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Host preference of the fruit borer, *Helicoverpa armigera* (Hubner) on tomato varieties in mid hills of Himachal Pradesh

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Abstract
Relative performance of 8 different tomato varieties *viz.*, Palam Pink, Solan Vajar, Solan Lalima, Naveen 2000+, Yash Tomato, Rakshita, Red Gold and Heem Sohna were evaluated against the preference of tomato fruit borer during 2014-2015 in the entomology farm of Dr. YS Parmar University of Horticulture and Forestry, Nauni (HP). The lowest egg count (0.65 egg/plant) was recorded on 'Naveen 2000+' followed by 'Solan Lalima' (0.77 egg/plant) while, 'Red Gold' was found to have significantly the highest egg count (2.41 eggs/plant). The varieties 'Solan Lalima', 'Solan Vajar', 'Naveen 2000+' and 'Rakshita' were categorized as less susceptible with 20.1-30.0% fruit damage, whereas, 'Heem Sohna', 'Yash' and 'Palam Pink' were categorized as susceptible variety with 30.1-40.0% fruit damage and 'Red Gold' was found to be highly susceptible variety with >40% fruit damage. Therefore, none of the screened varieties was found to be resistant to the *H. armigera* attack but those with least preference level can be utilized in developing the tolerant varieties for mid hill condition.

Keywords: *Helicoverpa, armigera*, tomato, varieties, fruit damage, susceptible, resistant

1. Introduction
In Himachal Pradesh tomato crop is grown in an area of 29.43 thousand hectares with production of 627.28 thousand metric tons. The largest part of tomato is produced in the mid hills and especially the Solan district with more than 42% of total area and more than 44% of total production of tomato in Himachal Pradesh [1]. Among vegetables, tomato due to is tenderness and softness is more prone to insect pests like, tomato fruit borer, the greenhouse whitefly, serpentine leaf miner, root knot nematode etc [5]. Of these, the tomato fruit borer, *Helicoverpa armigera* (Lepidoptera: Noctuidae) causes major damage [12]. It is a highly polyphagous pest that attacks over 100 plant species including widely grown and economically important crops such as cotton, maize, tobacco, pigeon pea, chickpea, tomato and pea [3]. Larvae affect almost all the aerial parts of the tomato plant causing major economic loss by completely deteriorating the fruits [13, 23]. Serious infestation causes necrosis to the leaf chlorophillus tissue, suppresses tomato flowers to bloom and makes the mature fruits unfit for consumption [7]. The foremost approach followed by the farmers to combat this pest is by application of pesticide over the foliage and fruit, so as to kill the early instars before they enter the fruit. But the overdependence and indiscriminate use of chemical pesticides has resulted in several problems like development of resistance, outbreak of secondary pests, environmental pollution, health hazards and reduction of biodiversity of natural enemies increasing the cost of production [14]. So the most decent step to avoid the attack of this pest is to choose that variety which can resist its attack. In view of this the present study was planned to evaluate the response of available tomato varieties in the field condition through varietal screening for identifying the most resistant variety.

2. Materials and methods
The seed material of eight tomato (*Solanum lycopersicum* L.) varieties *viz.*, Palam Pink, Solan Vajar, Solan Lalima, Naveen 2000+, Yash Tomato, Rakshita, Red Gold and Heem Sohna for the present studies was procured from different certified sources. The field experiments were conducted in randomized blocks design with three replications during the years 2014 and 2015 in the experimental farm of the Department of Entomology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP).

Thirty-day old seedlings of each variety were transplanted at a recommended spacing of 90×30 cm for hybrids and 60×45 cm for open pollinated varieties. The cultural practices except insecticidal application measures were followed as per the crop production guidelines for horticultural crop in mid hill areas of Himachal Pradesh.

Five plants per replication were tagged at random and monitored weekly starting one week after transplanting. At each observation, the number of *H. armigera* eggs and larvae per plant from randomly-selected plants in each plot were recorded starting from the first appearance of eggs till the infestation of fruit borer was over and the mean was calculated. After each picking, total numbers of damaged and undamaged tomato fruits of individual variety from three replications were counted and their fresh weight were recorded to calculate percent of fruit infestation and percent fruit weight loss. The percentage data obtained from the field experiment were subjected to arcsine (angular) transformation [6].

The percent fruit damage was worked out using the following formula:

$$\text{Percent fruit infestation} = \frac{\text{Number of damaged fruits}}{\text{Total number of tomato fruits}} \times 100$$

The percent fruit weight loss was worked out by the following formula:

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

The damage by fruit borer was judged on the basis of percent fruit infestation for estimating resistance and susceptibility of different tomato varieties to tomato fruit borer as per the method given by Kashyap and Verma [11]. Accordingly, the fruits with no damage were regarded as highly resistant, 0-10.0 percent fruits damaged as resistant, 10.1- 20.0 percent as moderately resistant, 20.1 - 30.0 percent as moderately susceptible, 30.1- 40.0 percent fruits as susceptible while 40.1 percent and above fruits damaged as highly susceptible.

2.1 Statistical analysis: Mean values of data from various experiments were subjected to statistical analysis after suitable transformation and correlation analysis between different factors were obtained using SPSS16.

3. Results and Discussion

The data presented in Table 1 revealed that the high infestation occurred as soon as the crop came into flowering and decreased as the season processed. During this period, the egg count of the pest ranged from 0.65 to 2.41 eggs/plant. The lowest egg count (0.65 egg/plant) was recorded on Naveen 2000+ followed by Solan Lalima (0.77 egg/plant), Solan Vajar (1.08 eggs/plant), Yash (1.45 eggs/plant), Rakshita (1.57 eggs/plant) and Heem Sohna (1.68 eggs/plant). Red Gold was found to have significantly the highest egg count (2.41 eggs/plant). Further the data presented in Table 1 showed that larval count/plant ranged from 0.17 to 1.45 larvae/plant. The highest larval count (1.45 larvae/plant) was recorded on 'Heem Sohna' followed by 'Red Gold' (1.44 larvae/plant), Palam Pink (1.26 larvae/plant), Yash (1.01 larvae/plant), Rakshita (0.88 larvae/plant), Naveen 2000+ (0.61 larvae/plant), Solan Vajar (0.57 larvae/plant) and the lowest larval count/plant was recorded on variety 'Solan Lalima' (0.17 larvae/plant). Muahmmad *et al*. [16] recorded 1.50 larvae/plant as the highest larval population on hybrids Roma VFN and NARC-1 in Pakistan. Usman and Khan [24] recorded minimum number of larvae/plant on genotypes 'Chinar' (1.52 larvae) and 'R165' had significantly the highest larval population/plant (2.10 larvae). Variations in fruit damage in the present studies and the studies carried out by above mentioned workers might be due to the differences in tomato varieties and their genetic potential that resisted the attack of the borer on some varieties as observed in the present studies.

Table 1: Egg and Larval count/plant of tomato fruit borer on different tomato varieties.

Varieties	Mean egg and larval count in the indicated months										Mean no. of eggs/ plant	Mean no. of larvae/plant
	May						June					
	12-05-15		19-05-15		26-05-15		2-06-15		9-06-15			
	Eggs	larvae	Eggs	larvae	Eggs	larvae	Eggs	larvae	Eggs	larvae		
Palam Pink	0.53	1.93	0.53	0.60	0.53	0.86	0.86	1.40	2.33	1.53	0.96	1.26
SolanVajar	0.93	1.33	0.46	0.06	0.93	0.13	1.86	0.06	1.20	1.26	1.08	0.57
SolanLalima	1.80	0.13	0.13	0.20	0.00	0.13	0.40	0.20	1.53	0.20	0.77	0.17
Naveen 2000+	0.86	0.86	1.06	1.60	0.46	0.26	0.33	0.20	0.53	0.13	0.65	0.61
Yash	1.73	0.66	3.40	0.26	0.86	1.60	0.60	1.40	0.66	1.13	1.45	1.01
Rakshita	2.00	1.66	1.33	0.53	0.80	0.46	1.46	0.80	2.26	0.93	1.57	0.88
Red Gold	1.80	1.20	3.13	1.33	3.66	1.40	1.53	1.26	1.93	2.00	2.41	1.44
HeemSohna	1.00	1.06	1.73	1.00	3.26	2.26	1.66	0.86	0.73	2.06	1.68	1.45
Mean	1.33	1.10	1.47	0.70	1.31	0.89	1.09	0.77	1.40	1.15		

For Egg count CD $_{(p=0.05)}$: Varieties: 0.67
Days: NS
Interaction: 1.51
For Larval count CD $_{(p=0.05)}$: Varieties: 0.39
Days: 0.31
Interaction: 0.88

Percent fruit infestation by the tomato fruit borer on eight tomato varieties was assessed on number basis while percent fruit weight loss was evaluated on the basis of weight of fruits. The percent tomato fruit borer infestation diversed significantly among the different tomato varieties (Table 2). It ranged from 15.57% (Solan Lalima) to 45.30% (Red Gold). Singh and Narang [18] found 51.20% fruit damage by *H. armigera* in unsprayed tomato plants in Punjab. Khanam *et al*. [12] reported that fruit infestation by tomato fruit moth varied from 17.33 to 43.57%, while Sahu *et al*. [17] described 16.29 to 34.77% fruit damage in the different tomato genotypes and also from Syria, Daboul *et al*. [4] accounted that infestation

due to fruit moth among different varieties ranged from 47.88% to 21.7%. Parallel results were obtained by Mohommad *et al* [15] who recorded the percent tomato fruit infestation ranging from 37.69 (Roma VFN) to 12.30% (Sahil). The peak infestation was recorded in the last two weeks of May month which is in concurrence with those of Singh and Singh [19] and Kakar *et al*. [10] who recorded peak infestation of fruit borer during March-May in Punjab whilst, Srivastava *et al*. [21] reported March as the peak period of infestation in tomato in Uttar Pradesh which might be due to difference in seasonal changes prevailing in mid-hills and other areas.

Table 2: Percent fruit infestation and fruit weight loss by tomato fruit borer larvae in different tomato varieties.

Sr. No.	Varieties	Fruit borer infestation (%)	Fruit weight loss (%)
1	Palam Pink	34.16 (35.45)	35.48 (36.38)
2	Solan Vajar	27.94 (30.74)	21.17 (26.85)
3	Solan Lalima	15.57 (22.76)	18.94 (24.90)
4	Naveen 2000+	16.11 (23.03)	12.46 (19.29)
5	Yash	34.13 (34.89)	30.80 (32.25)
6	Rakshita	21.01 (26.280	24.42 (28.54)
7	Red Gold	45.30 (42.20)	41.18 (39.65)
8	Heem Sohna	39.34 (38.43)	30.10 (32.60)

CD $_{(p= 0.05)}$: Percent fruit infestation: 9.27
Percent fruit weight loss: 8.78
*Figures in parentheses are Angular transformed values.

The fruit weight loss ranged from 41.18 to 12.46% (Table 2). 'Red Gold' had significantly the highest fruit weight loss (41.18%) while the lowest fruit weight loss was examined in 'Naveen 2000+' (12.46%). These results are in conformity with those of Sahu *et al*. [16] who reported 13.61 to 28.23% fruit weight loss in different tomato varieties. On the basis of percent fruit infestation none of the tested variety was found resistant. 'Red Gold' was found to be highly susceptible having infestation more than 40% and 'Palam Pink', 'Yash' and 'Heem Sohna' were found susceptible with 30.10 to 40% fruit damage whilst, 'Solan Lalima', 'Solan Vajar', 'Naveen 2000+' and 'Rakshita' were categorized as moderately or comparatively less susceptible with infestation rate falling between 20.1 to 30.0% (Table 3). The results of present study are in agreement with those of Tewari and Krishnamoorthy [22] who reported avoidable yield losses of 22.39-37.79% in tomato in Karnataka. Kashyap and Verma [11] registered 42-55% damage of tomato fruits in susceptible varieties while it was only 1.7 to 2.9% in resistant varieties. Among the 44 tomato varieties screened by Amutha and Manisegaran [3], one accession namely LE 228 was found to be resistant, which had the lowest fruit damage (2.4%) as against 33.6% in susceptible one (LE 4). Singh *et al*. [20] screened 13 tomato varieties in central agriculture university, Imphal-Manipur during 2010-2011 and categorized tomato variety Manikhumnu with 22.83% damage as moderately susceptible while NS -538 with 8.47% infestation as resistant. The results regarding maximum attack of fruit borer on flower buds and fruits than on leaves holds the studies carried out by Jayaraj [8] who evidenced less feeding preference of *H. armigera* to tomato foliage.

Table 3: Infestation index of different tomato varieties to tomato fruit borer.

Sr. No.	Varieties	Infestation index (% damage)	Rating
1	None	0-10.0	Resistant
2	None	10.1- 20.0	Moderately resistant
3	Solan Lalima, Naveen 2000+, Solan Vajar and Rakshita	20.1- 30.0	Moderately susceptible
4	Palam Pink,, Yash and Heem Sohna	30.1- 40.0	Susceptible
5	Red Gold	>40	Highly susceptible

The fruit infestation of different varieties when subjected to correlation analysis with fruit weight loss, larval and egg count data of *H. armigera*, discovered that tomato fruit borer infestation was positively correlated with fruit weight loss (r=0.789), larval count/plant (r= 0.886) and egg count/plant (r= 0.782) (Table 4). Thus it is revealed that more number of eggs and larvae resulted in high percent fruit borer infestation which caused more weight loss in tomato fruits. These results concord with those reported by Kashyap and Verma [10, 11]; Sahu *et al*. [17] and Zahid *et al*. [25] who also obtained fruit infestation to be positively correlated with *H. armigera* egg and larval count.

Table 4: Coefficient of correlation between tomato fruit borer infestation with fruit weight loss, larval and egg count of tomato fruit borer.

Tomato Fruit borer infestation (%)	Percent fruit weight loss	Larval population/ plant	Egg population/plant
	0.789*	0.886*	0.782*

* $p \leq 0.05$

4. Conclusion

Based on the percent fruit infestation and fruit weight loss it can be alleged that none of the tested varieties were found to be completely free from the attack of *H. armigera*. However, varieties that performed better in the field can be further explored for breeding the tolerant varieties. In this context, investigating their various plant characters from a view point of host plant resistance to *H. armigera*, would be effective contribution towards development of a resistant variety that can be incorporated into an IPM strategy for the mid hills area of Himachal.

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