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Bio physical mechanism of resisitance to major pests of brinjal

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ABSTRACT: An Experiment was carried out with 44 brinjal genotypes at college farm, College of Horticulture, Dr.Y.S.R. Horticultural University, V.R.Gudem to see the effect of biophysical characters of plants on the infestation of major pests on different brinjal genotypes. It was observed that among the characters influencing Trichome density (-0.797 and -0.809), internodal length (-0.242 and -0.257), fruit length width ratio (-0.249 and -0.254) exhibited strong negative correlation with respect to Fruit and shoot damage. While shoot thickness (0.980 and 0.991) and diameter of fruit (0.426 and 0.445) showed significant positive correlation by fruit and shoot borer. Subsequently, Jassid intensity was showed significant positive correlation with shoot thickness (0.401), while negative correlation was observed with trichome density (-0.275) and fruit length width ratio (-0.232). Furthermore, whitefly and hadda beetle number showed negative correlation with shoot thickness (-0.474 and -0.517) and positive correlation with trichome density (0.323 and 0.436), internodal length (0.376 and 0.383).

Keywords: Biophysical, resistance, brinjal and major pests

INTRODUCTION

Brinjal, also known as eggplant or aubergine (*Solanum melongena* L.) is an imperative vegetable crop grown in India and other parts of the world. Diminutive productivity of brinjal accountable by numerous factors, as it is subjected to insect pest are the main constraint in the successful cultivation of brinjal right from nursery stage till harvesting (Reghupathy et al., 1997). Moderate temperature and high humidity is positive discrimination to the population build-up of insect pests due to seasonal changes (Shukla et al., 2010 and Bhushan et al., 2011). Amongst the chemical control is most widely used and it become the chief source in farmers field level for managing insect pests in brinjal it leads to insect pests developed resistance. Environmental contamination, bioaccumulation and bio magnification of toxic residues and commotion in ecological balance due to repeated use of broad spectrum synthetic chemicals. Hence, there is an imperative need to look for safer alternative pest management tactics. Use of resistant varieties is recognized as a significant tool in bio intensive pest management system. Attraction, feeding and oviposition of the insect pests coupled with morphological and physical characteristics of plants and fruits. Although host plant resistance alone or in amalgamation with other methods is environmentally safe and companionable with IPM, however this approach is realistic only when resistant varieties of crops subsist and recognized. Number of pesticide applications can be reduced even a moderate level of resistance (Srivastava and Butani 1998). However, a colossal scope exists in finding resistant sources to major pests as a sizable share of 4,343 brinjal accessions (NBPGR-2015, New Delhi) conserved at the NBPGR still tranquil. In this background, the present investigation was carried out to screen 44 brinjal genotypes for their response to major pests and to expedite their morphological attributes of resistance to the pests. Keeping in view the economic importance of brinjal crop in daily use, where use of insecticides is not desirable, the present studies were undertaken to find out the source of resistance against the major insect pests of brinjal.

MATERIALS AND METHODS

A field experiment was conducted in augumented randomized block design (RABD). The genotypes of 44 brinjal varieties screened against major pests. Four weeks old seedlings were transplanted with a spacing of 75 x 60 cm during September to March 2016 at College of Horticulture, Dr.Y.S.R.Horticultural University, V.R.Gudem. The cultural practices except plant protection measures were followed as per the crop production guide for horticultural crops. They were planted by maintaining ten plants per treatment/entry. Five plants per treatment were tagged at random and observed for the incidence of major pests in each brinjal genotype at weekly interval starting from transplanting to harvest (David, 2000). The pest population/ damage were recorded at weekly interval commencing from seventh day after transplanting (DAT).

Field screening of brinjal genotypes

After transplanting at vegetative growth phase number of infested shoots from five randomly selected and tagged plants from a plot were counted as against total number of shoots per plant and per cent shoot infestation by shoot and fruit borer, *Leucinodes orbonalis* was worked out. The observations on shoot infestation were taken at 15 days interval up to the fruiting stage. At the time of harvesting, the fruits of each plot were harvested separately and numbers of healthy and infested fruits per plot were counted. At the same time weight of healthy and infested fruits were taken to work out per cent infestation on weight basis. The observations were taken at each picking of ten days interval till 13th picking.

The number of nymphs and adults of leafhopper, *Amrasca devastans* were assessed on three leaves (one from bottom, middle and top) in five selected plants by examining each leaf carefully during early morning hours, when the pest was less active. To begin with, leafhoppers on upper surface of the leaves were counted and then the leaf was tilted carefully to count population on the lower surface. The number of grubs and adults of *H. vigintioctopunctata* were recorded from three leaves, one each from top, middle and bottom part of five randomly selected plants. Mean was worked out and expressed as number per three leaves (Murugesh, 1997). Similarly whitefly, *Bemisia tabaci* and the population was expressed as number per three leaves. The observations were taken at standard week intervals.

Analysis of biophysical characteristics of brinjal genotypes

Plant height: Plant height was recorded from the ground level to the top most bud leaf of the plants at the time of flowering and presented in centimeters.

Number of primary branches: Number of branches arising from the main stem was recorded from all the sample plants at the peak harvest stage and average was worked out.

Trichome density on leaves: Three brinjal leaves in five randomly selected plants were carefully examined for the presence of trichomes and were counted from both upper and lower (25 mm^2) area of the same leaves under trinocular zoom stereo microscope.

Internodal length: The Inter nodal length was recorded for each selected plant which were randomly taken from the observational plants and expressed in centimeters.

Shoot thickness: Five randomly selected shoots per plant were taken for measuring their girth at 2.5 cm below the tip and averages were calculated. Vernier calipers was used for this purpose.

Days to first flowering: Number of days from the date of transplanting to the first flowering of observational plants was recorded and the average obtained.

Fruit length: Five fruits were selected at random from the observational plants. Length of the fruits was measured as the distance from pedicel attachment of the fruit to the apex using twine and scale. Average was taken and expressed in centimeters.

Fruit width: Five fruits were selected at random from the observational plants and width of the fruits was measured by using vernier caliper. Average was taken and expressed in centimeters.

Calyx length: The length of calyx was recorded for each fruit selected at random from the observational plants and expressed in centimeters.

Pedicel length: The pedicel length was recorded for each fruit selected at random from the observational plants and expressed in centimeters.

Fruit circumference: Girth of the fruits was taken at broadest part from the same fruits used for recording the fruit length. Average was taken and expressed in centimeters.

Fruit weight: Weight of fruits was measured and average was found out and expressed in grams.

Number of fruits per plant: Total number of fruits produced per plant till last harvest was counted.

Fruit length and width ratio: Shape index was calculated by taking the ratio of fruit length and fruit width.

Yield per plant: Weight of total number of fruits was measured and expressed in grams and the average yield per plant was recorded till the last harvest.

RESULTS AND DISCUSSION

Biophysical basis of resistance in brinjal genotypes against major pests of brinjal

The morphological and biophysical characteristics of shoot and fruits are associated with attraction, feeding and oviposition of the pest of brinjal. Therefore, the identification of biophysical characteristics from insect resistant varieties is most practical significance and efforts were made to determine the morphological basis of resistance in brinjal genotypes against damage caused by major pests.

a) Biophysical characters of brinjal shoot in relation to major pests of brinjal

Table 2. Comparison of trichome density with the damage intensity and population of major pests in brinjal genotypes

Genotype	Trichomes density on leaf (25mm²)*	Shoot & Fruit borer Shoot damage (%)**	Jassids Percent intensity	Jassids Pop / 3 leaves	whitefly Pop / 3 leaves	Hadda beetle Pop / 3 leaves
Gottivada Local	191.61	15.87 (23.80)	10.20 (18.96)	3.91	4.43	12.81
Andra Local	165.21	15.01 (23.11)	18.45 (25.77)	4.06	4.55	11.18
Irapaduguda-B	136.61	26.98 (31.61)	50.61 (45.68)	8.39	2.47	6.71
Irapaduguda-W	119.81	32.76 (35.24)	26.09 (31.05)	5.85	3.91	9.06
Tuni Local	248.61	10.78 (19.49)	14.02 (22.32)	4.62	4.55	12.82
Babajipeta-1	133.21	27.34 (31.85)	26.88 (31.56)	6.28	4.03	9.15
Babajipeta-2	113.21	29.12 (32.98)	28.64 (32.68)	6.39	3.87	9.58
Hiramandal-1	152.61	14.96 (23.07)	50.00 (45.33)	8.15	3.51	9.18
Hiramandal-2	149.01	20.98 (27.58)	26.63 (31.40)	7.21	4.03	10.8
AU-1	145.21	30.01 (33.54)	25.66 (30.76)	6.28	3.79	9.42
EC-144145	180.72	17.92 (24.71)	24.93 (29.62)	4.82	3.2	9.05
EC-169061	121.92	25.8 (30.20)	57.58 (49.03)	7.95	2.72	7.37
EC-169084	293.92	4.32 (11.67)	18.40 (25.07)	3.62	4.16	11.82
EC-169089	256.92	6.53 (14.48)	18.18 (24.91)	3.82	4.12	10.73
EC-316273	253.72	5.71 (13.49)	18.45 (25.11)	3.81	3.96	9.61
EC-316309	269.12	5.32 (13.01)	19.89 (26.16)	3.28	4.16	10.62
EC-316315	249.32	13.3 (21.06)	41.13 (39.56)	5.17	3.88	8.28
EC-316742	155.32	4.98 (12.56)	29.09 (32.31)	6.28	3.4	8.73
EC-373524	236.92	9.34 (17.47)	18.33 (25.02)	4.06	3.96	11.48
IC-089955	266.32	5.37 (13.07)	26.89 (30.91)	6.28	3.84	9.61
IC-090050	274.27	4.11 (12.02)	9.90 (18.67)	3.48	5.22	12.95
IC-090177	253.67	7.94 (16.69)	17.98 (25.42)	4.17	4.72	12.48
IC-090199	272.67	4.21 (12.16)	22.00 (28.30)	4.61	4.6	12.26
IC-090273	274.47	8.01 (16.76)	62.50 (52.57)	8.39	2.56	7.28
IC-090674	263.67	6.11 (14.63)	17.55 (25.10)	4.06	4.84	11.74
IC-090696	175.67	16.78 (24.50)	15.00 (23.12)	4.62	4.52	13.48
IC-110949	251.47	6.87 (15.52)	21.98 28.29)	4.59	4.48	11.4
IC-111322	210.67	8.89 (17.67)	21.67 (28.07)	4.73	4.08	11.95
IC-111346	227.87	8.45 (17.22)	18.18 (25.57)	4.82	4.8	11.82
IC-111392	279.27	7.11 (15.78)	25.35 (30.56)	6.17	3.2	8.62
IC-111427	140.37	21.45 (27.26)	27.86 (31.53)	5.17	3.63	7.51
IC-111448	239.17	11.79 (19.75)	17.86 (24.67)	3.28	4.39	9.61
IC-112309-A	241.17	17.56 (24.44)	16.51 (23.64)	3.59	4.47	15.12
IC-126918	139.37	19.12 (25.60)	26.13 (30.41)	5.28	3.39	8.17
IC-127021	137.17	14.67 (22.19)	15.22 (22.63)	3.62	4.67	9.82
IC-127071	185.37	32.18 (34.23)	26.00 (30.33)	4.39	3.35	8.01
IC-127074	238.57	28.88 (32.18)	51.97 (45.80)	7.6	2.03	5.62
IC-316291	183.77	18.44 (25.10)	51.04 (45.27)	7.48	2.07	5.77
IC-336474	125.97	31.34 (33.71)	50.36 (44.88)	7.17	2.11	5.59
IC-344674	126.77	24.78 (29.52)	20.83 (26.82)	3.73	2.27	7.39
Bhagymathi(C1)	261.35	5.98 (13.52)	14.02 (21.57)	3.71	4.29	10.06
Dommeru(C2)	134.05	23.78 (28.85)	27.18 (31.10)	4.84	3.58	8.26
Gulabi(C3)	248.25	9.91 (18.35)	46.61 (42.77)	5.62	2.73	9.17

W.G.Local (C4)	142.88	22.67 (28.08)	36.18 (36.68)	5.77	4.24	8.28
Mean	**201.528**	**22.27**	**31.06**	**5.34**	**3.79**	**9.78**
Std Error	**8.749**	**1.11**	**1.27**	**0.23**	**0.12**	**2.22**
Ci – Cj	0.079	**0.476**	**0.110**	0.003	0.002	0.004
BiVi - BiVj	0.158	**0.952**	**0.221**	0.006	0.005	0.009
Ci – VI	0.140	**0.842**	**0.195**	0.006	0.004	0.008

Ci – Cj (Critical diference between check and check), BiVi – BiVj (Critical diference between the blocks), Ci – VI (Critical diference between the variety and variety).

Morphological characters like shoot thickness, plant height, number of primary branches, internodal lengths of all the brinjal genotypes were given in Table 1.

Shoot thickness (cm)

Significant variation was observed with respect to shoot thickness which ranged from 0.31 to 0.64 cm. Among the different brinjal genotypes screened the lowest mean value of shoot thickness (0.31cm) was noticed in genotypes EC-169084, EC-316742, IC-090050 and IC-090199 which was statistically on par with Bhagyamathi (0.32 cm). However, the highest mean value (0.64 cm) was recorded in Irapaduguda-W which was 1.23 times larger than the susceptible check Dommeru local (0.51 cm) Amongst the other indigenous collections, IC-090674, IC-110949, IC-111392 were recorded with 0.35,0.36,0.37 cm shoot thickness which are statistically different than the other genotypes. Among the other exotic collections the lowest shoot thickness was recorded in EC-373524 (0.39 cm) and EC-144145 (0.45 cm). Shoot thickness of 0.42 cm was recorded in the Tuni local which was the lowest among the land races.

Plant height (cm)

Considerable variation was observed with respect to plant height which ranged from 45.70 to 82.18 cm. The genotype IC-126918 recorded the maximum height of 82.18 cm, followed by EC-144145 (78.85 cm), EC-169061 (78.09 cm) while EC-316742 recorded the minimum height of 45.70 cm which was 1.06 times lesser than the Bhagyamathi (48.74 cm). Among the land races, Hiramandalam-2 local has attained the maximum plant height of 70.97 cm, followed by Tuni local (69.81 cm) and the lowest plant height was observed in AU-1 (52.44 cm). Amongst the other indigenous collections *viz.,* IC-111427, IC-127021, IC-111448 were recorded with 74.41, 73.34, 71.78 cm plant height which are statistically different than the other genotypes.

Number of primary branches

There was significant variation among genotypes for number of primary branches ranging from 4.43 to 8.23. The genotype Hiramandal-2 recorded the maximum number of primary branches 8.23, followed by IC-090050 (7.99) and Babajipeta-2 (7.83) while Irapaduguda-W recorded the minimum primary branches of 4.43. Among the other indigenous collections *viz.,* IC-090273, IC-110949, IC-127071 and IC-127074 were recorded with 7.59, 7.39, 7.04 and 7.04 primary branches. Among the exotic collections EC-144145 and EC-169061 recorded the maximum number of primary branches of 7.35 and 6.95. While the number of primary branches recorded were more in Bhagyamathi (5.8) compared to Gulabi (4.51) and Dommeru local (5.2).

Internodal length (cm)

Considerable variation was observed with respect to internodal length which ranged from 1.95 to 10.05 cm. The genotype IC-090177 recorded the maximum internodal length of 10.05 cm, followed by IC-090199 (9.65) while IC- 112309-A recorded the minimum internodal length of 1.95 cm. The variety Bhagyamathi (6.46) and Gulabi (7.53) possess larger internodal length than the Dommeru local (6.14). Among the land races, Babajipeta-1 local has attained the maximum internodal length of 8.26 cm, followed by Gottivada local (8.16 cm), Babajipeta-2 (7.96cm) and the lowest internodal length was observed in AU-1 (7.06 cm). Amongst the other indigenous collections *viz.,* IC-090199, IC-090050 and IC-111322 were recorded with 9.65, 8.05 and 7.85 cm internodal length which are statistically different than the other genotypes.

The shoot thickness has negative correlation with the shoot and fruit borer infestation. The low per cent shoot damage (4.11%) and per cent intensity of hopper burn (9.90%) was recorded in the genotype IC-090050 due to profound impact of minimum shoot thickness (0.31 cm) in the resistant genotype. On the reverse, shoot damage (23.78%) and hopper burn intensity (27.18%) was higher in the susceptible check Dommeru local due to higher shoot thickness (0.51 cm). The results are in accordance with the findings of Grewal and Singh (1992), Patil and Ajri (1993) and Pradhan (1994). Webster (1975) found

that the mechanical resistance factors like solidness of stem, tissue's thickness, anatomical adoptions and structures for protection of the plants have proven resistance against major pests. The larval entry is affected by thick cuticle and small pithy stem in the resistant varieties as described earlier by Panda *et al*. (1971).

Trichome density of brinjal genotype leaves influencing major pests of brinjal

There was considerable variation among genotypes under study for trichome density (Table 2 and plate 1) of different brinjal genotypes ranging from 113.21 to 293.92. The genotype EC-169084 recorded the maximum trichome density of 293.92 per 25 mm^2 which was 1.12 and 1.18 times more than the resistant check Bhagyamathi (261.35) and Gulabi (248.25), followed by IC-111392 (279.27), IC-090273 (274.47) and IC-090050 (274.27) while Babajipeta-2 recorded the minimum trichome density of 113.21 which was 0.84 and 0.79 times lesser than the Dommeru local (134.05) and West Godavari local (142.88). Amongst the indigenous collections viz., IC-090199, IC-089955, and IC-090674 were recorded with maximum trichome density of 272.67, 266.32 and 263.67 which are statistically different than the other genotypes. Between the exotic collections maximum trichome density was recorded in the genotypes *viz.,* EC-316309 (269.12), EC-169089 (256.92) and EC-316273 (253.72) respectively.

The lowest per cent fruit damage by *L. orbonalis* was observed in the genotype IC-090050 (10.26 %), followed by IC-090199 (12.75%), EC-169084 (13.03 %). Nevertheless, the Tuni local showed fruit damage of 25.63 per cent which showed 1.71 times lesser fruit damage than the susceptible check Dommeru local (43.88%). While the lowest per cent shoot damage was observed in the genotype IC-090050 (4.11%), followed by IC-090199 (4.21 %) which is statistically on par.

The per cent hopper burn intensity ranged between 9.90 to 62.50 per cent. One genotypes *viz*., IC-090050 with 9.90 per cent hopper burn intensity was considered as highly resistant to *A. devastans* which was 1.41 and 2.74 times lesser than Bagyamathi and Dommeru local in per cent jassid intensity. In contrary the population count was lower in land races like Gottivada local (3.91), Andra local (4.06), Tuni local (4.62).

Among the different brinjal genotypes screened against the whitefly, The least number whitefly population per three leaves / pant (2.03) was noticed in genotype IC-127074 and the highest population (5.22 /plant) was recorded in IC-090050 and on the land race Irapaduguda-B only 2.47 whiteflies were found per plant.

Trichome density of resistant brinjal genotypes had negative impact on the infestation and intensity of major pests of brinjal as the trichomes do not favour the female moth for oviposition and then to the neonate larvae to reach towards normal boring site.

The lowest per cent of shoot damage (4.11%) and hopper burn intensity (9.90%) was recorded in the genotype IC-090050 due to high trichome density 274.27 (25 mm^2 on leaf). Whereas, the highest per cent of shoot damage (32.76%) and per cent intensity of hopper burn (26.09%) were recorded in the genotype Irapaduguda-B due to low trichome density 119.81 (25 mm^2 on leaf). However, in the susceptible check Dommeru local, trichome density is as low as 134.05 per 25 mm^2 on leaf with higher shoot damage of 23.78% and hopper burn intensity of 27.18%. On the contrary, the trichome density is positively correlated with the whitefly population where they preferred more pubescence for their feeding, growth and survival. The present findings are in accordance with the reports made by Oatman (1959), Panda and Das (1975), Ishaque and Choudhari (1984), Kale *et al* (1986) and Naqvi *et al*. (2008). Similarly, Javed *et al.* (2011) also reported strong and negative correlation between trichome density and infestation of *L. orbonalis*. Morphological bases of resistance against jassids are consequential to high mid rib hair density and longer midrib hairs in the resistant accessions which was in concurrence with the findings of Malini *et al.* (2013).

b) Biophysical characters of brinjal in relation to *L. orbonalis* infestation.

Different characters like days to first flowering, length of the pedicel, length of the calyx of all the brinjal genotypes were given in (Table 3)

Days to first flowering

Significant variation was noticed with respect to days to first flowering which ranged from 15.26-59.38 DAT. The genotype Andra local took maximum days for first flowering (59.38 DAT), followed by Hiramandal-2 (59.25DAT) while, IC-344674 recorded the minimum days for first flowering 15.26 DAT which was 2.23 and 2.92 times lesser than the Bhagyamathi (34.05) and Gulabi (44.67). Amongst the other indigenous collections *viz.,* IC-112309-A, IC-316291, IC-111448 and were recorded with 58.36, 56.2 and 52.46 days to first flowering, which are statistically different than the other genotypes. Among the exotic collection EC-316315 (50.49), EC-316742 (48.01), EC-316309 (41.96) and EC- 169061 (41.77) were recorded with maximum days for first flowering.

Table 4. Biophysical Characters of brinjal fruits in relation to fruit and shoot borer infestation

Genotype	Length of Fruit (cm)	Dia. of Fruit (cm)	Fruit L/W Ratio (cm)	Fruit Wt (gm)	Fruit Circum. (cm)	Fruits/ Plant	Fruits yield/ Plant	Fruit borer damage %
Gottivada	15.31	9.61	1.58	379.93	30.98	4.46	1732.49	33.65 (35.78)
Andra	12.41	7.09	1.75	215.43	22.38	12.11	2646.86	31.89 (34.70)
Irapaduguda-B	10.21	7.42	1.36	124.43	18.79	12.51	1594.62	45.81 (42.92)
Irapaduguda-W	11.41	6.2	1.85	160.43	20.04	10.81	1772.25	71.69 (58.17)
Tuni	9.51	6.81	1.39	216.68	20.44	15.51	3398.71	25.63 (30.74)
Babajipeta-1	10.36	8.19	1.25	160.43	22.73	13.71	2237.5	47.03 (43.62)
Babajipeta-2	11.81	7.42	1.58	171.68	23.03	14.91	2597.75	49.81 (45.21)
Hiramandal-1	10.41	5.48	1.92	116.43	16.61	12.61	1506.18	31.73 (34.60)
Hiramandal-2	12.01	5.42	2.25	119.43	15.98	8.81	1090.18	41.97 (40.70)
AU-1	9.31	4.52	2.1	98.43	13.04	10.31	1054.78	52.64 (46.83)
EC-144145	8.46	5.91	1.38	102.76	18.57	7.61	782.26	36.81 (37.02)
EC-169061	9.26	4.43	2.05	122.51	16.72	8.84	1082.27	44.95 (41.77)
EC-169084	8.26	4.43	1.82	105.26	15.9	8.18	851.12	13.03 (20.83)
EC-169089	8.46	3.49	2.39	65.01	11.2	9.64	746.68	18.10 (24.85)
EC-316273	10.16	4.22	2.37	121.26	15.4	11.14	1318.44	17.63 (24.50)
EC-316309	13.36	6.26	2.09	204.76	26.9	9.14	1789.93	13.07 (20.86)
EC-316315	7.16	4.02	1.74	47.51	14	10.37	444.16	27.8 (31.49)
EC-316742	10.16	3.54	2.83	69.76	12.23	11.24	765.25	13.06 (20.86)
EC-373524	7.06	4.37	1.57	91.26	14.5	9.79	801.89	24.00 (29.00)
IC-089955	7.46	3.86	1.89	155.01	17.57	6.04	810.34	16.14 (23.36)
IC-090050	7.22	3.2	2.18	31.49	12.64	31.59	1032.14	10.26 (19.00)
IC-090177	8.12	3	2.6	41.08	11.09	14.19	620.37	21.78 (28.14)
IC-090199	9.22	4.78	1.88	74.74	14.43	13.49	1045.36	12.75 (21.24)
IC-090273	8.42	6.32	1.3	158.58	20.93	4.53	756.32	21.90 (28.22)
IC-090674	10.12	4.73	2.08	67.98	16.48	8.68	627.3	18.03 (25.45)
IC-090696	10.42	7.93	1.31	83.58	13.01	6.96	619.65	33.96 (35.96)
IC-110949	8.42	1.93	2.56	25.8	13.09	8.29	251.54	19.00 (26.16)
IC-111322	9.22	3.17	2.96	61.08	12.08	4.26	297.55	23.65 (29.42)
IC-111346	8.52	3	2.07	76.08	14.01	8.39	675.47	22.16 (28.40)
IC-111392	7.72	4	1.83	87.58	14.58	8.83	810.37	19.49 (26.52)
IC-111427	8.61	3.97	2.21	84.73	13.99	11.58	943.17	42.78 (40.52)
IC-111448	6.41	5.36	1.26	129.73	19.23	8.07	1008.92	27.32 (31.18)
IC-112309-A	8.41	4.68	1.85	153.23	17.75	12.96	1947.86	34.70 (35.76)
IC-126918	7.91	5.2	1.58	148.89	24.2	7.1	1019.12	41.07 (39.53)
IC-127021	7.61	3.18	2.42	47.23	11.91	8.53	364.87	30.90 (33.44)
IC-127071	7.41	5.05	1.53	162.23	9.67	8.79	1388	54.99 (47.53)
IC-127074	7.71	3.11	2.5	165.23	18.07	11.38	1842.32	48.59 (43.86)
IC-316291	6.91	4.55	1.57	63.53	17.97	7.12	414.33	37.11 (37.20)
IC-336474	6.41	5.05	1.33	65.53	21.62	7.81	473.79	54.03 (46.98)

IC-344674	8.61	5.15	1.73	82.23	17.37	6.36	484.98	44.51 (41.52)
Bhagymathi(C1)	7.23	3.08	2.36	33.22	10.89	12.64	419.07	17.84 (24.60)
Dommeru(C2)	8.61	6.76	1.28	52.5	17.9	13.97	582.92	43.88 (41.19)
Gulabi(C3)	9.41	3.75	2.5	56.37	11.28	15.7	883.79	24.59 (29.39)
W.Godavari (C4)	10.42	8.39	1.24	156.06	22.43	8.43	1315	43.29 (40.85)
Mean	**9.128**	**5.044**	**1.978**	**112.661**	**16.901**	**10.396**	**923.85**	**33.86**
Std Error	**0.284**	**0.259**	**0.1**	**9.889**	**0.7**	**0.663**	**119.857**	**1.36**
Ci - Cj	**0.506**	**0.589**	**0.225**	**4.710**	**0.795**	**3.831**	**138.52**	**0.079**
BiVi - BiVj	**1.012**	**1.178**	**0.451**	**9.421**	**1.590**	**7.661**	**277.05**	**0.159**
Ci - VI	**0.894**	**1.041**	**0.399**	**8.327**	**1.405**	**6.772**	**244.88**	**0.140**

Ci – Cj (Critical diference between check and check), BiVi – BiVj (Critical diference between the blocks), Ci – VI (Critical diference between the variety and variety).

Length of the pedicel (cm)

Considerable variation was observed with respect to pedicel length which ranged from 1.91-7.06 cm. The genotype IC-110949 recorded the maximum pedicel length of 7.06 cm, followed by IC-111322 (6.88 cm), IC-336474 (6.88 cm), IC-090050 (6.80 cm) and IC-316291 (6.59 cm) which were statistically on par. While, EC-169089 recorded the minimum pedicel length of 1.91 cm which was 0.40 times lesser than Bhagyamathi. Among the land races, Hiramandal-1 has attained the maximum pedicel length of 6.02 cm, followed by Irapaduguda-B (5.16), Hiramandal-2 (5.12cm) and the lowest pedicel length was observed in Tuni local (3.06 cm). Amongst the exotic collection maximum pedicel length were recorded in EC-316309 (5.74 cm), EC-144145 (4.93 cm), EC-169084 (4.17 cm) and EC-316742 (4.15 cm) respectively.

Length of the calyx (cm)

Significant variation was found among the genotypes in relation to length of the calyx ranging from 2.3 - 6.9 cm. The genotype Dommeru local recorded the maximum calyx length of 6.9 cm on par with IC-090050 5.87 cm), followed by Babajipeta-1 (5.75 cm), West Godavari local (5.2 cm) and Gulabi (5.28 cm) were recorded the maximum calyx length. Amongst the exotic collection, maximum calyx length was recorded in EC-144145 (4.66 cm), EC-316742 (4.52 cm) and EC-316309 (4.45 cm). Amongst the indigenous collections *viz.,* IC-111322, IC-127074 and IC-090273 were recorded the maximum calyx length of 4.57 cm, 4.53 cm and 4.12 cm respectively.

The genotypes with fruits having long pedicel were more susceptible than those with short pedicel. The pedicel length had a strong and positive correlation with the susceptibility to fruit borer. In the present investigation, Genotype IC-090050 recorded the maximum calyx length, followed by Babajipeta-1, West Godavari local and Gulabi. Maximum pedicel length recorded in the genotype IC-110949, followed by IC-111322, IC-336474. The above results are in accordance with the findings of Patil and Ajri (1993). Calyx is the most important morphological component which has strong association with pest infestation.. The long and big or loose calyx in the highly susceptible genotypes might help the young borer to hide and get easily into the fruit through the soft tissue below the calyx. The present results are in conformity with those of Patil and Ajri (1993) who reported a strong and positive correlation between calyx length and fruit infestation.

c) Biophysical characters of brinjal fruit in relation to *L. orbonalis* infestation.

Different characters like length of the fruit, diameter of fruit, Fruit Length and width ratio, fruit weight, fruit circumference, fruits/Plant and fruit yield/Plant of all the brinjal genotypes were given in (Table 4)

Length of the fruit (cm)

Considerable variation was observed with respect to fruit length which ranged from 6.41 to 15.31 cm. The genotype Gottivada local recorded the maximum fruit length of 15.31 cm, followed by EC-316309 (13.36 cm), Andra local (12.41cm) and Hiramandal-2 (12.01) while IC-111448 recorded the minimum fruit length of 6.41 cm. Amongst the other indigenous collections *viz.,* IC-090696, IC-090674, IC-090199 and IC-111322 were recorded with fruit length of 10.42, 10.12, 9.22 and 9.22cm which are statistically different than the other genotypes. Along with exotic collection maximum fruit length were recorded in the genotypes EC-316309 (13.36 cm), EC-316273 (10.16 cm) and EC-316742 (10.16 cm) respectively.

Table 5. Correlation of biophysical characters and infestation of major pests in brinjal genotypes

S. T	T. L	P H	Pb/Pt	I. L	D .F. F	L. Pe	L. Cx	L. Fr	D. Fr	FL/W	F. Wt	F.C	Fr/ Pt	Js. No	Wf.No	Hb.No	Lo SD	Lo FD	Js.Int	FY/Pt
1.000	-0.771	0.064	0.014	-0.264	0.054	0.176	0.106	0.089	0.404**	-0.287	0.253	0.277	-0.088	0.499	-0.474**	-0.517	0.991	0.980	0.401**	0.446**
	1.000	-0.126	0.002	0.182	-0.138	-0.157	-0.155	-0.262	-0.426**	0.127	-0.131	-0.260	0.116	-0.464**	0.323*	0.436**	-0.809	-0.797	-0.275	-0.250
		1.000	0.230	0.099	0.052	-0.120	-0.027	0.130	0.111	-0.117	0.179	0.237	0.056	-0.140	0.098	-0.009	0.089	0.106	0.036	0.109
			1.000	0.191	-0.041	0.299*	0.017	0.028	-0.061	0.051	-0.003	-0.042	0.169	0.143	0.075	0.075	0.037	-0.011	0.094	0.190
				1.000	0.435**	-0.091	0.246	0.520	0.271	0.083	0.109	0.075	0.248	-0.035	0.376*	0.383*	-0.257	-0.242	-0.064	0.133
					1.000	0.088	0.332*	0.414**	0.312*	-0.191	0.221	0.219	0.239	0.017	0.289	0.253	0.078	0.098	0.025	0.402**
						1.000	0.321*	-0.046	-0.117	0.091	-0.248	0.054	0.142	0.114	-0.106	-0.068	0.171	0.156	0.109	0.005
							1.000	0.134	0.175	-0.042	-0.075	0.103	0.389**	0.043	0.029	-0.084	0.112	0.069	0.076	0.108
								1.000	0.628	0.085	0.644	0.537	-0.063	0.004	0.223	0.266	0.125	0.132	-0.132	0.395**
									1.000	-0.300*	0.693	0.739	-0.114	0.144	-0.014	-0.009	0.445**	0.426**	0.045	0.539
										1.000	-0.329*	-0.502	-0.016	-0.181	0.237	0.357*	-0.254	-0.249	-0.232	-0.289
											1.000	0.782	-0.210	0.021	0.017	0.084	0.264	0.264	-0.051	0.591
												1.000	-0.203	0.147	-0.116	-0.118	0.295	0.288	0.105	0.437**
													1.000	-0.176	0.281	0.224	-0.101	-0.145	-0.162	0.332*
														1.000	-0.769	-0.688	0.499	0.469**	0.834	0.105
															1.000	0.847	-0.458**	-0.425**	-0.789	0.114
																1.000	-0.496	-0.475**	-0.755	0.129
																	1.000	0.982	0.393**	0.437**
																		1.000	0.362*	0.426**
																			1.000	-0.022
																				1.000

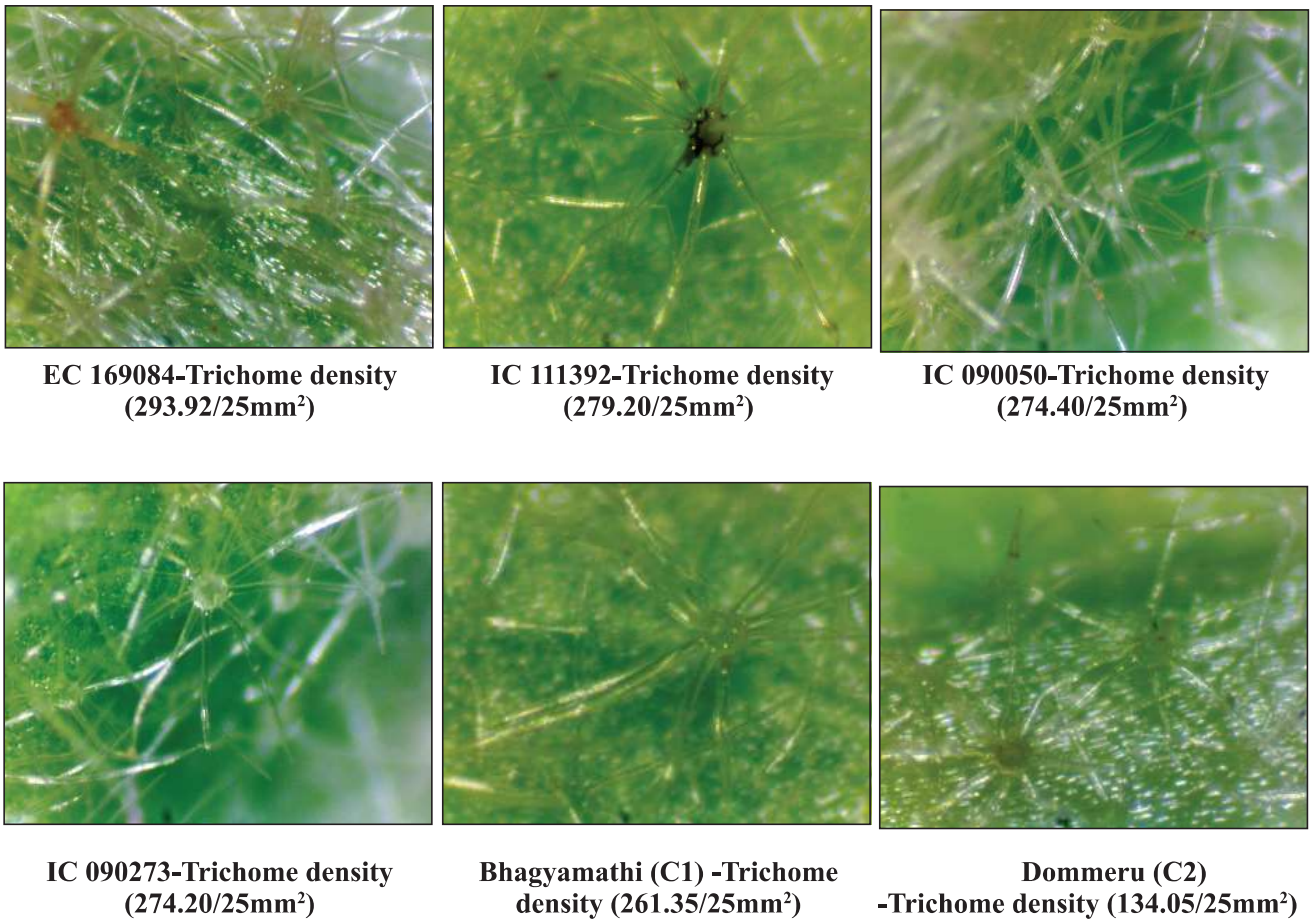
1) S. T- Shoot thickness(Cm), **2) T. L -**Trichom density (25mm^2), **3) P .H-**Plant height, **4) P.b/Pt-**Primary branches /Plant, **5) I. L -**Inter nodal length, **6) D .F. F -** Days to first flowering, **7) L. Pe -**Length of the Pedicle(Cm), **8) L. Cx-**Length of the Calyx(Cm) , **9) L. Fr-**Length of Fruit (Cm) , **10) D. Fr-**Diameter of fruit (Cm) ,**11) FL/W-** Fruit length and width ratio, **12) F. Wt -**Fruit weight (gm), **13) F.C-**Fruit circumference (Cm), **14) Fr/ Pt -**Fruit /Plant, **15) Js. No -**Jassis number, **16) Wf.No -**Whitefly number, **17) Hb.No -**Hadda beetle number, **18) Lo SD-**L.orbonalis Shoot damage (%), **19) Lo FD-**L.orbonalis Fruit damage (%), **20) Js.Int-**Jassid intensity, **21) FY/Pt-**Fruit yield /Plant. **Correlation values (r) - 0.297at 5% L.O.S and 0.384 at 1% L.O.S**

Diameter of fruit (cm)

Significant variation was found among the genotypes with respect to fruit diameter which ranged from 1.93-9.61 cm. Highest fruit diameter was recorded in the genotype Gottivada local (9.61cm), followed by West Godavari local (8.39 cm) and Babajipeta-1(8.19 cm), while the genotype IC-110949 recorded the lowest fruit diameter (1.93cm) which was 1.59 times lesser than Bhagyamathi (3.08 cm). Amongst the other land races Irapaduguda-B, Babajipeta-2 and Andra local were recorded with 7.42, 7.42 and 7.09 cm which was 1.09, 1.09 and 1.02 times more fruit diameter than Dommeru local (6.76 cm). Amongst the other indigenous collection IC-090696, IC-090273 and IC-111448 were recorded with 7.93, 6.32 and 5.36 cm which are statistically different. Among the exotic collection EC-316309 and EC-144145 were recorded with more fruit diameter 6.26 and 5.91 respectively.

Fruit Length and width ratio (cm)

There was considerable variation with respect Fruit length and width ratio which ranged from 1.25 to 2.96 cm. the genotype IC-111322 were recorded with highest fruit length and width ratio of 2.96 which was 1.25 times more than Bhagyamathi (2.36 cm), followed by EC-316742 (2.83 cm), IC-110949 (2.56 cm) and IC-127021(2.42 cm) while the genotype Babajipeta-1 recorded the least fruit length and width ratio of 1.25 cm which was 1.02 times lesser than the Dommeru local (1.28). Amongst the land races Hiramandal-2, Hiramandal-1 and Irapaduguda-W were recorded with highest fruit length and width ratio of 2.25, 1.92 and 1.85 cm. Among the other exotic collections *viz.,* EC-169089, EC- 316273 and EC-316309 were recorded with highest fruit length and width ratio of 2.39, 2.37 and 2.09 cm respectively. Amongst the indigenous collections IC-090177, IC-110949 and IC-127074 were recorded with maximum fruit length and width ratio of 2.6, 2.56 and 2.5 cm respectively.



EC 169084-Trichome density (293.92/25mm²)

IC 111392-Trichome density (279.20/25mm²)

IC 090050-Trichome density (274.40/25mm²)

IC 090273-Trichome density (274.20/25mm²)

Bhagyamathi (C1) -Trichome density (261.35/25mm²)

Dommeru (C2) -Trichome density (134.05/25mm²)

Plate 1. Trichome density on leaf (no/25mm²)

Fruit weight (g)

Considerable variation was observed with respect to fruit weight which ranged from 25.80 to 379.93 g. The genotype Gottivada local recorded the maximum fruit weight of 379.93 g, followed by Tuni local (216.68 g), Andra local (215.43g) and EC-316309 (204.76 g) while IC-110949 recorded the minimum fruit weight of 25.80 g which was 0.77 times lesser than Bhagyamathi (33.22 g). Amongst the other indigenous collections *viz.,* IC-127074, IC-127071, IC-090273, IC-089955 and IC-112309-A were recorded with maximum fruit weight of 165.23, 162.23, 158.58, 155.01 and 153.23 gm which are statistically different than the other genotypes. Among the exotic collection maximum fruit weight were recorded in the genotypes EC-169061 (122.51 g), EC-316273 (121.26 g) and EC-144145 (102.76 g) respectively.

Fruit circumference (cm)

There was significant variation with respect to fruit circumference which ranged from 9.67 to 30.98 cm. The genotype Gottivada local recorded the maximum fruit circumference of 30.98 cm, followed by EC-316309 (26.9 cm), IC-126918 (24.2 cm) and Babajipeta-2 (23.03 cm) while IC-127071 recorded the minimum fruit circumference of 9.67 cm which was 0.88 times lesser than Bhagyamathi (10.89). Among the land races Babajipeta-1, Andra local and Tuni local were recorded with the maximum Fruit circumference of 22.73, 22.38 and 20.44 cm. Amongst the indigenous collections viz., IC-336474, IC-090273, IC-111448 and IC-127075 were recorded with maximum fruit circumference of 21.62, 20.93, 19.23 and 18.07 which are statistically different than the other genotypes. Along with exotic collection maximum fruit circumference were recorded in the genotypes EC-144145 (18.57 cm), EC-169061 (16.72 cm) and EC-169089 (15.9 cm).

Fruits/Plant

There was significant variation among genotypes for number of fruits per plant ranging from 4.26 to 31.59. The genotype IC-090050 recorded the maximum number of fruits 31.59 which was 2.49 times more than resistant check Bhagyamathi, followed by Tuni local (15.51) and Babajipeta-2 (14.91) while, IC-111322 recorded the minimum number of fruits 4.26 which was 2.96 times lesser than Bhagyamathi. Among the indigenous collections *viz.,* IC-090177, IC-090199, IC-112309-A and IC-111427 were recorded with 14.19, 13.49, 12.96 and 11.58 number of fruits. Among the exotic collection EC-316742, EC-316273 and EC- 316315 recorded the maximum number of fruits 11.24, 11.14 and 10.37.

Fruit yield/Plant (g)

There was considerable variation among genotypes under study for Fruit yield per plant ranging from 251.54 to 3398.71. The genotype Tuni local recorded the maximum fruit yield of 3398.71gm which was 8.10 times more than Bhagyamathi (419.07) but its marketable yield is 2548.33, followed by Andra local (2646.86 gm), Babajipeta-2 (2597.75 gm) and Babajipeta-1 (2273.5 gm) while IC-110949 recorded the minimum fruit yield per plant of 251.54. Amongst the indigenous collections *viz.,* IC-112309-A, IC-127074, IC-090199 and IC-090050 were recorded with maximum fruit yield of 1947.86, 1842.32, 1045.36 and 1032.14 gm which are statistically different than the other genotypes. Along with exotic collection maximum fruit yield were recorded in the genotypes EC-316309 (1789.93 g), EC-316273 (1318.44 g) and EC-169061 (1082.27 g) respectively.

The morphological characters of the fruit like number of fruits per plant, fruit weight, length, circumference and diameter of the fruit has enormous influence on the fruit borer damage which determines the yield of the crop. Highly significant and positive correlation between fruit diameter and degree of fruit infestation was reported by Subbaratnam and Butani (1981) and Naqvi *et al.* (2008). Highly significant and positive correlation between pericarp thickness and fruit infestation. Resistance in long fruited genotypes was reported by Krishnaiah and Vijay (1975), Lal *et al*. (1976), Dhooria and Chadha (1981); Ishaque and Choudhuri (1984); Mishra *et al*. (1988); Singh and Chadha (1991) and Chandrashekhar *et al.* (2009) notice for shoot and fruit borer in brinjal.

On the contrary, Grewal and Singh (1995) and Gupta and Kauntey (2008) did not find any linear correlation between length and diameter of fruits and degree of fruit infestation although, the varieties with narrow pericarp were found less susceptible.

In the present investigation the highest fruit diameter was recorded in the genotype Gottivada local (9.61cm) which was highly favourable for the larvae of the fruit and shoot borer damage and which could be the prime reason for its susceptibility. However, Tuni local recorded the maximum fruit yield of 3398.71 g which was 8.10 times more than Bhagyamathi (419.07) but its marketable yield is 2548.33, followed by Andra local (2646.86 g), Babajipeta-2 (2597.75 g) and Babajipeta-1 (2273.5 g) while IC-110949 recorded the minimum fruit yield per plant of 251.54.

The shoot and fruit borer resistance in long fruited may be due to anatomical characters like tightly arranged seeds in mosocarp, thick fruit skin and closely packed vascular bundles in pulp. Sometimes the resistance could

be attributed to a large number of small sized fruits per plant along with late and longer fruiting period which were noticed in the current investigation. Similarly, Oatman (1959) stated that due to tight arrangement of seeds in mesocarp of fruit found in *Solanum incanum, S. integrifolium* and *S. khasianum* showed resistance against shoot and fruit borer in brinjal. the round fruited varieties are found to be more attacked to shoot and fruit borer than long and long narrow fruited.

d) Character association between the biophysical characters and infestation of major pests in brinjal genotypes

The results presented in the (Table 5) signifies that the yield per plant showed significant positive correlation with shoot thickness (0.446), days to first flowering (0.402), length of the fruit (0.395), fruit calyx (0.437), fruits/plant (0.332), shoot damage (0.437) and fruit damage (0.426), while yield per plant showed negative correlation with trichome density (- 0.250) and fruit length and width ratio (-0.289).

Fruit damage by fruit and shoot borer showed significant positive correlation with shoot thickness (0.980), diameter of fruit (0.426) and fruits per plant (0.469), while Fruit damage showed negative correlation with trichome density (-0.797), internodal length (-0.242) and fruit length and width ratio (-0.249).

Shoot damage by fruit and shoot borer showed significant positive correlation with shoot thickness (0.991) and diameter of fruit (0.445). While Shoot damage showed negative correlation with trichome density (-0.809), internodal length (-0.257) and fruit length and width ratio (-0.254).

Jassid intensity based on hopper burn symptoms showed significant positive correlation with shoot thickness (0.401), while Jassid intensity showed negative correlation with trichome density (-0.275) and fruit length and width ratio (-0.232).

Jassid number showed significant positive correlation with shoot thickness (0.499). While, jassid number showed negative correlation with trichome density (-0.464).

Whitefly number showed significant positive correlation with trichome density (0.323) and internodal length (0.376) whereas, whitefly population per three leaves showed negative correlation with shoot thickness (-0.474).

Hadda beetle number showed significant positive correlation with trichome density (0.436), internodal length (0.383) and fruit length and width ratio (0.357). While, hadda beetle number showed negative correlation with shoot thickness (-0.517).

Shoot thickness is positively correlated with per cent fruit and shoot damage. Whereas, trichome density on leaves was significantly negatively correlated with jassid number, per cent shoot and fruit damage. Internodal length is significantly positive correlated with whitefly number and hadda beetle number. Whereas days to first flowering and length of fruit high significantly positively correlated with fruit yield per plant. The results of the study are in accordance with the findings of Mishra and Mishra (1990), Ponnuswami and Irulappan (1994), Vadivel and Bapu (1998), Bansal and Mehta (2008) and Jadhao *et al*. (2009)

In general, the plant characters like shoot thickness, fruit length and width ratio, Internodal length trichome density on leaves showed impact in the moderately resistant varieties. While seeking development regarding host plant resistance these characters should get main concern.

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