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Varietal Screening of Tomato to Tomato Fruit Borer, *Helicoverpa armigera* (Hub.) and Associated Tomato Plant Characters

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Abstracts: The screening of thirty tomato varieties/lines to tomato fruit borer, *Helicoverpa armigera* (Hub.) infestation in relation to their morphological characters was conducted in different laboratories of BAU and Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during rabi season, November 1999 to March 2000. The tomato fruit borer infestation varied significantly among the varieties/lines and also with the age of the tomato plants. Among the varieties/lines, V-29 and V-282 were found moderately resistant and susceptible, respectively. Plant height, stem diameter, total number of branches/plant, total number of leaves/plant, 2nd leaf area, total leaf chlorophyll, number of leaf hair and number of fruits/plant of V-29 line were 81.74 cm, 1.45 cm, 14, 453, 19.58 sq.cm, 1.13 mg/g, 12 and 48, respectively. Again the aforementioned characters for V-282 line were 80.74 cm, 1.18 cm, 9, 396, 21.57 sq.cm, 1.24 mg/g, 17 and 30, respectively.

Key words: Tomato, *Helicoverpa armigera* (Hub.), resistant, morphological characters

Introduction

Tomato (*Lycopersicon esculentum* Mill) is one of the most popular and nutritious vegetable crops in Bangladesh which belongs to the family Solanaceae. It ranks next to potato and sweet potato in the world vegetable production (Anonymous, 1997) and tops the list of conned vegetables (Choudhary, 1979).

In Bangladesh, recent statistics shows that tomato was grown in 35000 acre of land and the total production was approximately 98000 metric tons in 1998-1999. Thus the average yield of tomato was 2.8 ton/acre (Anonymous, 1999). The yield is quite low as compared to that of other tomato producing countries such as India (15.14 t/ha), Japan (57.14 t/ha) and USA (65.06 t/ha), respectively (Anonymous, 1998). The causes of low yield of tomato in Bangladesh are unavailability of quality seeds of improved varieties, fertilizer management, disease and insect infestation and improper irrigation. Tomato is very much susceptible to insect attack from seedling to fruiting stage. This crop is attacked by different species of insects in Bangladesh. Among them, tomato fruit borer, *Helicoverpa armigera* (Hub.) is the serious one. This has been reported to cause damage to the extent of about 50-60% fruits (Singh and Singh, 1977). The pest is active throughout the year at places having moderate climate but its activity is adversely affected by severe cold. A study revealed that it is very active during the Rabi season. The damage by *H. armigera* starts soon after fruiting periods of the crop and the newly hatched larvae bore into the fruit and feed inside. As a result, the fruits become unfit for human consumption.

Though the pest is serious/major in status, the management of this pest through non-chemical tactics (cultural, mechanical, biological and host plant resistance etc.) undertaken by the researcher throughout the world is limited. The research works on non-chemical control measures of this pest are scanty. So, the use of chemical insecticides is regarded to be the most useful measure to combat this pest. Now, our slogan is " save the environment in order to save us". For that reasons, the Ecologists, Entomologists and Zoologists gave great importance to IPM programme. There are six steps in IPM. Among them, use of resistant cultivars ranks the first. So, developing the resistant variety tomato is urgent. Research works in this discipline are few in Bangladesh. To minimize the use of synthetic insecticides and problems arising out of their frequent use, it is very essential to cultivar a resistant and tolerant variety against insect-pests specially tomato fruit borer. Therefore, the present research programme was undertaken to use resistant variety (s) of tomato in vegetable pest management programme, which is considered to be economical and safer as compared to the chemical control. In view of this requirement, an experiment was undertaken to find the resistant, tolerant tomato variety (s) of tomato resistant to fruit borer with the following objectives:

- To test damage level caused by tomato fruit borer of resistant and susceptible tomato varieties/lines by field screening.
- To identify the plant morphological characters influencing the infestation rate of tomato fruit borer.

- To study the relation of leaf colour/pigment (i.e. chlorophyll 'a' and 'b') with infestation rate of tomato fruit borer.

Materials and Methods

The research work was carried out at Genetics and plant breeding farm (GPB farm) and at different Laboratories of Bangladesh Agricultural University (BAU) and Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during the period from November 1999 to March 2000. The experimental field belongs to the old Brahmaputra Alluvium Soil Tract characterized by sandy loam soil with fine texture having a pH value of 6.5 (Uddin, 1975; Anonymous, 1979).

For the experiment, thirty tomato varieties/lines were used. Most of them were obtained from Genetics and plant Breeding Department, BAU, Mymensingh and the rest were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur and Asian Vegetable Research and Development Centre (AVRDC), Taiwan.

Field screening of tomato varieties/lines against tomato fruit borer: Thirty tomato varieties/lines viz. V-40, V-80, V-187, V-231, V-250, V-258, V-259, V-280, V-282, V-321, V-332, V-374, V-378, Ratan, V-29, V-382, V-387, V-422, V-423, V-433, V-453, Manik, V-14, V-8, V-52, V-56, V-94, V-3, BRRI-10 and V-167 were screened for tomato fruit borer resistance in Genetics and plant breeding farm, BAU, Mymensingh.

Seeds of different varieties/lines were sown separately in a well-prepared seed-bed to raise seedling and proper care was taken during raising of the seedlings, which were spaced at 1 m in a unit plot of 5.4 m^2. Twenty-days old seedlings were transplanted at the main field. The total plot area was 1056 m^2 which was divided into 3 replications, where each replication contained 30 varieties/lines. Twenty-eight plants were planted in each variety/line with 50 cm distance from plant to plant. Line to line distance was 60 cm. Intercultural operations were performed as and when necessary throughout the growth period of the crop. Chemical control measures were not taken against insect pests.

Data were recorded at 30, 50 and 70 days after transplanting (DAT). Total number of infested and healthy shoots and fruits were counted and percentage of infestations of tomato fruit borer was calculated and graded from the mean percentages according to the method of Mukhopardhay and Mandal (1994). Statistical analysis was done by using MSTAT package computer programme. Mean differences were adjusted with DMRT (Duncan, 1955; Gomez and Gomez, 1984).

Calculation of percentage of tomato fruit borer infestation: For collecting data on the percentage of tomato fruit borer infested plant, total number of plants and the number of tomato fruit borer infested plants in each plot were recorded. Then the percentage of tomato fruit borer infested plants was recorded. The damaged plants were then graded by Mishra *et al.* (1996).

Identification of plant morphological characters influencing the infestation rate of tomato fruit borer: Data were collected from 10 plants of each variety/line of each replication. Data or morphological characters viz. Plant height (cm), stem diameters (cm), number of branches per plant, number of leaves per plant, second leaf area (cm), leaf hair per unit area, leaf chlorophyll, fruit no per plant were recorded at 30, 50 and 70 days after transplanting (DAT). Mean values of each entry from different DAT were analyzed statistically.

To determine the extent of interrelationship among tomato fruit borer infestations and tomato plant characters, correlation matrix for all possible data combinations was worked out by the method of Hayes *et al.* (1955). Correlation co-efficient were further partitioned into characters of direct and indirect effects by path co-efficient analysis originally developed by Wright (1923) and later described by Dewey and Lu (1959), taking all the characters into consideration. Tomato fruit borer infestations were considered as a resultant variable. The relative importance of each independent variable for tomato fruit borer infestations were carried out by logistic regression model since the independent variable was in percentage form.

Study on the relation of leaf colour/pigment (i.e. chlorophyll 'a' and 'b') with infestation rate of tomato fruit borer: Leaf chlorophyll was estimated from the second leaf counted from the top of the shoot. For this purpose, second leaf was randomly selected from 10 different plant in each entry in a replicate and leaf pigment was estimated. Leaf pigments were estimated as outlined by Yoshida *et al.* (1976).

Results and Discussion

Percentage of tomato fruit borer infestation of selected tomato varieties/lines at different ages: The percentage of tomato fruit borer infestation of different varieties/lines at different plant ages has been presented in Table 1. The percentage of tomato fruit borer infestation ranged from 0.01057 (V-29) to 29.11 (V-374) at early stage of fruit and 17.33 (V-29) to 43.57 (V-422) at ripening stage of fruit. The

Table 1: Percentage of tomato fruit borer infestation of 30 selected Tomato varieties/lines at different ages, Rabi, 1999-2000

Varieties lines with accession no.	Percentage of tomato fruit borer infestation				Level of resistance
	At early stage	At ripening stage	Mean	Rank	
V - 40	11.58d-h	26.57d-f	19.07g-l	23	MT
V - 50	6.797g-j	27.70d-f	17.25j-l	26	MT
V - 187	21.08a-e	32.56b-d	26.82b-f	6	S
V - 231	15.19b-g	26.23d-f	20.71f-k	20	MT
V - 250	14.96b-g	26.41d-f	20.69f-k	21	MT
V - 258	22.83a-c	32.34b-d	27.59b-d	4	S
V - 259	14.78b-g	28.79d-f	21.79d-k	17	MT
V - 280	10.97d-h	36.42a-c	23.70b-I	14	MT
V - 282	0.6620ij	27.97c-f	14.32l	29	T
V - 321	2.14a-f	36.63ab	28.38a-c	3	S
V - 332	1.782h-j	31.08b-d	15.72kl	28	MT
V - 374	29.11a	29.69b-e	29.40ab	2	S
V - 378	16.82b-g	24.47d-g	20.65f-k	22	MT
Rat-n	10.37e-I	29.37e-g	17.53I-l	25	MT
V - 29	0.01057j	17.33g	8.670m	30	T
V - 382	20.83a-e	32.78b-d	26.81b-f	7	S
V - 387	20.07a-f	32.34b-d	26.21b-f	9	S
V - 422	23.71ab	43.51a	33.61a	1	HS
V - 423	19.64a-f	31.65b-d	25.64b-f	10	S
V - 433	21.76a-d	31.11b-d	26.43b-f	8	S
V - 453	19.39a-f	29.12b-f	24.26b-h	13	MT
Manik	18.90a-f	26.77d-f	22.83c-j	16	MT
V - 14	16.78b-g	29.19b-f	22.98b-j	15	MT
V - 8	17.78b-f	31.47b-d	24.66b-g	12	MT
V - 52	17.57b-g	32.98b-d	25.28b-g	11	S
V - 56	23.24a-c	27.95c-f	27.26b-e	5	S
V - 94	12.59c-g	20.77fg	16.68j-l	27	MT
V - 3	11.67d-h	30.44b-d	21.06e-k	19	MT
BARI-10	9.274f-j	27.05b-f	18.16h-l	24	MT
V-1 67	12.52c-g	24.90d-g	21.71d-k	18	MT
Sx	2.458	1.894	1.469	-	-
Stage of fruit	14.82b	29.52a	-	-	-

CV (%) = 15.98 HS = Highly susceptible, S = susceptible, MT = Moderately tolerant, T= Tolerant.

Table 2: Plant height (cm) of 30 selected Tomato varieties/lines at different ages, Rabi, 1999-2000

Variety/line with accession no.	Plant height (cm)				
	30 DAT	50 DAT	70 DAT	Mean	Rank
V-40	61.57f-l	70.37I-k	80.15g	70.70j-l	27
V-50	66.71d-h	72.90f-k	87.37d-g	75.66f-I	20
V-187	87.30a	100.2a	113.5a	100.3a	1
V-231	80.00b	94.74ab	110.5a	95.09b	3
V-250	68.50d-f	79.13d-h	94.83c-f	80.82de	10
V-258	63.73e-j	79.50d-h	93.30c-f	78.84d-g	16
V-259	72.38cd	91.77bc	105.7ab	89.94c	6
V-280	63.99e-j	79.56d-h	93.77c-f	79.11d-g	15
V-282	66.84d-h	80.02d-g	95.36c-e	80.74de	11
V-321	57.84j-l	71.00h-k	84.99fg	71.27I-l	25
V-332	59.24h-l	75.27e-j	88.63d-g	74.38g-j	22
V-374	57.30j-l	73.50e-k	84.75fg	71.85I-l	24
V-378	62.67f-k	80.93d-f	96.49cd	80.03d-f	13
Ratan	58.53I-I	72.13g-k	90.10d-g	73.59h-k	23
V-29	62.93f-j	81.53de	100.8bc	81.74de	9
V-382	82.79ab	95.95ab	106.1ab	94.96b	4
V-387	80.89ab	93.45ab	107.4ab	93.92bc	5
V-422	77.22bc	97.38ab	113.0a	95.88b	2
V-423	65.96d-I	78.40d-I	91.60c-e	78.65d-g	17
V-433	54.70l	65.30k	85.89e-g	68.63l	30
V-453	66.40d-h	80.40d-g	93.49c-f	80.10d-f	12
Manik	66.42d-h	79.33d-h	92.60c-f	79.45d-f	14
V-14	67.74d-g	77.34d-I	89.22d-g	78.10.e-h	18
V-8	71.18c-e	84.38cd	94.26c-f	83.27d	7
V-52	63.13f-j	71.83g-k	89.13d-g	74.70g-j	21
V-56	60.14g-l	68.17jk	80.60g	69.64kl	28
V-94	55.47k-l	68.03jk	89.86d-g	71.12I-l	26
V-3	65.85d-I	78.40d-I	87.13d-g	77.13e-h	19
BARIB10	54.54l	70.53I-k	81.17g	68.75l	29
V-167	67.43d-g	85.03cd	93.38c-f	81.95de	8
Sx	1.723	1.944	2.250	1.134	
DAT	66.31c	79.88b	93.84a	δx:0.3586	

CV (%) = 4.25 DAT = Days after transplanting.

Table 3: Stem diameter (cm) of 30 selected Tomato varieties/lines at different ages, Rabi, 1999-2000

Variety/line with accession no.	Stem diameter (cm) 30 DAT	50 DAT	70 DAT	Mean	Rank
V-40	1.210ab	1.527a-c	1.904c-e	1.547b	3
V-50	0.9653b-f	1.362c-f	1.727c-I	1.351b-g	10
V-187	1.276a	1.675a	2.333a	1.762a	1
V-231	0.9400b-f	1.149g-k	1.450I-j	1.180I-m	20
V-250	0.9267c-f	1.147g-k	1.407j	1.160I-m	22
V-258	1.273a	1.593ab	2.170ab	1.679a	2
V-259	0.9033c-g	1.370c-f	1.780c-h	1.351d-g	11
V-280	1.110a-d	1.539a-c	1.903c-e	1.517bc	5
V-282	0.8633d-g	1.203f-j	1.474ij	1.180 I-m	19
V-321	1.027a-e	1.233e-I	1.610g-j	1.290f-I	15
V-332	0.9800b-f	1.284e-h	1.636e-j	1.300f-I	13
V-374	0.9020c-g	1.271e-h	1.607g-j	1.260g-j	16
V-378	1.093a-d	1.307d-g	1.600g-j	1.333e-g	12
Ratan	0.6267gh	1.132g-k	1.483ij	1.080k-o	26
V-29	1.100a-d	1.493a-d	1.889c-f	1.494bc	6
V-382	1.060a-e	1.442b- e	1.848c-g	1.450b-e	8
V-387	1.073a-e	1.416b-e	1.930b-d	1.473b-d	7
V-422	0.8067e-g	1.122g-k	1.509h-j	1.146j-n	23
V-423	0.7933e-g	1.199f-j	1.606g-j	1.199h-l	18
V-433	0.9467b-f	1.264e-h	1.663d-j	1.291f-I	14
V-453	1.160a-c	1.441b-e	1.963bc	1.521bc	4
Manik	0.9767b-f	1.392b-f	1.843c-g	1.404c-f	9
V-14	0.9100c-f	1.108g-k	1.497ij	1.162I-m	21
V-8	0.7133f-g	1.039i-k	1.398j	1.050m-o	28
V-52	0.5100h	1.080h-k	1.468ij	1.019no	29
V-56	0.7100f-h	1.085h-k	1.453ij	1.083k-o	25
V-94	0.4910h	0.9513k	1.428j	0.9567S8o	30
V-3	0.8073e-g	1.035I-k	1.553h-j	1.135j-m	24
BARI B10	0.6977f-h	1.012j-k	1.493ij	1.068l-o	27
V-167	0.8100e-g	1.197f-j	1.627f-j	1.211 h-k	17
Sx	0.06325	0.0483	0.06325	0.03333	
DAT	0.9221c	1.269 b	1.670 a	δx : 0.0105	

CV (%) = 7.63 DAT = Days after transplanting

Table 4: Total number of branches per plant of 30 selected Tomato varieties/lines at different ages, Rabi, 1999-2000

Variety/line with accession no.	Total number of branches per plant 30 DAT	50 DAT	70 DAT	Mean	Rank
V-40	8.273d-I	12.31f-k	19.49b-I	13.36e-g	16
V-50	14.97a-c	19.49b	26.18ab	20.21b	2
V-187	9.173d-h	14.42c-I	19.27b-I	14.29de	13
V-231	10.02d-g	15.16b-h	20.34a-I	15.17c-e	10
V-250	8.093e-I	14.10d-I	18.91b-I	13.70e-d	15
V-258	10.92c-f	15.55b-h	19.53b-I	15.33c-e	9
V-259	6.640f-I	10.06i-k	16.14d-I	10.95f-I	22
V-280	6.343g-I	9.633i-k	13.54hi	9.83g-I	27
V-282	5.410hi	7.823k	14.60g-I	9.27hi	28
V-321	7.013f-I	13.15e-j	12.47i	10.88f-I	24
V-332	8.360d-I	13.17e-j	16.65c-I	12.74e-h	17
V-374	7.367f-I	12.06g-k	15.39e-I	11.61e-I	21
V-378	9.847h	15.35b-g	19.77b-I	15.03c-e	11
Ratan	9.623d-h	13.91e-j	20.47a-I	14.67d-f	12
V-29	6.173g-I	8.950jk	25.99a-c	13.70e-g	14
V-382	12.33b-e	20.07b	25.44a-d	19.28b	5
V-387	12.52b-d	18.94b-d	24.54a-f	18.67bc	6
V-422	12.26b-e	17.71b-e	23.02a-h	17.66b-d	8
V-423	14.48a-c	19.31bc	24.87a-e	19.55b	4
V-433	18.20a	25.23a	29.04a	24.16a	1
V-453	15.33ab	19.22bc	24.64a-f	19.73b	3
Manik	12.54b-d	17.21b-f	23.79a-g	17.85b-d	7
V-14	7.833f-I	11.59g-k	16.70c-I	12.04e-I	19
V-8	5.443hi	11.06g-k	15.17f-I	12.56e-I	18
V-52	6.477f-I	10.22h-k	16.07d-I	10.92f-I	23
V-56	5.427hi	9.600i-k	15.25f-I	10.08g-I	16
V-94	5.783g-I	9.043jk	16.12d-I	10.32g-I	25
V-3	7.047f-I	11.63g-k	16.53d-I	11.74e-I	20
BARIB10	4.267I	7.970k	14.71g-I	8.98hi	29
V-167	4.250I	7.300k	14.32g-I	8.61i	30
Sx	1.010	1.137	2.105	0.91	
DAT	9.083c	13.71b	19.50a	δx:0.20	

Within column, mean followed by same letter (s) did not differ significantly at P < 0.01 by DMRT
DAT = Days after transplanting

Table 5: Total number of leaves per plant of 30 selected Tomato varieties/lines at different ages, Rabi, 1999-2000

Varieties/line with accession no.	Total number of leaves per plant				
	30 DAT	50 DAT	70 DAT	Mean	Rank
V-40	333.6h-k	386.0f	421.7a-k	380.5j-m	25
V-50	290.5jk	361.5f	391.5kl	347.8m	29
V-187	366.4g-k	429.0d-f	461.2g-k	418.8i-l	20
V-231	397.3f-z	454.9d-f	496.9e-k	449.7g-I	15
V-250	500.6ef	540.3b-f	584.4ef	541.8e	7
V-258	441.9f-h	503.1c-f	534.0e-I	493.0e-g	11
V-259	387.5g-k	428.0d-f	466.8f-k	427.4h-k	19
V-280	381.6g-k	425.0d-f	437.6h-k	414.7i-l	21
V-282	356.6g-k	398.3f	431.9h-k	395.6i-m	23
V-321	355.5g-k	397.3f	430.4h-k	394.4i-m	24
V-332	419.5f-i	464.4c-f	488.0b-k	457.4f-i	13
V-374	287.7k	276.0f	308.0l	290.6n	30
V-378	386.7g-k	419.0ef	488.9e-k	431.5h-k	17
Ratan	368.2g-k	409.0ef	460.9g-k	412.7i-l	22
V-29	378.1g-k	428.7d-f	550.5e-h	452.5f-i	14
V-382	675.1dc	780.5ab	843.9cd	766.5c	4
V-387	577.2de	685.0a-d	775.4d	679.2d	6
V-422	778.4a	890.7a	958.7b	876.0b	2
V-423	453.4fg	537.1b-f	602.9e	531.2e	8
V-433	854.8a	671.8a-e	1116.0a	980.8a	1
V-453	605.0cd	718.8a-c	792.3d	705.4d	5
Manik	766.5ab	875.1a	940.2bc	860.6b	3
V-14	452.9fg	538.9d-a	572.8e-g	521.6e	9
V-8	463.8fg	516.0c-a	550.7e-h	510.1ef	10
V-52	372.8g-k	436.6d-a	482.2f-k	430.5h-k	18
V-56	436.8fg	492.0c-f	527.1e-j	485.3e-h	12
V-94	320.3i-k	365.1f	426.5i-k	370.6k-m	26
V-3	333.3h-k	365.8f	411.3j-l	370.1k-m	27
BARIB10	380.0g-k	446.8d-f	484.8e-k	437.2g-j	16
V-167	321.7i-k	361.4f	403.5kl	362.2lm	28
Sx	24.27	58.51	27.16	14.77	
DAT	448.1c	510.1f	561.4a	δx:3.303	

CV (%) = 8.75 DAT = Days after transplanting

Table 6: Second leaf area (cm2) of 30 selected Tomato varieties/lines at different ages, Rabi, 1999-2000

Varieties/lines with accession no.	2nd leaf area (cm2)				
	30 DAT	50 DAT	70 DAT	Mean	Rank
V-40	24.50a-d	21.64b-d	21.13a-c	22.43cd	4
V-50	23.77a-f	21.74bc	21.17a-e	22.23c-e	5
V-187	23.10a-f	19.22c-h	17.29e-k	19.87d-i	12
V-231	20.05c-i	16.27d-i	16.36f-k	17.56i-o	20
V-250	18.27d-j	15.75e-i	13.03k	15.69m-p	26
V-258	19.64c-j	17.26c-i	14.16jk	17.01j-o	21
V-259	14.24I-k	17.74c-i	18.14c-j	18.59g-l	17
V-280	18.33d-j	15.64e-i	14.75i-k	16.24l-o	25
V-282	24.05a-e	21.28b-d	19.39a-h	21.57c-f	7
V-321	23.99a-e	21.48b-d	21.10a-f	22.19c-e	6
V-332	24.94a-c	22.54bc	20.01a-f	22.83bc	3
V-374	26.65ab	26.02ab	22.66ab	25.11ab	2
V-378	16.69g-j	14.32g-i	15.18g-k	15.40op	28
Ratan	17.62f-j	19.62c-g	17.66d-j	18.30h-n	18
V-29	16.02h-j	19.01c-h	23.70o	19.58e-j	13
V-382	23.49a-f	19.62c-g	15.08h-k	19.41f-k	15
V-387	22.75a-g	19.47c-g	15.22d-k	19.13f-k	16
V-422	18.08e-j	14.61f-i	16.12f-k	16.27l-o	24
V-423	23.98a-e	19.46f-i	17.53d-j	20.32c-h	10
V-433	16.58g-j	13.72i	16.23f-k	15.46np	27
V-453	21.98b-h	20.83c-e	19.05b-i	20.62c-h	9
Manik	28.34a	28.65a	23.15ab	26.71a	1
V-14	19.62c-j	19.26c-h	15.60g-k	18.16h-n	19
V-8	18.76c-j	17.38c-i	14.12jk	16.75k-o	22
V-52	14.95I-k	13.38hi	15.73f-k	14.89op	29
V-56	22.00b-h	19.65c-g	21.82a-d	21.16c-g	8
V-94	18.08e-j	20.25c-e	22.13a-c	20.15c-i	11
V-3	9.90k	12.47I	17.49e-j	13.29p	13
BARIB10	13.43jk	16.25d-i	19.52a-g	16.40l-o	23
V-167	14.92I-k	19.83c-f	23.60a	19.45f-k	14
Sx	1.414	1.200	0.9835	0.6416	
DAT	20.18a	18.83b	18.27c	δx:0.1433	

CV (%) = 10.08
Within column, means followed by same letter (s) did not differ significantly at $P < 0.01$ by DMRT
DAT = Days after transplanting

Table 7: Total leaf chlorophyll (mg/g) and total leaf hair per unit area (10 mm 2) of 30 selected Tomato varieties/lines at different ages, Rabi, 1999-2000

Varieties/ Lines	Total leaf chlorophyll (mg/g)		Total leaf hair per unit area (10 mm 2)	
	Mean	Rank	Mean	Rank
V-40	0.2393k	26	11.19i-l	26
V-50	0.7763hi	23	15.37e-i	14
V-187	0.6384ij	24	12.93g-k	18
V-231	0.8263g-i	22	19.89c-e	6
V-250	0.8691gh	21	18.26c-f	8
V-258	0.5176j	25	11.36h-l	24
V-259	0.2319k	27	22.17bc	4
V-280	0.1247k	30	11.17h-l	22
V-282	1.237a-d	9	16.74d-g	9
V-321	0.9669e-h	19	12.82g-k	19
V-332	1.077d-f	15	13.41g-k	17
V-374	1.279a-d	7	9.00kl	29
V-378	0.9750e-h	18	12.59g-k	20
Ratan	1.155c-e	12	16.11d-h	12
V-29	1.126de	13	11.78h-l	21
V-382	0.9058f-h	20	11.22i-l	25
V-387	0.1410k	29	10.41j-l	27
V-422	1.099d-l	14	18.33c-f	7
V-423	1.025e-g	16	14.30f-j	16
V-433	1.158c-e	11	29.10a	1
V-453	0.1513k	28	27.23a	2
Manik	1.023e-g	17	14.82f-j	15
V-14	1.164b-e	10	16.67d-h	10
V-8	1.247a-d	8	16.61d-g	11
V-52	1.444a	1	25.45ab	3
V-56	1.351a-c	6	10.06j-l	28
V-94	1.364ab	5	7.787l	30
V-3	1.394a	3	11.72h-l	23
BARIB10	1.393a	4	20.67cd	5
V-167	1.430a	2	15.39e-i	13
Sx	0.04830		1.084	
CV (%)	8.58		12.10	

Within column, means followed by same letter (s) did nit differ significalntly at P < 0.01 by DMRT

percentage of tomato fruit borer infestation varied significantly among the tomato varieties/lines at different plant ages. On an average, the highest percentage of infestation was found in V-422, which was significantly different from other varieties/lines except V-321 and V-374. The lowest percentage of infestation was observed in the line V-29, which was observed in the line V-29 and was also significantly different from other varieties/lines. Percentage of tomato fruit borer infestation varied significantly with the age of the tomato plants.

Among the thirty tomato varieties/lines none was found resistant to tomato fruit borer in Rabi season. Similar findings were observed by Mishra *et al.* (1996) and Husain *et al.* (1998). On an average, V-29 was found to be moderately resistant.

The lines of V-282 and V-332 were susceptible. The varieties/lines of V-40, V-80, V-187, V-250, V-258, V- 259, V-280, V-321, V-374, V-378, Ratan, V-382, V-387, V-422, V-423, V-433, V-453, Manik, V-14, V-8, V-52, V-56, V-94, V-3, BARI-10, V-167 were found to be highly susceptible. In all varieties/lines, the infestation was lower at early fruiting stage and increased gradually at the ripening stage of fruit.

Identification of the plant Morphological characters influencing the infestation rate of tomato fruit borer

Plant height (cm) of selected Tomato varieties/lines at different ages: Plant height of different tomato varieties/lines at different ages has been presented in Table 2. The plant height ranged from 54.54 (BARI-10) to 87.30 (V-187) at 30 DAT, 65.30 (V-433) to 100.2 (V-187) at 50 DAT and 80.15 (V-40) to 113.5 (V-187) at 70 DAT. Plant height varied significantly with ages of the tomato plant. Average highest plant height (100.3) was recorded in the variety V-187, which was significantly different from other varieties/lines. The average lowest plant height was recorded in the line V-453, which was significantly identical with that of the variety/line V-40, V-321, V-94 and BARI-10. Plant height also varied significantly among the days after transplanting. The highest plant height (93.84) was observed at 70 DAT, which was significantly different from that at 30 and 50 DAT.

Stem diameter (cm) of selected tomato varieties/lines at different ages: The stem diameter varied significantly among the varieties/lines at different ages (Table 3). The stem diameter of different tomato varieties/lines ranged from 0.4910 (V-94) to 1.276 (V-187) at 30 DAT, 0.9513 (V-94) to 1.675 (V-187) at 50 DAT 1.398 (V-8) to 2.333 (V-187) at 70 DAT. On the basis of average stem diameter V-187 was the thickest variety, which was significantly different from other varieties/lines but identical to that of V-258. Lowest stem diameter was recorded in the line V-94, which was significantly identical from Ratan, V-8, V-52, V-56, BARI-10. Stem diameter varied significantly with ages of the tomato plants. Significantly highest stem diameter (1.67) was recorded at 70 DAT, which was significantly different from 30 and 50 DAT.

Number of branches per plant of selected tomato varieties/lines at different ages: Total number of branches per plant of different tomato varieties/lines has been represented in Table 4. The number of branches per plant varied significantly among the varieties at different ages. Average highest number of branches was recorded in the line V-433, which was significantly different from other varieties/lines. Average lowest umber of branches was recorded in the line V-167, which was significantly identical from that of V-259, V-280, V-282, V-321, V-321, V-374, V-14, V-8, V-52, V-56, V-94, V-3, BARI-10. Significantly highest number of branches was observed at 70 DAT (19.50) which was significantly different from 30 and 50 DAT.

Table 8: Number of fruits per plant of 30 selected Tomato varieties/lines at different ages, Rabi, 1999-2000

Varieties/lines with accession no.	No. of fruit per plant			
	70 DAT	90 DAT	Mean	Rank
V-40	70.67 a-f	107.7 b-f	89.25 b-d	10
V-50	90.33 ab	102.7 a-c	105.8 ab	7
V-187	18.00 l	42.67 h-k	29.35 h-j	28
V-231	38.33 g-l	66.33 f-k	52.53 e-i	19
V-250	55.67 d-j	88.33 c-h	71.89 c-e	14
V-258	33.67 g-l	69.67 f-k	52.50 e-i	20
V-259	34.33 g-l	64.00 f-k	49.09 e-j	21
V-280	17.67 l	33.67 jk	25.70 ij	29
V-282	24.33 kl	35.00 jk	29.95 h-j	27
V-321	27.33 j-l	45.33 g-k	36.35 g-j	26
V-332	54.33 d-k	91.33 c-g	72.97 c-e	12
V-374	19.33 l	39.00 I-k	38.03 g-j	25
V-378	29.67 I-l	56.33 g-k	43.24 f-j	24
Ratan	82.33 a-d	124.3a -d	103.6 ab	8
V-29	31.67 I-l	58.67 g-k	48.19 f-j	22
V-382	50.67 e-k	78.33 e-j	61.88 e-g	16
V-387	42.00 f-l	64.33 f-k	53.32 e-h	18
V-422	19.33 l	27.00 k	22.97 j	30
V-423	88.67 a-c	130.7 a-c	109.5 ab	5
V-433	50.67 e-k	58.33 g-k	54.53 e-h	17
V-453	72.33 a-f	140.0 ab	106.2 ab	6
Manik	100.3 l	154.3 a	127.3 a	1
V-14	77.33 a-e	153.7 a	115.5 ab	3
V-8	60.00 c-i	85.00 d-i	72.70 c-e	13
V-52	63.00 b-h	85.33 d-i	74.52 c-e	11
V-56	33.00 h-l	56.33 g-k	44.81 f-j	23
V-94	79.67 o	125.3 a-d	111.6 ab	4
V-3	64.33 b-g	122.3 a-e	93.53 bc	9
BARI B10	89.33 a-c	164.0 a	126.7 a	2
V-167	53.00 d-k	80.33 d-j	66.92 d-f	15
Sx	6.969	10.46	6.251	

CV (%) : 22.01
Within column, means followed by same letter (s) did not differ significantly at $p < 0.01$ by DMRT.
DAT = Days after transplanting.

Table 9: Co-relation matrix between Tomato plant characters and Tomato fruit borer infestation rate Rabi, 1999-2000

Characters	Stem diameter (cm)	Number of branches /plant	Number of leaves/ plant	Second leaf area (cm^2)	Total leaf chlorophyll (mg/g)	Leaf hairs/ $10mm^2$	Number of fruits/ plant	Tomato fruit borer infestation
Plant height (cm)	0.362*	0.263	0.258	-0.145	-0.363*	-0.004	-0.386*	0.243
Stem diameter (cm)		0.341	0.131	0.238	-0.736**	-0.180	-0.287	0.101
Number of branches / plant			0.715**	0.036	-0.303	0.286	0.142	0.256
Number of leaves / plant				-0.070	-0.117	0.407*	0.042	0.412*
Second leaf area (cm2)					-0.083	-0.340	0.131	-0.085
Total leaf chlorophyll (mg/g)						-0.004	0.181	-0.125
Leaf hairs/10 mm2							0.142	0.068
Number of fruits / plant								-0.312

* $P < 0.05$ ** $P < 0.01$

Table 10: Path co-efficient analysis of plant characters influencing tomato fruit borer infestation rate Rabi, 1999-2000

Characters	Plant height (cm)	Stem diameter (mm)	Number of branches /plant	Number of leaves/ plant	Total leaf chlorophyll (mg/g)	Leaf hairs/ $10mm^2$	Number of fruits/ plant	Tomato fruit borer infestation
Plant height (cm)	**0.0006**	-0.0716	0.0085	0.1178	0.0519	0.0005	0.1354	0.243
Stem diameter (mm)	0.0002	**-0.1979**	0.0123	0.0598	0.1053	0.0206	0.1006	0.101
Number of branches /plant	0.0001	-0.0674	**0.0361**	0.3264	-0.0433	-0.0327	-0.0498	0.256
Number of leaves /plant	0.0001	-0.0259	0.0258	**0.4566**	0.0167	-0.0466	-0.0147	0.412
Total leaf chlorophyll (mg/gm)	-0.0001	0.1457	-0.0109	-0.0534	**-0.1431**	0.0004	-0.0063	-0.125
Leaf hairs / 10mm2	-0.000002	0.0356	0.0103	0.1858	0.0005	**-0.1145**	-0.0498	0.068
Number of fruits/ plant	-0.0002	0.0567	0.0051	0.0192	-0.0259	-0.0163	**-0.3507**	-0.312

Residual effect is the square root of: 0.7029791
N.B. : Bold figure are the direct effects

Number of leaf per plant of selected tomato varieties/lines at different ages: Number of leaves per plant of different tomato varieties/lines at different plant ages ranged from 287.7 (V-374) to 778.4 (V-422) at 30 DAT, 276.0 (V-374) to 890.7 (V-422) at 30 DAT and 308.01 (V-374) to 1116.0 (V-433) at 70 DAT (Table 5). The average highest number

(980.08) of leaves was recorded in the line V-433, which was significantly higher than the ages of tomato plant. The average highest number of leaves was recorded at 70 DAT (561.4) which was significantly different from 30 DAT and 50 DAT.

Second leaf area (cm^2) of selected tomato varieties/lines at different ages: Area of second leaf varied significantly among the varieties at different ages (Table 6). Second leaf area ranged from 9.90 (V-3) to 28.34 (Manik) at 50 DAT, 12.47 (V-3) to 28.65 (Manik) at 50 DAT and 13.03 (V-250) to 23.70 (V-29) at 70 DAT. Area of second leaf also varied significantly with the age of the tomato plant. Average largest second leaf area (26.71) was observed in the variety Manik, which was significantly different from other varieties/lines but identical to that of line V-374. The average shortest second leaf area 13.29 was recorded in the line V-3, which was significantly different from other varieties/lines but identical with V-250, V-433 and V-52. Significantly highest mean of second leaf area (20.18) was recorded at 30 DAT, which was significantly different from 50 and 70 DAT.

Total chlorophyll (mg/g) content of selected tomato varieties/lines at 50 DAT: Total chlorophyll content of different tomato varieties/lines ranged from 0.1247 (V-280) to 1.444 (V-52) at 50 DAT (Table 7). The average highest amount of total chlorophyll content was estimated in the variety V-52, which was significantly different from other varieties/lines but identical with V-8, V-374, V-56, V-94, V-3, BARI-10, V-167. In respect of total chlorophyll, the lowest amount was from other varieties/lines but identical with V-40, V-259, V-382 and V-453.

Total leaf hair per unit area (10 mm^2) of selected tomato varieties/lines: Total number of leaf hair per unit area (10 mm^2) of different tomato varieties/lines ranged from 7.787 (V-94) to 29.10 (V-433) (Table 7). The highest number of leaf hair per unit area was observed in the line V-433, which was significantly similar with V-453 and V-52 but different from other varieties/lines. The lowest number of leaf hair per unit area was observed in V-94, which was significantly identical with V-40, V-258, V-280, V-374, V-29, V-382, V-387, V-56 and V-3.

Number of fruits per plant of selected tomato varieties/lines at different ages: Number of fruit per plant of different tomato varieties/lines at different plant ages ranged from 17.67 (V-280) to100.3 (Manik) at 70 DAT and 27.00 (V-422) to 164.0 (BARI-10) at 90 (Table 8). The average highest number of fruit (127.3) was recorded in the variety Manik, which was also significantly different from that of other varieties/lines but identical with V-80, Ratan, V-423, V-453, V-14, V-94 and BARI-10. The average lowest number of fruit (22.97) was observed in the line V-422, which was significantly different from other varieties/lines but identical with V-187, V-259, V-280, V-282, V-321, V-374, V-378, V-29 and V-56. Fruit number per plant varied significantly with the ages of tomato plant.

The highest plant height, stem diameter, number of branches per plant, number of leaves per plant, second leaf area, number leaf hair, total leaf chlorophyll, number of fruits per plant, percentage of tomato fruit borer infestation were observed in the varieties/lines V-187, V-187, V-433, V-433, Manik, V-433, V-52, Manik and V-422 resrectively although the lowest attack was found in the variety Manik by Husain *et al.* (1998) and Ratan was found as a moderately susceptable variety. On the other hand, the lowest plant height, stem diameter, number of branches per plant, number of leaves per plant, second leaf area, number leaf hair, total leaf chlorophyll, number of fruits per plant, percentage of tomato fruit borer infestation were observed in the varieties V-433, V-94, V-167, V-374, V-3, V-94, V-422, V-280 and V-29, respectively.

Quantitative relationships: Experimental information on correlation co-efficient is particularly useful for measuring the relationship among the variables. Tomato fruit borer infestation was found the be positively correlated with the plant height (0.243), stem diameter (0.101), number of branches per plant (0.256), number of leaf per plant (0.412) and leaf hair per unit area (0.068) but negatively correlated with second leaf area (-0.085) and leaf chlorophyll (-0.125) (Table 9). The results from correlation co-efficient indicate that plant height, stem diameter, number of branches per plant, number leaf leaves per plant can influence (induce) higher fruit borer infestation. On the other hand, second leaf area, leaf chlorophyll decrease the infestation of tomato fruit borer. Tomato fruit borer infestation had significant correlation with number of leaves per plant at 5% level.

The estimation correlation co-efficient among tomato fruit borer infestation and tested plant character were partitioned into direct and indirect effects and have been presented by path co-efficient analysis in Table 10. The direct effect of plant height on tomato fruit borer infestation was positive (0.0006). Its indirect effects via number of branches per plant, number of leaves per plant, leaf chlorophyll, leaf hair per unit area, number of fruit per plant were positive, but via stem diameter was negative, which made the correlation co-efficient between plant height and tomato fruit borer infestation to be negative. Stem diameters had a negative direct effect (-0.1979) and its indirect effect via plant height, number o branches per plant, number of leaves per plant, leaf chlorophyll, leaf hair per unit area, number of fruit per plant were positive, which made the total correlation co-efficient between stem diameter and tomato fruit borer infestation positive. The direct effect of number of branches per plant on tomato

fruit borer infestation were positive (0.0361). Its indirect effects via plant height, number of leaves per plant were positive but via stem diameter, leaf chlorophyll, leaf hair per unit area number of fruit per plant were negative, which made the total correlation co-efficient between number of branches per plant and tomato fruit borer infestation negative. Number of leaf had a positive direct effect (0.4566). Its indirect effect via plant height, number of branches per plant, leaf chlorophyll had a positive effect but via stem diameter, leaf hair per unit area and number of fruit per plant had positive effect which made the total correlation co-efficient between number of leaves per plant and tomato fruit borer infestation was positive. The direct effect of leaf chlorophyll on tomato fruit borer infestation were negative (-0.1431). Its indirect effects via plant height, number of branches per plant, number of leaves per plant and number of fruit per plant were negative but stem diameter and leaf hair per unit area were positive, which made the total correlation co-efficient leaf chlorophyll and tomato fruit borer infestation positive. Leaf hair had a negative direct effect (-0.1145). Its indirect effects via plant height and number of fruit per plant were negative but stem diameter, number of brunches per plant, number of leaves per plant and leaf chlorophyll were positive, which made the total correlation co-efficient between leaf hair per unit area and tomato fruit borer infestation positive. The direct effect of fruit no per plant on tomato fruit borer infestation were negative (-0.3507). Its indirect effects via plant height, leaf chlorophyll and leaf hair per unit area were negative but stem diameter, number of branches per plant, number of leaves per plant were positive, which made the total correlation co-efficient between number of fruit per plant and tomato fruit borer infestation positive.

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