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RELATIONSHIP BETWEEN MORPHOLOGICAL CHARACTERS OF DIFFERENT AUBERGINE CULTIVARS AND FRUIT INFESTATION BY *LEUCINODES ORBONALIS* GUENEE

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Abstract

Response of different aubergine cultivars against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee.) was evaluated at National Agriculture Research Centre, Islamabad during 2007-08 and 2008-09. The results reflected different levels of infestation in all cultivars by the pest. Cultivar Naeelam showed maximum fruit infestation (58.60 and 48.09%) followed by Black long (47.93 and 33.31%), while minimum was observed in Nirala with 24.75 and 21.57% fruit infestation during 2007-08 and 2008-09, respectively. Similarly, shoot infestation was found maximum in Naeelam (43.15 and 33.75%) followed by Kanha-091 (37.72 and 28.73 %) and Nirala was found to be least attacked by the pest showing 19.27 and 15.81% shoot infestation during 2007-08 and 2008-09, respectively. The correlation of different morphological plant characters with fruit infestation indicated very strong and negative correlation between fruit infestation and leaf trichomes, stem thickness and stem hair density. A negatively significant correlation was found between fruit infestation and plant height (r = – 0.716), crown hair density (r = – 0.672) while the correlations of leaf hair density (r = – 0.623), and leaf area (r = – 0.613), was also significant and negative but not so strong. There was positive correlation with fruit yield (q/acre) and positive and non significant correlation with number of primary branches/plant with r-value 0.661and 0.319, respectively.

Introduction

Brinjal, also known as eggplant or aubergine belonging to the family "Solanaceae", is one of the common and popular vegetables grown throughout the world. The family contains more than 2450 species distributed in 95 genera (Mabberley, 2008). There are 3 main varieties of bringal generally cultivated in Pakistan. The crop is extensively damaged by insect pests and diseases apart from other constraints. In Pakistan, aubergine is mainly cultivated on small scale, but is a potential source of income for the farmers.

Several factors are responsible for the low productivity of aubergine in Pakistan. These include biotic factors as insect pests and pathogens. The losses caused by brinjal pests vary from season to season depending upon environmental factors (Gangwar & Sachen, 1981). The most extensive pest of this vegetable is brinjal shoot and fruit borer (*Lucinodes orbonalis* Guenee) which reduces the yield and inflicts colossal loss in production. Due to its high reproductive potential, rapid turnover of generations and intensive cultivation of aubergine in both wet and dry seasons, the pest poses a serious threat. The newly hatched larvae bore into the petioles, midribs of large leaves and young tender shoots. The entry place of the larvae is closed by their excreta and feeding is internal (Butani & Jotwani, 1984). A single larva of *L. orbonalis* is enough to damage 4-6 healthy fruits (Anonymous, 2010).Due to larval activity, translocation mechanism of nutrients in shoot is affected causing dropping and withering of shoots (Alam & Sana, 1962). In later stages the larvae bore into young fruits through the soft calyx tissue leaving no sign of infestation (Butani & Jotwani, 1984). Secondary infestation by certain bacteria may cause further loss to the quality of the fruit (Islam & Karim, 1994) through fruit rottening which renders them unfit for marketing and human consumption. This pest causes 31-86% fruit damage in Bangladesh (Alam *et al.,* 2003) which may reach up to 90% (Rahman, 1997) and 50-70% in Pakistan (Saeed & Khan, 1997). This pest is serious problem for the aubergine growers and may reduce the crop yield up to 60-70-70 % (Shailendra and Pras Nath, 2010).

For the management of this pest organic insecticides are being used, but the use synthetic insecticides is very hazardous to human health as the crop is a staple food and consumed in its original form. Pesticide use is also a threat to natural enemies and non target insects. Extensive and indiscriminate use of pesticides is responsible for the development of resistance in the pests; persistent effects of chemicals, constantly polluting our environment and through bio-magnification have become the part of human food chain. Thus the unchecked use of chemicals is hazardous not only to humans but to other flora and fauna. The most important and effective way to manage an insect pest is the use of resistant cultivars. Host plant resistance strategy serves as an excellent component when integrated with other approaches as it has several advantages over other measures. It is highly compatible with pesticides and biological control agents. Besides its effectiveness, selectivity against the pest and relatively long stability makes this tactic a cornerstone of IPM systems. The resistant varieties can easily be adopted in crop production schemes and reduce the cost of produce. Therefore, objectives of this study are to determine the response of different morphological characters of aubergine cultivars against brinjal fruit and shoot borer.

Materials and Methods

The research work was conducted at the National Agricultural Research Centre, Islamabad. Aubergine germplasm for the preliminary screening for resistance against *L. orbonalis*, was taken from National Agricultural

Research Centre, Islamabad and different seed stores of Rawalpindi, Taxila and. Gujranwala. The cultivars used were Violet Prince 101, Ep-273, Kanha-091, Anmol, Karishma, Nirala, Brinjal long, Long purple black, Naeelam, Brinjal pusa Karanti, Purple long, Chinese brinjal and black long. The experiment was conducted in Randomized Complete Block Design using 13 brinjal cultivars with 4 replications during 2007-08. Plots measuring 11.5 × 7.0 m were prepared for sowing. All the recommended agronomic practices (weeding, hoeing, application of farm yard manure etc.) were followed in these plots. Seedlings of each of 13 varieties were raised in green house of vegetable section of NARC, Islamabad. Four weeks after germination, seedlings of each variety were transplanted to experimental plots. A plant to plant distance of 60 cm and row to row distance of 75 cm was maintained while transplanting the seedling. The larval population of brinjal shoot and fruit borer was recorded from 10 randomly selected aubergine plants from each experimental unit; one leaf each from top, middle and lower portion of each selected plant at weekly intervals. The average larval population per leaf was calculated lately. The infestation of brinjal shoot and fruit borer larvae on shoots and fruits of different cultivars of aubergine was recorded by counting healthy and damaged shoots and fruits from 10 randomly selected plants from each experimental unit. The data were taken regularly at weekly intervals. Then percentage values for both shoot and fruit damage were calculated. The data regarding population and infestation percentage of brinjal shoot and fruit borer (*L. orbonalis*) on aubergine cultivars recorded during preliminary screening trial was subjected to statistical analysis and the means were compared by Duncan's Multiple Range Test at 5% probability. Out of 13 aubergine cultivars, two cultivars viz., Nirala, Anmol were found relatively resistant 3 cultivars viz., Karishma, Kanha-091, EP-273 intermediate resistant and 2 susceptible cultivars i.e., Naeelam, Black long. Their morphological characteristics were studied based on fruit infestation and sown again on the same experimental area next year (2008) for the final screening.

Morphological characters of aubergine plants: Morphological variations in 7 aubergine cultivars were studied to investigate their role against fruit infestation of *L. orbonalis* from (Table 1).

Yield (kg/plot) of different aubergine cultivars were taken starting from first picking up to final picking and converted into q/acre. Then the yield of various aubergine cultivars was correlated with the extent of infestation on fruits to each cultivar.

Statistical analysis: The data regarding different parameters were subjected to analysis of variance using M Stat Software to evaluate the difference between morphological characters of different cultivars and their means comparison was conducted using LSD-Test at 5% level of probability. The data were then processed for simple correlation and Multiple Linear Regression analysis to determine their impact on fruit infestation caused by brinjal shoot and fruit borer (*L. orbonalis*).

Results and Discussion

Larval population/ Leaf: Means comparison of the data pertaining to number of larval population per leaf showed significantly different response of cultivars during 2007. The cultivar Naeelam showed maximum larval population per leaf (1.14), while Nirala was proved comparatively less preferred by larvae of the brinjal shoot and fruit borer (Table-2). During final screening trial maximum larval population of *L. orbonalis* was found in both Naeelam (1.03) and Black long (0.98) and were found statistically similar (Table 3). Nirala was comparatively less preferred with 0.15 larvae per leaf followed by Anmol (0.32 larvae per leaf).

Shoot infestation (%): The comparison of means of the data regarding percent shoot infestation of *L. orbonalis* during preliminary screening trial revealed significantly high difference among cultivars at 5% probability (Table 2). Maximum shoot infestation was observed on the cultivar Naeelam (43.15%) followed by Kanha-091 with 37.72% shoot infestation. Cultivar Nirala had minimum (19.27%) shoot infestation. During second year of the study (2008), minimum shoot infestation was observed in Nirala (15.81%) which was statistically similar with EP-273 having 16.55 % shoot infestation. Whereas, Naeelam was the most preferred cultivar for brinjal shoot and fruit borer with mean value of 33.75 % followed by Kanha-091 with 28.73% shoot infestation. Jat *et al*., (2003) reported 3.28 to12.71% variations in shoot infestation in 10 different varieties of aubergine. Lowest shoot infestation (3.28%) was observed in Arka Kasumkara. Similarly, Senapati (2003) also recorded very low shoot infestation (4 to 11.1%) during screening of twelve aubergine cultivars against *L. orbonalis.* The very low shoot infestations in these studies may be attributed to the different climatic conditions and varieties in their experiments.

Fruit infestation (%): During first year of studies, cultivar Naeelam showed maximum fruit infestation i.e., 58.60 %, followed by Black long (47.93 %). The minimum fruit infestation (24.75 %) was recorded on Nirala which differed significantly from all other cultivars (Table-2). During final screening, it was observed that Naeelam showed maximum fruit infestation i.e. 48.09 percent followed by Black long (33.31%). The fruit infestation was recorded to be 30.03, 29.76, 28.84 and 28.18 % on the Anmol, Kanha (091), Karishma and EP-273 cultivars, respectively and did not show significant difference with each other. The minimum fruit infestation i.e., 21.57% was observed on Nirala. Comparable range of fruit infestation was 20.23 to 45.61% reported by Jat *et al*., (2003), though they used different set of varieties/cultivars in their experiment. Similarly, Krishna *et al.*, (2001) found 43% fruit infestation in Ramy round purple of India which was comparatively the most susceptible while minimum shoot infestation was reported in SM-02. Kumar & Shukla (2002) found 33 to 53% damage of fruits in 12 different cultivars of aubergine. Similarly, Ashoke & Abhishek (2002) while evaluating 12 aubergine cultivars in field conditions reported 33.65-53.02% fruit infestation of *L. orbonalis* larvae. Conversely, Chaudhary & Sharma (2000) found very low

attack of brinjal shoot and fruit borer (2.88-5.64%) during screening of nine genotypes of aubergine. Gangopadhay *et al.,* (1996) found infestation of *L. orbonalis* in every variety under investigation; moreover exotic varieties were more infested as compared to the local ones. Sharma *et al*., (1998) evaluated the response of 8 cultivars of aubergine for tolerance against *L. orbonalis*, but their results could not be compared with present studies due to difference in genotypes used in their experiments.

Table1. Morphological characteristics of aubergine cultivars and the methodology used for their study.

Morphological characteristics	Methodology
Hair density on fruit crown /cm²	The fruits were randomly collected each from ten different plants (from each of the test entry). From crown of each fruit three pieces of one cm^2 were cut and examined under Microscope to count their hair density/cm^2 and average was worked out.
Hair density of leaf lamina /cm²	Three pieces of leaf lamina each of one cm^2 area were cut from top, middle, and lower portion leaves of the randomly selected ten plants from each experimental unit. Number of hair/cm^2 from each piece was counted under Microscope and their average was worked out.
Hair density on shoots /cm	The number of hairs /cm of the shoot were counted by taking a piece of one cm from ten randomly selected plants from each experimental unit at an interval of 40, 90, and 140 days after transplantation.
Plant height /cm	Height of ten randomly selected plants from each plot was measured with the help of meter rod at an interval of 40, 90 and 140 days after transplanting of brinjal plants and finally their averages were computed.
Stem girth/ mm	The stem girth was recorded from randomly selected ten plants from each experimental unit with the help of measuring tape at an interval of 40, 90 and 140 days after transplantation.
Leaf area/cm^2	Three leaves each from upper, middle and lower portion of each test entry were taken and brought in the laboratory. Leaf area (cm^2) was measured with the help of leaf area meter at an interval of 40, 90, and 140 days after transplanting.
Number of primary branches/ plant	Total primary branches arising from the basal node were counted from randomly selected ten plants in each plot and their average was worked out.
Trichomes/leaf	Total number of trichomes from upper, middle and lower leaves of different plants from each plot, were examined to count the average number of trichomes present on its upper side.

Table 2. A comparison of mean values for the data regarding larval population and fruit (%) infestation of *Leucinodes orbonalis* (Guenee) in different aubergine cultivars during 2007.

Cultivars	Larval population ($Leaf^{-1}$)	Shoot infestation (%)	Fruit infestation (%)
Naeelam	1.14 a	43.15 a	58.60 a
Brinjal long	0.42 d	32.41 f	47.93 b
Kanha-091	0.56 bc	30.90 g	45.74 bc
Long purple black	0.53 c	34.18 d	45.31 bc
Purple long	0.60 b	34.46 d	44.29 bc
Brinjal pusa kranti	0.54 c	36.08 c	43.66 bc
Ep-273	0.35 ef	37.72 b	43.04 bc
Chinese brinjal	0.55 c	36.37 c	42.64 bc
Anmol	0.44 d	33.71 de	41.93 c
Black long	0.38 e	32.44 ef	41.09 c
Karishma	0.34 f	31.67 fg	40.96 c
Violet prince 101	0.34 f	34.46 d	40.79 c
Nirala	0.29 g	19.27 h	24.75 d
LSD	0.345	1.279	4.773
Analysis of variance	$F_{12, 675}$ =1398.80 p<0.000**	$F_{12, 987}$ = 545.32 p<0.000**	$F_{12, 519}$ = 71.20 p<0.000**

Mean sharing similar letters are not significant different by LSD Test at p=0.05

Morphological Characters

Hair density on leaf lamina (cm^2): Data revealed that cultivar Nirala had the highest average hairs density (308.5/cm^2) on leaf lamina followed by Ep-273 and Anmol, which were statistically similar with 293.5 and 290.6/cm^2 hair density, respectively (Table 4, Column-I). The lowest hair density was found in case of Naeelam (214.7cm^2) which was statistically similar with Black long (214.8cm^2) and Karishma (216.1/cm^2).

Hair density on fruit crown (cm^2): The cultivar Nirala had maximum number of hairs on crown (152.1/cm^2) followed by Ep-273 (137.4 cm^2) showing significant difference and minimum number of hairs on crown were recorded on Naeelam (84.16/cm^2) which was statistically similar with Anmol (85.47/ cm^2) (Table 4, Column-II).

Hair density on shoot (cm): Cultivar Naeelam had minimum hair density on shoots (162.7/cm) and was statistically different from all the other cultivars, whereas maximum hair density was observed in case of Nirala (202.8/cm) followed by Ep-273 (193.8/cm) which was at par with Karishma (190.8cm) (Table 4, Column-III).

Leaf Area (cm^2): Leaf area was observed maximum in cultivar Naeelam (93.92 cm^2) which was statistically similar with EP-273 (92.99 cm^2). Anmol, Kanha-091 and Karishma were statistically similar with 68.46, 66.22 and 58.96cm^2 leaf areas, respectively (Table 4, Column-IV).The minimum leaf area was found in Naeelam (30.06 cm^2) which was statistically similar with Black long (31.05 cm^2).

Stem girth (mm): Maximum stem girth was found in cultivar Nirala (64.85mm) followed by EP-273 (58.97 mm). Karishma, Kanha-091 and Anmol were statistically similar with 54.33, 53.56 and 52.21mm stem girth respectively (Table-4, Column-V), while the minimum stem girth was recorded in case of Naeelam (42.67mm).

Plant height (cm): Nirala had maximum plant height (125.0 cm) which was statistically at par with EP-273 and Anmol having 124 and 123.5 cm plant height, respectively (Table 4, Column-VI). The minimum plant height was recorded in case of cultivars Naeelam (119.8cm) and was statistically at par with Black long (120.6cm).

Number of primary branches / plant: Mean comparison of the data regarding number of primary branches/plant is given in Table 4, Column-VII. The result revealed that the cultivars under study did not differ significantly from one another. Number of primary branches ranged from 3.75 to 3.00 in cultivar Nirala and Naeelam, respectively.

Number of Trichomes / leaf: Cultivar Nirala had the maximum number of trichomes on the surface of leaf i.e. 17.67 followed by 16.45 and 13.92 on EP-273 and Karishma, respectively, whereas Naeelam had minimum number of trichomes on leaf (10.05) (Table 4, Column-VIII).

Fruit Yield (q/acre): Mean comparison of the data regarding fruit yield of different aubergine cultivars is presented in Table 4, Column-IX. The results depicted maximum fruit yield in Nirala followed by EP-273 with 28.18 and 26.58 q/acre, respectively. Cultivars Karishma, Kanha-091 and Anmol were statistically similar with 24.29, 24.00 and 23.82 q/acre, respectively, while minimum fruit yield was observed in Naeelam (13.20q/acre).

Table 3. A comparison of mean values for the data regarding larval population and fruit (%) infestation of *Leucinodes orbonalis* (Guenee) in different aubergine cultivars during 2008.

Cultivars	Larval population ($Leaf^{-1}$)	Shoot infestation (%)	Fruit infestation (%)
Naeelam	1.03 a	33.75 a	48.09 a
Kanha-091	0.39 b	27.34 c	33.31 b
Ep-273	0.37 b	17.92 e	30.03 c
Karishma	0.39 b	28.73 b	29.76 c
Anmol	0.32 c	20.88 d	28.84 c
Black long	0.98 a	16.55 f	28.18 c
Nirala	0.15 d	15.81 f	21.57 d
LSD	0.06	0.994	2.687
Analysis of variance	$F_{6, 363}$ =547.07 p<0.000**	$F_{6, 531}$ = 1116.21 p<0.000**	$F_{6, 279}$ = 287.39 p<0.000**

Mean sharing similar letters are not significant different by LSD Test at p=0.05

Table 4. Means comparison of the data regarding morphological characters with % infestation fruit and yield of different aubergine cultivars *Solanum melongena* L.

Cultivar	Leaf lamina hair density (cm^2)	Fruit crown hair density (cm^2)	Shoot hair density (cm)	Leaf area (cm2)	Stem girth (mm)	Plant height (cm)	No. of primary branches/plant	Trichomeper leaf	Fruit yield Q/acre
Nirala	308.5 a	152.1 a	202.8 a	93.92 a	64.85 a	125.0 a	3.75 a	17.67 a	28.18 a
Ep-273	293.5 b	137.4 b	193.8 b	92.99 a	58.97 b	124.0 ab	3.50 a	16.45 b	26.58 b
Karishma	216.1 d	117.3 c	190.8 bc	58.96 b	54.33 c	121.4 cd	3.25 a	13.92 c	24.29 c
Kanha 091	263.4 c	111.0 d	186.7 c	66.22 b	53.56 c	122.5 bc	3.50 a	12.75 d	24.00 c
Anmol	290.6 b	97.24 e	174.5 d	68.46 b	52.21 c	123.5 ab	3.25 a	11.85 de	23.82 c
Black long	214.8 d	85.47 f	174.1 d	31.05 c	46.97 d	120.6 de	3.25 a	11.05 e	14.30 d
Naeelam	214.7 d	84.16 f	162.7 e	30.06 c	42.67 e	119.8 e	3.00 a	10.05 f	13.20 e
LSD	5.824	5.624	5.898	17.31	2.289	1.435	0.878	0.952	0.910
Analysis of variance	$F_{6, 27}$ =450.91 p<0.000**	$F_{6,27}$= 185.12 p<0.000**	$F_{6, 27}$ = 48.27 p<0.000**	$F_{6, 27}$ =19.72 p<0.000**	$F_{6, 27}$ =90.11 p<0.000**	$F_{6, 27}$ =15.39 p<0.000**	$F_{6, 27}$ =0.68 p<0.000**	$F_{6, 27}$=76.93 p<0.000**	$F_{6,27}$ =1461.66 p<0.000**

Mean sharing similar letters are not significant different by LSD Test at p=0.05

Correlation between fruit infestation caused by *L. orbonalis* and Morphological characters: An attempt was made to investigate the correlation between various morphological characteristics of plant genotypes with percent fruit infestation of *L. orbonalis*. Correlation (r) between fruit infestation caused by the insect pest and morphological characters is shown in Table-5. The results were highly significant and gave a very strong correlation between fruit infestation and leaf trichomes, stem thickness and stem hair density with r = – 0.821, r = – 0.819 and r = – 0.807, respectively. Strong and significant correlation was found for plant height (r = – 0.716), crown hair density (r = – 0.672) while that of leaf hair density (r = – 0.623), and leaf area(r = – 0.613), were also significant and negative but not so strong. There was positive correlation with fruit yield (q/acre) and positive and non significant correlation with number of primary branches/plant with r-value 0.661and 0.319, respectively. Regression Models along with Coefficient of determination (R^2) between fruit infestation and various morphological plant factors (Table 6) indicated that leaf hair density (cm^2), crown hair density (cm^2)2, stem hair density and leaf area (cm^2) were the most important characters having $100R^2$ values 38.90, 14.90, 18.10 and 5.90, respectively. In the current studies the trichomes and hairs on different parts of the plant seem to have a significant role towards non preference for fruit infestation which is in conformity with the findings of Hossain *et al*., (2004). According to these researchers, less number of trichomes may be responsible for the susceptibility of brinjal plant to shoot and fruit borer. The stem thickness had strong and negative correlation with fruit infestation while fruit yield had significant positive correlation which indicated that with the increase in yield, infestation also increased. These results may be partially compared with those of Hazra *et al.,* 2004, who reported positive and significant effect of both thickness of terminal shoot (0.53) and fruit weight (0.45) on the susceptibility to fruit infestation of the pest. It is concluded from the present studies that Nirala cultivar showed resistance against Brinjal Shoot and Fruit Borer and should be recommended for cultivation. Moreover, the information regarding association of different plant characters with insect infestation may be useful in the efficient breeding programme for selection of better genotypes.

Table 5. Correlation between fruit infestation caused by *Leucinodes orbonalis* (Guenee) and Morphological plant characters of various selected aubergine cultivars (*Solanum melongena* L.).

Morphological characters	Correlations
Leaf hair density	-0.623**
Crown hair density	-0.672**
Stem hair density	-0.807**
Leaf area	-0.613**
Shoot/stem girth	-0.819**
Plant Height	-0.716**
primary branches	0.319ns
Leaf trichomes	-0.821**
Yield	0.661**

ns = Non-significant
** = Significant at p≤0.01

Table 6. Multiple linear regression models along with coefficient of determination (R^2) between fruit infestation and various morphological plant factors.

Regression equation	R^2	100 R^2	Role of individual factors (%)
Y**= 63.357486 - 0.12425 X1	0.389	38.9	38.90
Y**= 66.617347 - 0.71301 X1 -0.15050 X2	0.538	53.8	14.90
Y**= 141.591222-0.052657 X1+0.13589 X2 -0.60923 X3	0.719	71.9	18.10
Y**= 147.214479 – 0.048388 X1 + 0.14561 X2 – 0.60542 X3**- 0.1244X4	0.721	72.1	0.20
Y**= 156.144788 – 0.13349 X1* + 0.00052 X2–0.60864 X3 ** + 0.015301 X4 + 0.29449 X5*	0.780	78.0	5.90
Y**= 132.173772 – 0.10182 X1* +0.012226 X2 – 0.42217 X3* + 0.22476 X4 + 0.30015 X5* – 0.6456 X6	0.797	79.7	1.70
Y**= 115.339383 – 0.10946 X1 + 0.011899 X2 – 0.42946 X3 +0.21496 X4 + 0.30794 X5* – 0.65325 X6 + 0.16926 X7	0.797	79.7	0.00
Y**= 67.950270 – 0.10758 X1 – 0.0054436 X2 – 0.31137 X3 + 0.27261X4 + 0.31586 X5* – 0.60609 X6 + 0.24933 X7 + 0.77333 X8	0.804	80.4	0.70

* = Significant at p≤0.05** = Significant at p≤ 0.01 Y = Fruit infestation (%) X_1 = Leaf hair density (cm^2)
X_2 = Crown hair density (cm^2) X_3 = Stem hair density (1 cm in length) X_4= Moisture (%) X_5 = Leaf area (cm^2)
X_6 = Shoot girth (mm) X_7 = Plant height (cm) X_8 = Leaf trichome (per leaf) X_9 = Yield

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