibre (r = -0.92). This finding was consistant with the earlier studies by Warade *et al.* (15) and Chandrashekhar (2) who showed that fibre had significantly negative correlation with per cent fruit infestation by fruit borer.

The total sugars content present in 23 accessions was significantly different with one another. The highest sugars content (1.76 g/100 g FW) was recorded in highly susceptible accession (72%), while lowest (0.75 g/100 g FW) was recorded in resistant accession IC280954 (7.89%). EFSB infestation had significant positive correlation with total soluble sugars (r = 0.65). Since sugar is considered one of the vital nutrients in plants, the difference in the relative amount of sugars between different genotypes with differential susceptibilities to fruit borer indicate that these compound might act as phago-stimulants to EFSB feeding on eggplant. The present result are in agreement with the findings of Jat and Pareek (5), and Elanchezhyan *et al.* (3) who reported that total sugars were positively correlated with fruit infestation. Higher concentration of sugars in eggplant fruits may act as feeding stimulant in the susceptible varieties. On correlating the protein content in fruits with borer infestation, a significant positive correlation was observed (r = 0.48) as earlier recorded by Chandrashekhar (2), and Jat and Pareek (5). A strong positive correlation was observed between the moisture content and EFSB infestation (r = 0.97). Similar correlation was reported by Elanchezhyan *et al.* (3) who reported that increase palatability of the food material with more moisture content in case of susceptible varieties.

Allelochemicals or secondary plant substances could possibly be responsible for ovipositional preference of the adults. Green fruit colour and seediness were associated with resistance to *L. orbonalis*, while purple fruit colour was associated with susceptibility to this insect. Expression of resistance to *L. orbonalis* was also associated with low amounts of sugars and high amounts of phenols. It is evident from the present study that the resistance is not conferred by any single character alone. The combination of biophysical and biochemical traits can be used as an effective and reliable selection criteria to select resistance plants. Nevertheless, it is suggested that the eggplant genotypes with green fruit colour and seediness with low amount of sugars, and high amounts of phenols may be used in hybridization programme to develop cultivars with resistance to *L. orbonalis*. The accessions identified as resistant can be utilized in the breeding programme for development of resistant cultivars.

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Table 2. Infestation of fruit and shoot borer, in relation to biochemical constituents of fruits.

Accession/ Variety	Moisture (%)	Ash (g/100 g) (FW)	Protein (g/100 g) (FW)	Dietary fibre (g/ 100 g) (FW)	Starch (g/100 g) (FW)	Sugars (g/100 g) (FW)	Phenols (mg/g) (FW)	Flavonols (mg/g) (FW)	% infestation (No. basis)	% infestation (wt. basis)
Pusa Shyamla	91.35	0.61	0.37	3.63	1.52	1.19	5.17	0.21	3.03	3.39
IC280954	91.36	0.60	0.26	3.53	1.19	0.85	4.66	0.17	7.89	11.97
IC099723	91.76	0.65	0.34	3.39	1.38	1.06	4.47	0.14	10.00	6.25
IC111013	91.76	0.60	0.61	3.59	1.35	0.86	4.19	0.15	11.76	15.70
IC111033	91.79	0.71	0.28	3.40	1.08	1.21	3.54	0.11	13.33	28.24
EC038474	92.02	0.54	0.57	2.96	1.43	0.92	3.58	0.12	15.00	19.14
KS331	92.04	0.76	0.55	2.84	1.11	0.95	3.56	0.12	16.32	14.36
IC112726	92.13	0.63	0.65	2.95	1.07	0.75	3.18	0.11	17.69	26.19
IC383102	92.26	0.74	0.45	2.90	1.33	1.05	3.15	0.11	19.04	31.60
Pusa Ankur	92.35	0.64	0.44	3.23	1.30	0.87	3.55	0.12	20.51	32.70
IC420590	92.39	0.61	0.34	3.29	1.08	0.82	3.90	0.13	22.22	22.48
Punjab Sadabahar	93.94	0.47	0.22	2.45	0.82	1.55	3.44	0.12	26.31	26.00
IC374852	94.02	0.53	0.45	2.51	1.02	1.76	3.04	0.10	37.50	35.02
IC089886	94.16	0.48	0.44	2.34	1.09	1.20	2.97	0.10	38.46	29.14
IC215020	94.23	0.50	0.75	2.41	0.83	1.63	2.97	0.10	42.85	39.17
IC415084	94.26	0.42	0.72	2.42	0.68	1.09	2.80	0.09	44.00	48.33
IC316258	94.39	0.39	0.74	2.48	0.55	1.52	2.55	0.09	45.24	51.42
IC545854	94.44	0.50	0.51	2.46	0.73	1.51	3.13	0.11	50.00	40.90
IC354721	94.44	0.48	0.62	2.24	0.85	1.10	3.16	0.11	51.35	49.82
IC320865	94.76	0.36	0.31	2.09	0.76	1.46	2.49	0.08	57.78	61.39
IC090910	94.81	0.41	0.72	2.34	0.56	1.24	1.92	0.07	64.29	60.00
IC112747	95.04	0.43	0.65	1.86	0.72	1.43	2.25	0.07	66.66	54.54
IC090093	95.88	0.31	0.58	1.77	0.58	1.76	1.67	0.06	72.00	63.63
$CD_{0.05}$	0.011	0.01	0.04	0.10	0.06	0.12	0.38	0.017	1.04	0.95
r	0.97*	-0.83*	0.48**	-0.92*	-0.88*	0.65*	-0.89*	-0.83*		

FW = Fresh weight, *Significant at ($P < 0.01$); **Significant at ($P < 0.05$)

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