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BIOCHEMICAL BASES OF EGGPLANT SUSCEPTIBILITY TO SHOOT AND FRUIT BORER AND THEIR GENETIC CONTROL

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ABSTRACT

A series of experiments were conducted involving 70 genotypes to identify the source of resistance against shoot and fruit borer of eggplant and to understand the biochemical bases of resistance and with two distinct categories of genotypes: 3 least/moderately susceptible (lines) and 6 highly susceptible (testers) to determine their genetic control. The genotypes showed different susceptibility grades, 40 most susceptible, 13 highly susceptible, 9 susceptible, 7 moderately susceptible and 1 least susceptible. Highly significant positive correlations between sugar and protein contents and borer infestation and highly significant negative correlation between phenol content and borer infestation revealed the proposition of larval non-preference and antibiosis mechanisms of resistance in the genotypes. Population means for shoot and fruit borer infestation, phenol and sugar contents in the fruits of the hybrids corresponded closely to the midparental values. It revealed much higher additive than dominance genetic variance for both shoot and fruit infestation. The inheritance was predominantly additive for phenol content and mainly dominance for protein content, while sugar content of the fruits was conditioned by additive and dominance variance, additive being greater in magnitude. Genotypes like HE 12, Pusa Purple Cluster having high phenols and lower sugar and protein contents in the fruits could effectively be utilized in breeding less susceptible eggplant varieties with good horticultural and cosmetic characters. The hybrids of such least/moderately susceptible x highly susceptible parents showed less susceptibility compared with the susceptible parent however, it will be essential to develop both the parental lines with higher phenol and lower protein and sugar contents in the fruits along with other good horticultural qualities to build up appreciable tolerance in the hybrids.

Key words: *Eggplant, Shoot and Fruit borer*

INTRODUCTION

The shoot and fruit borer (*Leucinodes orbonalis*) is the most serious insect-pest of eggplant (*Solanum melongena*) throughout India causing as high as 44% shoot and 100% fruit damage in severe infestation. The insecticide control method is relatively ineffective because of mode of damage, high operational cost and health hazard due to lasting pesticide residue in the fruits. Consequently, plant resistance would be useful either as a complete control measure or as a part of the integrated pest management programme with limited dependence on pesticides. Larval non-preference and antibiosis mechanisms operate in different crops for resisting the attack of many insect pests viz., shoot fly in sorghum (Dhawan *et al* 1993), tuber moth in potato (Das *et al* 1993), corn borer in maize (Williams et al 1997 and Kaur and Kanta, 2001), aphid in wheat (Havlickova 1996), brown plant hopper in rice (Soundararajan et al 2002), pod borer in cowpea (Oghiakhe *et al* 1993), aphid in mustard (Bhadauria *et al* 1996) and eggplant (Panda and Das 1975; Bajaj et al 1989 and Doshi 2004). Such resistance has reportedly been conferred on the host through over expression of phenolic compounds and down regulation of feeding stimulants for the insect pests like, free amino acids, protein, sugar contents..., etc. However, genetic control for the tolerance and the biochemical compounds conferring it in eggplant to shoot and fruit borer has not yet been reported. A series of experiments were thus conducted to identify the source of resistance against shoot and fruit borer of eggplant to understand the biochemical bases of resistance and to determine their genetic control towards framing strategies for resistance breeding.

MATERIALS AND METHODS

Seventy genotypes were grown in randomized block design with three replications for two consecutive years in autumn winter season (September-March) of 2001-2003 without any insecticide cover to allow natural infestation of shoot and fruit borer. Fortnightly observations were taken beginning 30 days after transplanting till the last fruit harvest was done. After recording the number of borer infested dead shoots, they were clipped off just above the point of insect burrow without destroying the larvae inside it. Single borer damage in the fruit was also considered as infested fruit. The percentage of borer infestation of both shoots and fruits were determined on number basis. Different biochemical compositions of fresh fruits of marketable maturity (15-

25 days after anthesis depending on the genotype) related to larval non-preference and antibiosis mechanism of host resistance were estimated from the sampled fruits of all the genotypes under second year screening (2001-2002) following standard methods: 1) total sugars by anthrone method (Dubois *et al* 1951) 2) crude protein through estimation of nitrogen by micro-kjeldahl method (Sadasivam and Manickam 1996), 3) total phenols by Folin-ciocalteau reagent method (Bray and Thrope 1954), and expressed on fresh weight basis. All these biochemical parameters were correlated with average shoot and fruit infestation over two years.

Three inbred genotypes viz. HE 12 (L_1), least susceptible, Pusa Purple Cluster (L_2) and Uttara (L_3), moderately susceptible containing low protein and sugar and high total phenol contents in the fruits (group 1) were crossed with 6 most susceptible inbred genotypes viz., BCB-1 (T_1), BCB-14 (T_2), BCB-15 (T_3), BCB-16 (T_4), BCB-72 (T_5) and BCB-87 (T_6) with high protein and sugar and very low total phenol contents in the fruits (group 2) in line x tester mating design. The 18 hybrids along with 9 parents were grown in autumn-winter season of 2003-04 to record natural infestation of shoot and fruit borer in them and to determine the protein, sugar and total phenol contents in the sampled fruits of marketable maturity with a view to elucidate their genetic control through data analysis following Kempthorne (1957).

RESULTS AND DISCUSSION

Field screening studies on fruit infestation suggested 40 genotypes as most susceptible showing infestation percentage to the tune and above the population mean (57.41%). By uniformly stepping down the population mean making four groups and subsequent clustering the genotypes in the respective groups, only one genotype HE12 (average 5.53 and 25.67% shoot and fruit infestation, respectively) could be grouped under tolerant/least susceptible category (Table 1). Of the 7 genotypes under moderately susceptible category, Pusa Purple Cluster (11.36 and 33.63% shoot and fruit infestation) and Uttara (12.18 and 35.17% shoot and fruit infestation) held promise for utilization in breeding programmes.

Table 1. Grouping of the 70 genotypes based on mean shoot and fruit infestation in two years.

Group	Shoot infestation		Fruit infestation	
	No. of genotypes	Mean percent	No. of genotypes	Mean percent
Least susceptible	1	5.53	1	25.67
Moderately susceptible	4	12.02	7	36.98
Susceptible	6	14.06	9	44.73
Highly susceptible	18	15.84	13	52.13
Most susceptible	41	17.65	40	64.04

Marked differences for fruit compositions were recorded in the genotypes under different susceptibility grades (Table 2). Highly significant positive correlations between sugar and protein contents and borer infestation and highly significantly negative correlation between phenol content and borer infestation (Table 3) amply justified the proposition of larval non-preference and antibiosis mechanisms of resistance being operative in the genotypes. The least susceptible genotype, HE 12 contained 30.2 and 56.1% less protein and sugar, respectively and 67.13% higher phenol in the fruits than the most susceptible genotypes. Such association of biochemical characters with tolerance to insect-pest find support from Panda and Das (1975), Bajaj *et al* (1989) and Doshi (2004) for shoot and fruit borer in eggplant, Das *et al* (1993) for tuber moth in potato, Williams *et al* (1997) for corn borer in maize, Singh and Jotwani (1980) for shoot fly in sorghum.

Table 2. Fruit composition in the genotypes under different susceptibility category

Character mean	Category of the genotypes				
	Least susceptible	Moderately susceptible	Susceptible	Highly susceptible	Most susceptible
Fruit weight (g)	50.17	62.18	78.25	101.22	139.93
Sugar content (g/100g fresh fruit)	1.48	2.10	2.51	2.79	3.62
Crude protein (g/100g fresh fruit)	1.17	1.34	1.41	1.55	1.69
Total phenol (mg/100g fresh fruit)	26.13	18.14	14.43	11.23	9.11

Table 3. Correlations of different fruit compositions with fruit infestation

Characters	Correlation coefficients(r)
Sugar content of fruit	0.86*
Protein content of fruit	0.88*
Phenol content of fruit	-0.59*

The three lines (female parent) containing higher phenol and lower sugar and protein contents in the fruits and expressing less susceptibility to shoot borer satisfied their choice in such genetic analysis. High susceptibility of the 6 tester parents to the infestation of shoot and fruit borer did not vary much among themselves which indicated less likelihood of getting variable hybrids with respect to tolerance attributes.

Population means for shoot and fruit borer infestation, phenol and sugar contents in the fruits of the hybrids (Table 4) closely matched with the midparental values indicating the absence of dominance and suggesting that the number of genes involved for larval non-preference and antibiosis through expression of these biochemical factors was not many.

Table 4. Shoot and fruit borer infestation and biochemical composition in the fruits (per 100 g fresh) of the parents and hybrids.

Parent/ hybrid	Protein (g)	Sugar (g)	Phenol (mg)	Shoot infestation (%)	Fruit infestation (%)
L_1	1.21	1.43	25.86	7.38	29.77
L_2	1.26	1.72	21.19	11.36	33.63
L_3	1.32	2.13	17.57	12.18	35.17
T_1	1.77	3.89	8.16	18.16	62.43
T_2	1.72	3.75	9.29	18.29	64.35
T_3	1.81	3.92	8.14	17.93	60.18
T_4	1.79	3.83	9.28	18.64	73.10
T_5	1.66	3.69	9.22	18.38	65.94
T_6	1.73	3.76	8.26	18.21	67.27
L_1 x T_1	1.47	2.17	17.49	9.59	43.54
x T_2	1.47	2.30	17.73	11.89	48.41
x T_3	1.52	2.21	17.17	11.87	51.76
x T_4	1.49	2.25	17.24	11.60	45.96
x T_5	1.45	2.25	17.59	12.06	46.19
x T_6	1.46	2.34	17.19	11.25	49.08
L_2 x T_1	1.49	2.24	14.59	13.57	47.51
x T_2	1.50	2.13	15.15	12.17	46.45
x T_3	1.56	2.29	14.71	12.28	48.53
x T_4	1.55	2.15	14.78	13.18	51.70
x T_5	1.48	2.33	15.12	13.72	51.38
x T_6	1.49	2.21	14.55	12.96	45.28
L_3 x T_1	1.57	2.27	13.16	13.58	51.40
x T_2	1.54	2.21	14.22	14.47	52.17
x T_3	1.49	2.31	12.97	13.13	48.61
x T_4	1.47	2.37	13.22	13.14	47.68
x T_5	1.52	2.34	13.17	14.19	44.97
x T_6	1.55	2.36	12.88	13.32	53.21

Additive (σ^2A) and dominance (σ^2D) variances calculated from the general combining ability (gca) and specific combining ability (sca) variances at F=1 (eggplant being self pollinated crop) revealed much higher additive than dominance genetic variance for both shoot and fruit infestation (Table 5) suggesting the importance of additive effect of the genes conditioning resistance through larval non-preference and antibiosis mechanisms. The inheritance was predominantly additive for phenol content and mainly dominance for protein content, while sugar content of the fruits was conditioned by additive and dominance variance, additive being greater in magnitude. Earlier reports of greater dominance effect for protein content in wheat (Dong et al 1995), higher additive variance for the control of protein content in lucerne (Guines *et al* 2002), predominant additive genetic control for tannin content in sorghum (Rodrigues *et al* 1998) and importance of additive gene effects for sugar content in sorghum stems (Cheng *et al* 1986) acceded to our findings. However, some other reports suggesting higher additive variance for the control of protein content in lucerne (Guines *et al* 2002) and cowpea (Hazra *et al* 1996) did not support the present findings.

Table 5. Estimates of combining ability and genetic component of variance

Character	Combining ability variances		Genetic component		Predictability ratio
	gca	sca	σ^2A	σ^2D	
Shoot infestation	0.83	0.45	1.66	0.45	0.79
Fruit infestation	1.41	0.58	2.83	0.58	0.83
Protein content	0.15	1.57	0.29	1.57	0.16
Sugar content	0.77	1.16	1.53	1.16	0.57
Phenol content	2.92	0.81	5.85	0.81	0.88

The genotypes like HE 12, Pusa Purple Cluster having high phenols and low sugar and protein contents in the fruits could effectively be utilized in breeding less susceptible eggplant varieties with good horticultural and cosmetic characters. However, striking proper balance for these biochemical compounds is necessary because both bitterness and discolouration in the fruits increase with increasing total phenol content (Chadha *et al* 1990), although high phenol level of 26.13mg/100 g fresh did not impart bitternesses in the fruits of HE 12 indicating higher threshold level of phenol for bitterness.

Development of hybrids emerged as the best breeding strategy in eggplant because of the preponderance of allelic and non-allelic interaction for fruit yield and yield components as revealed in several studies (Kathiria *et al* 1998; Vaghasiya *et al* 2000; Singh *et al* 2002 and Hazra and Roy, 2004). The hybrids of least/moderately susceptible x most susceptible parents in the present investigation showed less susceptibility to the borer compared to the most susceptible parent. However, it will be essential to develop both the parental lines with higher phenol and lower protein and sugar contents in the fruits along with other good horticultural qualities to build up appreciable tolerance in the hybrids.

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الأسس الكيموحيوية لوراثة صفة الحساسية لحفار ساق وثمار الباذنجان

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أجريت سلسلة من التجارب على سبعين تركيبا وراثيا من الباذنجان بغرض معرفة الأسس الكيموحيوية التى تتحكم فى وراثة صفة المقاومة لحفار ساق وثمار الباذنجان. وقد أظهرت هذه التراكيب الوراثية درجات مختلفة من الحساسية ، فقد وجد ٤٠ تركيبا وراثيا شديد الحساسية ، ١٣ تركيبا وراثيا عالية الحساسية ، ٩ تراكيب وراثية حساسة ، ٧ تراكيب وراثية معتدلة الحساسية وتركيبا واحد أقل حساسية. ووجد ارتباط معنوى وموجب بين محتوى الثمار من السكر والبروتين ودرجة الإصابة ، كذلك وجد ارتباط سالب ومعنوى بين محتوى الثمار من الفينولات ودرجة الإصابة.

ولفهم الأسس الكيموحيوية لوراثة صفة المقاومة لحفار ساق وثمار الباذنجان تم التهجين بين مجموعتين من التراكيب الوراثية للباذنجان ؛ المجموعة الأولى: استعملت كأمهات (Lines) وشملت ٣ تراكيب وراثية معتدلة فى درجة إصابتها والمجموعة الثانية إستعملت كآباء (Testers) وشملت ٦ تراكيب وراثية شديدة الحساسية فى درجة إصابتها. وبدراسة صفة المقاومة للأباء (٩) والهجن (١٨) وعلاقة المقاومة بمحتوى السكر ، والبروتين والفينولات فى الثمار ، وجد أن الجينات المضيفة كانت أكثر أهمية من الجينات السائدة فى التحكم فى صفة المقاومة.ويتحكم الفعل المضيف للجينات فى محتوى الثمار من الفينولات ، بينما يتحكم الفعل السيادى للجين فى محتوى الثمار من البروتين ، بينما يتحكم كل من الفعل المضيف والسيادى فى وراثة صفة محتوى الثمار من السكر.

أظهر التركيب الوراثى Pusa Purple Cluster, HE12 درجة معتدلة من المقاومة ، وذلك راجع إلى محتوى الثمار العالى من الفينولات والمحتوى المنخفض من السكر والبروتين ، كما أن ثمار هذين التركيبين الوراثيين ذات مواصفات بستانية جيدة ، لذلك يمكن تحسين صفة المقاومة لحفار ساق وثمار الباذنجان عن طريق استخدام هذين التركيبين الوراثيين فى برامج مستقبلية للتربية.

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