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Antixenosis mechanism of resistance in certain selected brinjal germplasm for resistance to brinjal shoot and fruit borer

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Abstract
Field experiments were conducted during rabi 2016 and 2017 to screen one hundred and one brinjal genotypes to brinjal shoot and fruit borer. Seven germplasm comprising three under resistant category, two under moderate resistant category along with one each of resistant and susceptible check germplasm were selected for study of antixenosis mechanism of resistance operating in them. It was observed that the fruit infestation percentage in the selected germplasm were negatively correlated to plant height, trichome density and number of seeds in the pulp whereas, a positive correlation existed with fruit length, fruit diameter, pedicel length and calyx length. As far as insect response to brinjal germplasm was concerned, it was observed that the females of brinjal shoot and fruit borer were more alighted on susceptible check and moderately resistant germplasm than resistant germplasm and resistant check. Larval orientation was more on susceptible check and resistant varieties attracted less larvae than moderately resistant lines. The females laid more eggs on susceptible check than moderately resistant and resistant germplasm. There was evidence of strong antixenosis mechanism in the selected germplasm against brinjal shoot and fruit borer.

Keywords: antixenosis mechanism, certain selected, brinjal germplasm, brinjal shoot, fruit borer

Introduction

Brinjal is one important vegetable crop grown in Asiatic and South East Asiatic countries. This is one of the important ingredient in the daily diet of both rich and poor people of many countries; more particularly in India. In Odisha, brinjal cultivation in the recent past has been seriously hampered due to single major insect pest, brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee (Pyralidae: Lepidoptera). This insect causes nearly 60-70% yield loss in brinjal (Singh and Nath, 2010) [1]. The chemical control approach has become highly futile due to development of insecticide resistance (cross resistance) in the insect. Lack of suitable resistant variety on commercial basis also compounds the problem. In the integrated management schedule of this insect, use of resistant variety is a very important component. With this objective, the present investigation was carried out to find out the source of resistance to BSFB amongst one hundred one brinjal germplasm through field screening and to further determine the antixenosis mechanism of resistance operating in the selected germplasm.

Materials and Methods

One hundred one germplasm lines were screened for two seasons i.e. during rabi, 2017 through 2018 in the Department of Entomology, College of Agriculture, OUAT, Bhubaneswar. Screening was undertaken in the same field and sowing and transplanting dates were almost same in both the seasons. All the recommended agronomic practices were taken up during the period of study. Per cent fruit infestation from five randomly selected plants per germplasm starting from fruit initiation to final harvest at weekly intervals was taken up during both the years and the average fruit infestation was worked out. Scoring was done for categorization of brinjal germplasm lines as per the method suggested by Thejavathu *et al.*, 1991 [14].

Seven brinjal germplasm lines *viz*; BBSR-117-1. BBSR-114, BBSR-145-1 (all resistant), BBSR-200 and BB-44 (moderately resistant) along with resistant check (CHES WS-1) and susceptible check (Jamusahi local), were selected for antixenosis mechanism study.

The selected germplasm were transplanted in rabi, 2018-19 in field condition following recommended agronomic parameters. Observation on fruit infestation was made starting from fruit initiation to final fruit harvest from five randomly selected plants of each germplasm. The average damage percentage was worked out taking all the observations into account. The germplasm were evaluated in plot size of 5×4 m^2 area with three replications. One week before final harvest the following morphological parameters were observed:

a. **Plant height:** The plant height was measured by a meter scale and expressed in centimetre. Five selected plants were used for taking average plant height in each replication.
b. **Fruit length:** Ten numbers of fruits were plucked from three to four plants for each germplasm in one replication and fruit length was measured in a scale. The average length fruit in each replication was expressed in centimetre.
c. **Fruit diameter:** The same fruits used for determining fruit length were also used for determining fruit diameter and was expressed in centimetre.
d. **Fruit pericarp thickness:** The same fruits were also used to determine the pericarp thickness. The fruits were cut in circular dishes at the maximum girth area and the thickness of pericarp was measured by a scale.
e. **Fruit shape:** The shape of the fruits of each germplasm was determined on eye estimation only.
f. **Pedicel length:** The pedicel attaching stem and fruit was measured by a scale. The pedicel of the same fruits used for fruit length measurement were measured and expressed in centimetre.
g. **Calyx length:** Ten calyx from one plant per germplasm per replication were taken from the plants and the average calyx length was determined, replication wise.
h. **Trichome density:** Trichome density from 1cm^2 leaf bit of individual germplasm was observed under the binocular microscope and the number of trichomes per 1cm^2 leaf area was determined. Ten such leaf bits per germplasm was used to measure the trichome density.
i. **No. of seeds per 50g pulp:** Fifty gram pulp from fruits of each germplasm were scooped out and the number of seeds present in the volume of pulp was determined.

For determining various non-preference parameters like adult and larval orientation and rate of oviposition the experiments were conducted in the green house at ICAR-CHES, Bhubaneswar. The following studies were made

a. Adult orientation Study

A circular galvanized tray with 2’ diameter and 3” height was constructed to study adult orientation. The seedlings (21d old) of each germplasm were transplanted on earthen pots (1kg soil capacity) with FYM and recommended fertilizers. These pots containing the test germplasm were placed towards the periphery of the tray. Thus, the pots were arranged in a circular fashion. The entire pots were caged by Mylar cage and the top of the cage was covered with muslin cloth to keep the plants pest free. From the rearing units, one hundred female moths were released at the centre of the cage.

The settling of the adults on different germplasm was recorded on 6, 12, 24h after release. The settling of the adults was expressed in percentage. The experiment had three replications.

b. Larval orientation

The experimental set up remained equal as that of adult orientation study. A Mylar film was cut into a circular fashion exactly fitting in to the diameter of the galvanised tray. Seven circular holes were made in such a way that brinjal plants in each pot will pass through the holes such that Mylar film sheet will remain above the top edge of the earthen pots. The entire structure will be caged and the top of the cage was covered by the muslin cloth. Fifty numbers of late second instar larvae were released on a paper on the mylar sheet and kept at the centre of the galvanised cage. Larval orientation towards the germplasm was recorded at 6, 12, 24 h after release of the larvae. The larval orientation was expressed in percentage.

c. Oviposition Study

In this study, individual germplasm of three weeks old were transplanted on earthen pots (1kg capacity) and covered by Mylar cage. The top of the mylar cage was covered with muslin cloth. Two weeks after transplanting, a pair of freshly emerged adults of BSFB was released in each cage. After 7 days, the cages were removed and the number of eggs laid on the plants was recorded. Each germplasm faced three replications.

The data were analysed as per RBD (Gomez and Gomez, 1984) to arrive at definite conclusion.

Results and Discussion

The data on per cent fruit damage and various plant biophysical characters have been presented in Table 1. It can be envisaged from Table 1 that the resistant check, CHES-WS-1 had the lowest fruit damage (4.00%) which was statistically different from rest of the germplasm lines. The line BBSR-117-1 resulted in 12.50% fruit damage which was also different from the others. The other two resistant lines *viz*; BBSR-145-1 and BBSR-114 supported 15.12 and 16.15% fruit damage and remained at par with each other. The moderately resistant lines BB-44 and BBSR-200 recorded 25.35 and 27.60% fruit damage respectively and were statistically different from each other. The susceptible check, Jamusahi local recorded highest fruit damage (58.95%) and was statistically significant from rest of the germplasm lines.

The Plant height varied significantly within the selected germplasm lines. It was highest in resistant check, CHES-WS-1 (88.92cm). In BB-44, the plant height was measured to be 66.08cm which was at par with BBSR-145-1. Hence, the plant height parameter did not substantially contribute towards resistance. It is common that plant height when increased, branches would be more and infestation would be more. Even some workers *viz*; Javed *et al.*, 2011 [2] has reported that plant height was negatively related to resistance to BSFB and our study corroborate with the findings of the above scientists.

The fruit length was measured to be minimum in resistant check (2.44cm) which was statistically different from rest of the treatments. The other selected germplasm *viz*; BB-44 (MR) (4.56cm) was at par with BBSR-117-1 (R) (4.61cm) and BBSR-200 (MR) (4.77cm). Both resistant lines BBSR-114 and BBSR-145-1 had 5.31 and 5.56 cm of fruit length. The susceptible check (Jamusahi local) accounted for a fruit length of 6.60cm which was significantly highest.

Pradhan *et al.*, 1994 [4] and Grehwal and Singh (1992) have earlier reported that fruit length was related to less infestation (low resistance). Length of fruit increased means fruit diameter will be less and mesocarp volume will be less. Hence, longer fruits have less fruit damage than comparatively short length fruits.

The data on fruit diameter also has been depicted in Table 1. It can be witnessed from the Table-1 that the fruit diameter was lowest in resistant check (1.33cm) which was statistically different. In rest germplasm BBSR-117-1 exhibited 3.49cm of fruit dia which was also different from the rest. However, the germplasm BBSR-114, BBSR-145-1, BBSR-200 and BB-44 had the fruit dia of 4.37, 4.34 and 4.55cm respectively which did not vary among themselves. The fruit of susceptible check Jamusahi local had a diameter of 5.29cm which was also statistically different from others.

It was inferred that less fruit diameter was responsible for lower fruit damage. Thus, lower fruit diameter can be accounted for as a morphological parameter of brinjal plants for resistance against BSFB. Many workers *viz*; Prasad *et al.*, 2014 [5] and Naqvi *et al.*, 2008 [3] also studied a similar phenomenon and expressed that fruits with less diameter contained less pulp and such fruits were unsuitable for the BSFB larvae survival. The present study is further strengthened due to the findings of the above authors.

Pericarp thickness in resistant check, CHES WS-1 was found to be highest (0.93cm) which was significantly different from rest of the selected germplasm. In BBSR-117-1, BBSR-145-1, BBSR-114 the pericarp thickness ranges from 0.56-0.58 cm having no statistical difference between themselves. Similarly, the moderately resistant germplasm BB-44 and BBSR-200 exhibited 0.45 and 0.59 cm pericarp thickness having no difference between themselves. The least pericarp thickness was observed in susceptible check (0.33cm).

Wagh *et al.*, 2012 and Chandrasekhar *et al.*, 2009 [6] also reported a similar correlation between pericarp thickness fruit infestation. Fruits with least infestation percentage were having more pericarp thickness than their susceptible counterparts.

The pedicel length was observed to be highest in Jamusahi local (6.57cm) which was distinctly different from others and it was followed by BBSR-117-1 (5.07cm). BBSR-117-1 was witnessed to be a separate germplasm and remained different from others. The germplasm BBSR-200, BBSR-145-1 and BB-44 were at par. Wagh *et al.*, 2012 and Niranjana *et al.*, 2015 have also observed a similar phenomenon in which pedicel length was a poor morphological trait.

It was observed from Table 1 that calyx length was minimum in resistant check (1.55cm). Even the resistant germplasm BBSR-117-1 possessed high calyx length (4.56cm). The susceptible check Jamusahi local had a calyx length of 3.55cm which indicated that calyx length was also a poor morphological parameter contributing towards resistance in brinjal to BSFB.

However, Patil and Ajri (1993) [13] observed that the resistant brinjal accession possessed less calyx length as compared to susceptible ones.

Trichome density per cm^2 leaf area was counted and has been depicted in Table 1. High trichome density was seen in resistant check, CHES-WS-1 (365.50) and remained statistically different. It was too observed that the germplasm varied significantly for each other. The susceptible check had the least density (95.67).

Trichome density was considered as a strong morphological trait responsible for high resistance in brinjal to the target plant. The fruit infestation percentage was high in germplasm having least trichome density as compared to high density germplasm. Javed *et al.*, 2011 [2] and Niranjana *et al.*, 2015 have also opined in a similar manner that supported our present study. High trichome density impeded larval movement and due to that there was variation in fruit damage percentage.

Fruit shape as a morphological trait was also observed. It was observed that though resistant check had a round shape than others, caused least fruit infestation (4.00 per cent). Though in literature it is cited that round fruits were more damaged (Pradhan *et al.*, 1994) [4] than oblong fruits, we here by substantiate to our findings.

The data on number of seeds present in 50g pulp has been depicted in Table-1. It was observed that the seediness was more in resistant check. CHES-WS-1 (1160.60 seeds) which was distinctly different from the rest. Other varieties also remained statistically different from each other. All the resistant and moderately resistant germplasm had higher number of seeds than susceptible check (556.82).

Seediness is a good character that imparts compactness of the fruit. More compactness is unfavourable for the neonate larvae of BSFB to penetrate and feed. Due to this tightness, the larvae succumb to death. Hence, more seeded germplasm were less preferred by BSFB. Khorseduzzaman *et al.*, 2008 also opined in a similar manner which strengthened our present findings.

The data on Correlation between fruit infestation and other biophysical parameters has been presented in Table 2. It can be inferred from Table 2 the plant height (r = -0.2350), trichome density (r = - 0.8523) and number of seeds per 50g pulp (r = - 0.8554) were negatively correlated to fruit infestation whereas, the fruit infestation was positively correlated to fruit length, fruit diameter, pedicel length and calyx length.

Ahmed *et al.*, 2009 and Naqvi *et al.*, 2008 [3] have also reported that plant height was positively correlated with fruit infestation which contradicts our findings. Lal *et al.*, 2006 [11] and Mishra *et al.*, 1988 [10] have observed that trichome density and number of seeds in pulp were significantly and negatively correlated to fruit damage.

Table 1: Morphological characters of brinjal germplasm in relation for resistance to brinjal shoot and fruit borer

Germplasm	Fruit infestation (%)	Plant height(cm)	Fruit length (cm)	Fruit dia (cm)	Pericarp thickness (cm)	Fruit shape	Pedicel length(cm)	Calyx length(cm)	Trichome density/cm^2	No of seeds/50g pulp
BBSR-117-1	12.50(20.70)^{b}	54.24^{b}	6.60 ^{d}	3.49 ^{b}	0.58 ^{c}	Long	5.07 ^{b}	4.56 ^{d}	248.67 ^{f}	910.80 ^{e}
BBSR-145-1	15.12(22.88)^{c}	64.50^{d}	5.56 ^{c}	4.39 ^{c}	0.56 ^{c}	Long	5.46 ^{c}	2.40 ^{b}	230.50 ^{e}	826.35 ^{d}
BBSR-114	16.15(23.69)^{c}	43.63^{a}	5.31^{c}	4.37 ^{c}	0.56 ^{c}	Oblong	6.06 ^{e}	2.59 ^{b}	210.67 ^{d}	824.69^{d}
BB-44	25.35(30.23)^{d}	66.08^{d}	4.56 ^{b}	4.55 ^{c}	0.45 ^{b}	Oblong	5.47 ^{c}	3.36 ^{c}	179.33 ^{c}	686.33^{c}
BBSR-200	27.60(31.69)^{d}	55.51^{b}	4.77 ^{b}	4.55 ^{c}	0.49 ^{b}	Oblong	5.41 ^{c}	2.62 ^{b}	122.50 ^{b}	666.33^{b}
CHESWS-1(RC)	4.00(11.54)^{a}	88.92^{e}	2.44 ^{a}	1.33 ^{a}	0.93 ^{d}	Round	2.54 ^{a}	1.55 ^{a}	365.50 ^{g}	1160.60^{f}
Jamusahilocal (SC)	58.95(50.16)^{e}	61.75^{c}	4.61^{b}	5.29 ^{d}	0.38 ^{a}	Oblong	6.57 ^{e}	3.55 ^{c}	95.67 ^{a}	556.82^{a}
SE(m) ±	0.45	0.830	0.103	0.08	0.01		0.071	0.092	2.340	1.89
CD (p=0.05)	1.32	2.44	0.31	0.23	0.04		0.21	0.28	6.91	5.59
CV (%)	2.81	2.30	3.54	3.33	3.89		2.29	5.00	2.12	0.41

*Figures in parentheses are arc sine transformed values

RC= Resistant Check SC= Susceptible Check

Table 2: Correlation between fruit infestation percentage and various biophysical parameters of the selected germplasms

Sl No.	Morphological Parameters	Correlation coefficient
1	Fruit infestation vs. Plant height	- 0.23
2	Fruit infestation vs. Fruit length	0.16
3	Fruit infestation vs. Fruit diameter	0.73*
4	Fruit infestation vs. Pedicel length	0.69*
5	Fruit infestation vs. Calyx length	0.36
6	Fruit infestation vs. Trichome density	- 0.85*
7	Fruit infestation vs. Number of seeds/50g pulp	- 0.85*
8	Fruit infestation vs. Pericarp thickness	- 0.49*

Adult orientation

The data on adult orientation as a preference parameter at different post release period has been presented in Table 3. It can be observed that, after 6h of exposure 6.32% adults alived in resistant check whereas 26.70% adults alived on susceptible check, Jamusahi local. On resistant and moderately resistant germplasm 12.62 to 14.02% adults were attracted. At 12h of post release period, the susceptible check attracted 26.4% adults.

While adult orientation percentage ranged from 13.12 to 14.78% on different resistant and moderately resistant brinjal germplasm. At this stage, the resistant check invited only 4.94% adults. After 24h of release it was visualised that the susceptible check could attract 26.42% adults towards them which was significantly highest than rest of the treatment. On the contrary, the resistant check could support 4.12% adults remaining as a statistically different treatment. All the resistant germplasm could attract 13.82 to 13.94% adults having no difference between themselves. Similarly, moderately resistant germplasm also didn't vary among themselves.

Larval orientation

Data on larval orientation has been presented in Table 3. It can be observed from the table that after 6h highest larval orientation was observed in Jamusahi local (27.79%) which was significantly different than rest of the treatments. The resistant check attracted only 7.58% larvae which was also significantly distinct from rest of the treatments. Among the resistant lines, BBSR-114 only invited 9.98% larvae was also statistically different from rest of the resistant lines. In other two resistant lines, larval orientation was at par. However, BB-44 and BBSR-200 could attract 14.82 and 15.43% larvae towards them. A distinct preference of larvae towards host plant was observed after 24h. While susceptible check invited 28.04% larvae at that time resistant check invited only 5.12% larvae. The resistant germplasm supported 10.98 to 13.66% larval orientation on them having distinct significant difference among themselves. The larval orientation between moderate resistant germplasm didn't vary and both the germplasm were at par with each other.

Table 3: Insect response study in selected brinjal germplasm against BSFB

Sl No	Germplasm	Adult orientation (%) at			Larval orientation (%) at			Oviposition
		6h	12h	24h	6h	12h	24h	
1	BBSR-117-1	13.50 (21.56)^{bc}	13.68 (21.70)^{bc}	13.94 (21.92)^{b}	12.56 (20.75)^{c}	13.22 (21.32)^{c}	13.66 (21.69)^{cd}	48.67^{b}
2	BBSR-145-1	14.02 (21.99)^{c}	14.17 (22.11)^{bc}	13.82 (21.82)^{b}	11.99 (20.25)^{c}	12.48(20.68)^{bc}	12.96 (21.10)^{bc}	52.16^{b}
3	BBSR-114	12.62 (20.81)^{b}	13.45 (21.51)^{b}	13.84 (21.84)^{b}	9.98 (18.41)^{b}	11.43 (19.78)^{b}	10.98 (19.35)^{b}	51.98^{b}
4	BB-44	14.02 (21.99)^{c}	14.78 (22.60)^{c}	14.08 (22.03)^{b}	14.37 (22.27)^{d}	14.82 (22.64)^{d}	14.18 (22.12)^{d}	58.67^{b}
5	BBSR-200	12.82 (20.98)^{b}	13.12 (21.31)^{b}	13.78 (21.79)^{b}	14.89 (22.69)^{d}	15.43 (23.12)^{d}	15.06 (22.38)^{d}	56.33^{b}
6	CHES-WS-1(RC)	6.32 (14.56)^{a}	4.94 (12.84)^{a}	4.12 (11.71)^{a}	8.42 (16.86)^{a}	7.58 (15.98)^{a}	5.12 (13.07)^{a}	28.64^{a}
7	Jamusahi local (SC)	26.70 (31.11)^{d}	25.86 (30.56)^{d}	26.42 (30.93)^{c}	27.79 (31.81)^{e}	25.04 (30.02)^{e}	28.04 (31.97)^{e}	94.12^{c}
SE (m)±		0.32	0.35	0.28	0.36	0.33	0.28	4.39
CD at 5%		0.93	1.02	0.82	1.06	0.96	0.84	13.20
CV (%)		2.46	2.72	2.19	2.82	2.57	2.26	13.60

*Figures in parentheses are arc sine transformed values
RC= Resistant Check SC= Susceptible Check

Oviposition Study

The rate of oviposition on different germplasm has been presented on Table 3. It can be visualised from table that the female BSFB laid 94.12 eggs which was statistically different from rest of the germplasm evaluated. The resistant check evaluated 28.64 eggs which was also statistically different from others. There was no difference in oviposition so far as resistant and moderately resistant germplasm concerned (48.67 to 58.67 eggs/plant).

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