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Plant morphological characters in various tomato germplasm imparting resistance against tomato fruit borer, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae)

Aoufa Mushtaq and Pathania SS

Abstract
Morphological plant factors as basis of resistance against *Helicoverpa armigera* in different tomato germplasms was conducted at Experimental Farm, Faculty of Agriculture SKUAST-K, during the year, 2016. The correlation analysis between fruit infestation by *H. armigera* and plant morphological characters revealed that plant height (r = 0.878, 0.844), stem diameter (r = 0.965, 0.943), number of branches per plant (r = 0.898, 0.877) and number of fruits per plant (r = 0.874, 0.834) was significant and positively correlated both on number and weight basis, respectively. While the number of flowers per inflorescence (r = -0.811, -0.779) and number of fruits per truss (r = -0.830, -0.812)) had significant and negative association with borer infestation.

Keywords: Morphological characters, correlation, tomato fruit borer, *Helicoverpa armigera*

Introduction
Tomato (*Lycopersicon esculentum* Mill) is an important and widely grown vegetable crop in the world. It is popularly known as Wolf apple, Love of apple or *Vilaayati baingan*. Tomato is originated in tropical America and was introduced in India by Portuguese. It is commercially grown across the length and breadth of country due to its wide adaptability to various agro-climatic conditions. It ranks third largest vegetable crop after potato and sweet potato, but it tops in the list of canned vegetables. It plays a major role in human nutrition as an excellent source of phosphorus, iron, vitamin A, B, C and E; which collectively may lower the risk and occurrence of some carcinogenic and heart diseases [1]. Besides, it contains moisture (94%), protein (0.9%), fat (0.2%), mineral matter (0.5%), fiber (0.8%) and carbohydrates (3.6%); and minerals such as potassium, calcium, iron, sodium, copper, manganese, zinc, sulphur, chlorine and chromium to the extent of 20.0, 146.0,48.0, 0.64, 129.0, 0.9, 0.26, 0.41, 11.0 and 6.0 mg per 100 gm weight of tomato fruit, respectively [2]. About 200 insect species have been reported to infest tomato worldwide, of which the fruit borer, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae) is one of the serious pests [3, 4, 5]. *H. armigera* larvae are extremely damaging because they prefer to feed and develop on the reproductive structures of crops which are rich in nitrogen [6] and these structures are often part of the crop that is harvested [7]. Among integrated pest management components; host plant resistance is being compatible with other available management strategies; the plant morphological factors for resistance interfere physically with the Locomotor mechanisms and more specifically with the mechanisms of host-selection, feeding, ingestion, digestion, mating and oviposition [8]. Host plant resistance refers to the heritable qualities of a cultivar to counteract the activities of insects, so as to cause a minimum per cent reduction in the yield as compared to other cultivars of the same species under similar conditions. In tomato, glandular or non glandular trichomes are generally present with much diversity that offers resistance against many pest species. Similarly, other plant factors like height, number of branches per plant, number of fruits per plant, fruit per truss etc. may contribute to plant resistance/susceptibility. Therefore this study has made an attempt to correlate the plant factors with pest population in different tomato germplasms.

Materials and Methods

In screening of tomato germplasms for their relative resistance/ susceptibility against tomato fruit borer, *H. armigera* infestation, one month old seedlings of different tomato genotypes were transplanted in the month of May, 2016 in Randomized Block Design, with all recommended agronomic package of practices of the University. At each harvest, weight and number of tomato fruits were recorded for each genotype per plot. The damaged fruits (presence of holes/or any other damage symptom) were separated from the healthy tomato fruits to work out Per cent fruit damage on Number and Weight basis as:

$$\text{Per cent fruit weight loss} = \frac{\text{Weight of damaged fruits}}{\text{Total weight of tomato fruits}} \times 100$$

$$\text{Per cent Damaged Fruits (Number basis)} = \frac{\text{No. of damaged fruits}}{\text{Total No. of tomato fruits}} \times 100$$

Method of observations of plant morphological characters

Plant morphological characters like plant height, stem diameter and number of branches per plant were recorded a week before final harvesting/at a time of last picking (different lines had different maturity/harvesting time). Plant height and stem diameter of each tomato line were been taken from five randomly selected and tagged plants replicated thrice, and were measured in centimeter with help of scale and digital vernier caliper, respectively. Similarly, the numbers of branches per plant were counted on same plant. Thus, the average plant height and number of branches per plant was worked out.

Number of flowers per inflorescence

The number of flowers in fifteen inflorescence (five in each replication) had been counted at 50 per cent of flowering and average number of flowers per inflorescence was calculated.

Number of fruits per plant

At each picking, total number of fruits comprising both healthy and infested fruits per plant was counted; thus average number of fruits per plant for each genotype was worked out and recorded.

Number of fruits per truss

The number of fruits in 15 trusses (five in each replication) was counted at each picking and average number of fruits truss per was worked out.

Results and Discussions

The data on different morphological characters of various tomato germplasm with relation to fruit damage both on number and weight basis is presented in Table 1.

Table 1: Morphological characters of tomato genotypes/varieties in relation to infestation by *Helicoverpa armigera* during 2016

S. No.	Genotypes/ varieties	Fruit damage (%)		Plant characteristics					
		No. basis	Wt. basis	Plant height (cm)	Stem diameter (cm)	No. of branches Plant^{-1}	No. of flowers inflorescence^{-1}	No. of fruits plant^{-1}	No. of fruits truss^{-1}
		$X_{1(a)}$	$X_{1(b)}$	X_2	X_3	X_4	X_5	X_6	X_7
1.	SK-TVAR-1107	33.52	32.64	106.27 (10.35)^{r}	1.67 (1.63)^{l}	13.05 (3.74)^{k}	3.16 (2.04)^{a}	47.20 (6.94)^{r}	3.01 (2.00)^{r}
2.	SK-TVAR-1101	11.78	12.93	57.36 (7.16)^{c}	1.22 (1.49)^{c}	10.02 (3.31)^{a}	4.92 (2.43)^{g}	22.60 (4.85)^{e}	3.73 (2.17)^{e}
3.	SK-TVAR-1181	9.16	8.65	63.20 (8.00)^{e}	1.26 (1.50)^{d}	10.68 (3.42)d	5.14 (2.47)^{h}	21.80 (4.77)^{c}	5.06 (2.46)^{c}
4.	SK-TVAR-1089	13.04	11.03	60.05 (7.79)^{d}	1.28 (1.51)^{d}	11.12 (3.48)^{e}	3.28 (2.07)^{b}	20.25 (4.60)^{b}	3.47 (2.11)^{b}
5.	SK-TVAR-1018	32.81	31.68	102.07 (10.14)^{q}	1.65 (1.62)^{kl}	11.91 (3.59)^{g}	3.32 (2.07)^{b}	45.70 (6.83)^{q}	3.22 (2.05)^{q}
6.	SK-TVAR-1093	6.35	7.64	56.03 (7.54)^{b}	1.10 (1.44)^{a}	10.22 (3.35)b	5.40 (2.52)^{i}	20.00 (4.58)^{a}	5.26 (2.50)^{a}
7.	SK-TVAR-1134	24.06	26.21	96.01 (9.84)^{n}	1.45 (1.56)^{h}	12.44 (3.66)^{h}	3.74 (2.17)^{d}	27.80 (5.36)^{g}	3.61 (2.14)^{g}
8.	SK-TVAR-1142	8.77	8.65	60.14 (7.80)^{d}	1.15 (1.46)^{b}	10.52 (3.39)^{c}	4.26 (2.28)^{e}	20.10 (4.59)^{a}	5.15 (2.48)^{a}
9.	SK-TVAR-1048	7.82	9.41	40.16 (6.41)^{a}	1.12 (1.45)^{ab}	10.46 (3.38)^{c}	5.31 (2.51)^{i}	20.00 (4.58)^{a}	4.22 (2.28)^{a}
10.	SK-TVAR-1121	31.05	33.54	98.21 (9.95)^{p}	1.62 (1.61)^{k}	12.85 (3.71)^{j}	3.51 (2.12)^{c}	30.60 (5.61)^{i}	3.41 (2.09)^{c}
11.	SK-TVAR-1083	11.24	12.29	60.19 (7.82)^{d}	1.36 (1.53)^{f}	9.98 (3.31)^{a}	4.92 (2.43)^{g}	22.40 (4.83)^{d}	4.72 (2.39)^{i}
12.	SK-TVAR-209	20.42	21.49	93.19 (9.70)^{k}	1.44 (1.56)^{h}	11.98 (3.60)^{g}	3.06 (2.01)^{a}	35.80 (6.06)^{m}	4.01 (2.23)^{e}
13.	BRDT-2	14.03	15.29	84.09 (9.22)^{h}	1.32 (1.52)^{e}	11.24 (3.49)^{f}	4.62 (2.36)^{f}	30.10 (5.57)^{h}	4.32 (2.30)^{g}
14.	BRDT-3	15.45	12.06	86.00 (9.30)^{h}	1.36 (1.53)^{f}	11.66 (3.55)^{f}	4.59 (2.36)^{f}	32.10 (5.75)^{i}	4.21 (2.28)^{h}
15.	H-86	10.62	8.29	65.02 (8.12)^{f}	1.18 (1.47)^{b}	10.72 (3.41)^{d}	5.01 (2.45)^{h}	21.70 (4.76)^{c}	4.96 (2.44)^{j}
16.	Arka Vikas	30.76	32.62	97.06 (9.90)^{o}	1.57 (1.60)^{j}	12.62 (3.69)^{i}	3.62 (2.14)^{c}	40.20 (6.41)^{p}	3.54 (2.12)^{c}
17.	Kashi Aman	23.06	26.34	95.00 (9.79)^{m}	1.50 (1.58)^{i}	12.27 (3.64)^{h}	3.83 (2.19)^{d}	37.40 (6.19)^{n}	3.72 (2.17)^{d}
18.	Local	19.61	17.06	92.01 (9.64)^{j}	1.42 (1.55)^{g}	11.86 (3.58)^{g}	4.18 (2.27)^{e}	34.40 (5.95)^{l}	4.12 (2.26)^{f}
19.	Punjab Chuhura	12.79	12.10	75.12 (8.71)^{g}	1.26 (1.50)^{d}	10.99 (3.46)^{e}	4.78 (2.40)^{g}	26.80 (5.27)^{f}	4.54 (2.35)^{h}
20.	Punjab Ratta	21.67	24.48	94.04 (9.74)^{l}	1.48 (1.57)^{i}	12.04 (3.61)^{h}	3.92 (2.21)^{d}	37.70 (6.22)^{o}	3.91 (2.21)^{e}
21.	Roma	16.02	15.82	90.36 (9.55)^{i}	1.39 (1.54)^{f}	11.72 (3.56)^{f}	4.33 (2.30)^{e}	33.60 (5.88)^{k}	4.17 (2.27)^{f}
	C.D.(p< 0.05)	-	-	(0.52)	(0.03)	(0.14)	(0.18)	(0.13)	(0.17)
	S.E(d)	-	-	(0.25)	(0.02)	(0.07)	(0.07)	(0.27)	(0.08)
	S.E(m)	-	-	(0.18)	(0.01)	(0.05)	(0.05)	(0.19)	(0.06)
	C.V.	-	-	(3.56)	(1.03)	(2.31)	(3.89)	(0.98)	(4.31)

Plant height (cm): A significant and positive correlation (r = 0.878 and 0.844) (Table 2, 3), existed between fruit infestation and plant height on number and weight basis, respectively. The plant height in different genotypes significantly varied from 106.27 to 40.16 cm. However, the genotype SK-TVAR-1048 recorded lowest plant height of 40.16 cm, whereas the maximum plant height was observed in genotype SK-TVAR-1107 (106.27 cm). These findings are more or less in conformity with the findings of Khanam *et al.* (2003) [9] who also reported positive but non-significant correlation (r = 0.243) between tomato plant height and fruit borer infestation, though the minimum (68.63 cm) and maximum average plant height (100.3 cm) in different genotypes was in accordance with present findings. The

present results are also in accordance with Ambulae and Radadia (2015) [10] who too revealed that fruit damage when correlated with plant height exhibited significantly positive (r = 0.77) correlation among them indicating that with increase in plant height led to increase in fruit infestation.

Table 2: Correlation matrix of different morphological characters of tomato germplasm with fruit damage on number basis

	Fruit damage (%) $X_{1(a)}$	Plant height (cm) X_2	Stem diameter (cm) X_3	No. of branches/plant X_4	No. of flowers/ inflorescence X_5	No. of fruits/ plant X_6
X_2	0.878 (0.000)					
X_3	0.965 (0.000)	0.900 (0.000)				
X_4	0.898 (0.000)	0.919 (0.000)	0.866 (0.000)			
X_5	-0.811 (0.000)	-0.742 (0.000)	-0.792 (0.000)	-0.795 (0.000)		
X_6	0.874 (0.000)	0.893 (0.000)	0.887 (0.000)	0.813 (0.000)	-0.691 (0.000)	
X_7	-0.830 (0.000)	-0.619 (0.003)	-0.790 (0.000)	-0.732 (0.000)	0.778 (0.000)	-0.688 (0.001)

Figures in parentheses are p values

Table 3: Correlation matrix of different morphological characters of tomato germplasm with fruit damage on weight basis

	Fruit damage (%) $X_{1(a)}$	Plant height (cm) X_2	Stem diameter (cm) X_3	No. of branches/plant X_4	No. of flowers/inflorescence X_5	No. of fruits/plant X_6
X_2	0.844 (0.000)					
X_3	0.943 (0.000)	0.900 (0.000)				
X_4	0.877 (0.000)	0.919 (0.000)	0.860 (0.000)			
X_5	-0.779 (0.000)	-0.742 (0.000)	-0.792 (0.000)	-0.795 (0.000)		
X_6	0.834 (0.000)	0.893 (0.000)	0.887 (0.000)	0.813 (0.000)	-0.691 (0.001)	
X_7	-0.812 (0.000)	-0.619 (0.003)	-0.790 (0.000)	-0.732 (0.000)	0.778 (0.000)	-0.688 (0.000)

Figures in parentheses are p values

Stem diameter (cm): A highly significant and positive correlation (r = 0.965 and 0.943) (Table 2, 3), was computed between stem diameter and fruit infestation on number and weight basis, respectively. The minimum stem diameter of 1.10 cm in genotype SK-TVAR-1093 had least fruit damage of 6.35 and 7.64 per cent both on number and weight basis, respectively. The maximum stem diameter (1.67 cm) in SK-TVAR-1107 recorded highest fruit damage of 33.52 per cent on number basis and 32.64 per cent on weight basis. However, commercial cultivars Arka Vikas, Kashi Aman, Punjab Ratta, Local, Roma and Punjab Chuhura recorded a stem diameter of 1.57, 1.50, 1.48, 1.42, 1.39 and 1.26 cm, respectively. The results are more or less in accordance with the findings of Ambulae and Radadia (2015) [10] and Khanam *et al.* (2003) [9] who recorded positive, but, non-significant correlation (r = 0.485) and (r = 0.101) of stem diameter with fruit damage by *H. armigera.* However, the findings are in contradiction with the findings of Daboul *et al.* (2011) [11] who observed negative and non-significant correlation (r =-0.99) between stem diameter and fruit borer infestation. It could be due to varied agro-climatic conditions and different germplasms.

Number of branches per plant: The number of branches per plant had significant and positive correlation (r = 0.898 and 0.877) with fruit infestation both on number and weight basis, respectively. The number of branches per plant in different genotypes significantly ranged from 13.05 to 9.98. The least number of branches per plant (9.98) was observed in genotype SK-TVAR-108 whereas maximum number of branches per plant (13.05) was recorded in genotype SK-TVAR-1107. The findings are in conformity with Rath and Tripathy (2006) [12] who reported a significantly positive correlation between number of branches and fruit infestation both on number basis (r = 0.819) and weight basis (r = 0.916). Similarly, Ambulae and Radadia (2015) [10] too opined that number of branches per plant had significant and positive correlation (r = 0.787) with fruit damage.

Number of flowers per inflorescence: A significant and negative correlation (r =-0.811 and-0.779) existed between number of flowers per inflorescence and fruit infestation on number and weight basis, respectively. The minimum number of flowers per inflorescence (3.06) was observed in genotype SK-TVAR-209, maximum number of flowers per inflorescence (5.40) was recorded in the genotype SK-TVAR-1093. The Results are in accordance with findings of Wani *et al.* (1998) [13] that number of inflorescence per plant and fruit borer infestation was negatively correlated (both on number and weight basis). Moreover, among different tomato varieties screened, Arka Vikas was found as highly susceptible to *H. armigera* infestation.

Number of fruits per plant: The number of fruits per plant was significant and positively correlated (r = 0.874 and 0.834) with fruit infestation by *H. armigera* both on number and weight basis, respectively. The minimum number of fruits per plant (20.00) was observed in genotype SK-TVAR-1093, and maximum number of fruits 47.20/plant, was registered in genotype SK-TVAR-1107. In commercial varieties too, the fruits per plant and borer infestation was significant and positively correlated, whereby the highest fruit damage of 30.76 and 32.62 per cent on number and weight basis, respectively, was registered in cultivar Arka Vikas with maximum bearing of (40.20 fruit/plant), though the least fruit damage of 12.79 per cent on number basis and 12.10 per cent on weight basis was recorded in variety Punjab Chuhura (26.80 fruits/plant). The results are in accordance with the findings of Rath and Tripathy (2006) [12] and Ambulae and Radadia (2015) [10] who reported a significant and positive correlation (r = 0.813) and (r = 0.738), respectively, between numbers of fruits per plant and *H. armigera* infestation.

Number of fruits per truss: A significant but negative correlation (r =-0.830 and-0.812) was computed between number of fruits per truss and fruit infestation both on number and weight basis, respectively. The genotype SK-TVAR-1093

recorded maximum fruits per truss (5.26), while, the minimum fruits per truss was recorded in genotype SK-TVAR-1107 (3.01/truss). The present findings are in accordance with the work of Wani *et al.* (1998) [13] who too recorded significant and negative correlation (r =-0.5119) between number of fruits per truss and fruit infestation by *H. armigera*. The maximum fruit infestation both on number (38.23%) and weight basis (40.17%) is more or less in accordance with present findings.

Conclusion

The study revealed that plant morphological characters such as number of flowers per inflorescence, number of fruits per truss, can be used as marker traits by breeders to develop insect resistant varieties of tomato against *Helicoverpa armigera* and thus maximize the economic returns without appreciable loss to the ecosystem by way of indiscriminate use of chemical insecticides.

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