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Appraisal of Different Tomato Genotypes against Tomato Fruit Worm (*Helicoverpa armigera* Hub.) Infestation

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Abstract.- Screening of tomato genotypes were conducted to devise an integrated pest management strategy against tomato fruit worm, *Helicoverpa armigera.* Fourteen commercially available tomato genotype *viz.* Mission 102, Sultan, 027, Chinar, GS 5575, Sourabh, T 7008, R 165, RK 101, Riogrande, Roma, Bambino, Super Classic and Roma VF were tested for resistance against *H. armigera* infestation under field conditions at the New Developmental Farm (NDF) of the University of Agriculture, Peshawar during 2009 and 2010. The genotypes Chinar, Sourabh and Sultan had minimum fruit weight loss (18.98%, 21. 01% and 21.89%, respectively) as well as minimum number of infested fruits (21.40%, 23.87% and 25.43%, respectively) by the *H. armigera*. These genotypes also had minimum *H. armigera* larval population, *i.e.* 1.52, 1.66 and 1.65 larvae/plant, respectively. The genotypes R 165 and GS5575 had maximum loss in fruit weight (37.40% and 36.36%) as well as maximum number of infested fruit (39.40% and 40.47%) with larval population of 2.06 and 2.10 larvae/plant. Chinar yielded significantly higher (20752 kg/ha) than other genotypes while Bambino gave the lowest yield (9546 kg/ha). There was positive correlation between fruit damage on the weight basis and number basis. The correlation between *H. armigera* larval population and yield was found to be negative. Negative correlation was also found between yield and fruit damage both on weight basis and number basis. Over all, Chinar gave better results as it was pest resistant as well as high yielding than other tested genotype.

Key words: *H. armigera* infestation, tomato genotypes, pest resistance, tomato yield.

INTRODUCTION

Several factors (poor quality seeds, disease and insect infestation etc.) stand responsible for low tomato production in Pakistan. Considerable reduction in tomato yield due to insect pests has been reported (Hoffmann *et al.*, 2007). Among the insect pests, Tomato fruit worm, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is major threat to tomato crop causing significant yield loss (Talekar *et al*., 2006). Worldwide annual crop loss due to *H. armigera* alone is approximately 5 billion US dollar (Sharma, 2001). In Pakistan, 32-35% fruit infestation by *H. armigera* was observed in tomato (Latif *et al*., 1997), where as 53% fruit loss was reported in Peshawar, Khyber Pakhtunkhwa Province (Inayatullah, 2007).

The lack of awareness regarding genotypes resistant to insect pests has led to the haphazard and injudicious use of pesticide. While, controlling Tomato fruit worm known as a polyphagous pest consumed around 80% of total pesticide in Pakistan (Shaheen, 2008). Due to environmental and health problems caused by pesticides (Ignacimuthu, 2007), alternative control measures that are ecologically safe and economically acceptable, should be focused.

Host plant resistance being compatible with other available pest management strategies is considered as an important component in IPM. Reduction in pest infestation to acceptable level has been reported due to the use of resistant variety alone or in combination with other control measures (Leuschner *et al.* 1985). However, there has been lack of information regarding resistance of commercially available tomato genotypes in Pakistan, particularly in Khyber Pakthunkhwa Province. The present study was therefore, aimed to evaluate the response of available tomato genotypes, including some new tomato hybrids against *H. armigera* in the field conditions for identifying most resistant genotype.

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MATERIALS AND METHODS

The experiment was carried out at the New Developmental Farm (NDF) of The University of Agriculture Peshawar during 2009 and 2010. Fourteen genotypes including 9 F1 hybrids (RK 101, Mission 102, Sultan, 027, Chinar, GS 5575, Sourabh, T 7008 and R 165) and 5 varieties (Riogrande, Roma, Bambino, Super Classic and Roma VF) were screened in this study. Healthy (disease free) seedlings (about 3-4″ tall) of all the genotypes were transplanted on ridges in separate plots, each measured 5.5 x 2.5 m. Plants were spaced 45 cm apart with 75 cm between the rows. The experiment was laid out in Randomized Complete Block Design with three replications. Normal agronomic practices (*e.g.,* ploughing, manuring and irrigation) were conducted uniformly and no preventative measures were applied. Data on the following parameters were recorded.

a. *Mean number of larvae/plant:* Number of larvae/plant was recorded by randomly selecting 5 plants per genotype in each replication. Data were recorded weekly started from the first appearance of larvae till the final harvest of the crops and their mean was calculated.

b. Percent fruit damage: After each picking, fresh weight and number of tomato fruits were recorded for each plot. The damaged fruits (presence of holes by fruitworm) were separated from the sound tomato fruits, weight and counted. The percent damage was determined by the following formula:

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

$$\text{Percent damaged fruits} = \frac{\text{number of damaged fruits}}{\text{total number of tomato fruits}} \times 100$$

c. *Total yield (kg/ha):* The weight of sound fruits of each picking was recorded individually for each plot and the yield was calculated by adding the yield from all pickings for each plot. The yield was then converted into per hectare basis with the following formula.

$$\text{yield (kg/ha)} = \frac{\text{yield / plot}}{\text{plot size}} \times 10000$$

Statistical analysis

The data recorded were subject to statistical analysis using Gen Stat and the means were compared by LSD Test at P= 0.05.

Table I.- Mean *H. armigera* larval population/plant on 14 tomato genotypes during 2009-2010.

Genotype	Mean larval population/plant		
	2009	**2010**	**Overall mean (2009-2010)**
GS 5575	1.91 a	2.20 ab	2.06ab
R 165	1.80 ab	2.40 a	2.10 a
027	1.67 a-c	2.08 b-d	1.87 bc
Sourabh	1.34 de	1.99 cd	1.66 de
Sultan	1.40 c-e	1.95 cd	1.67 de
T 7008	1.61 b-d	2.20 ab	1.90 bc
Chinar	1.15 e	1.89 d	1.52 e
Mission 102	1.23 e	1.97 cd	1.60 e
RK 101	1.16 e	2.07 b-d	1.61 e
Super Classic	1.72 ab	2.20 ab	1.96 a-c
Bambino	1.90 a	2.08 b-d	1.99 a-c
Riogrande	1.70 ab	2.14 bc	1.92 bc
Roma VF	1.55 b-d	2.09 b-d	1.82 cd
Roma	1.74 ab	2.05 b-d	1.89 bc
LSD $_{(0.05)}$	**0.2784**	**0.2097**	**0.1709**
Years			
2009			1.56 b
2010			2.09 a
Significance level			**
Interaction		Significance level	
Year x Genotype			**

Means in columns following similar letters are not significantly different at $\alpha = 0.05$ (LSD Test).
** Significant at $P \leq 0.01$

RESULTS AND DISCUSSION

Screening of tomato genotypes on the basis of H. armigera larval population/plant

The *H. armigera* larval population/plant recorded on different tomato genotypes during 2009 and 2010 are given in Table I. In 2009, significantly highest larval population/plant (1.90 and 1.91 larvae) was recorded on genotype Bambino and GS 5575, respectively and lowest larval population/ plant was recorded on genotypes Chinar (1.15 larvae), RK 101 (1.16 larvae) and Mission 102 (1.23 larvae). In 2010, the genotype R 165 had significantly highest larval population/plant (2.40

larvae) while lowest larval population/plant (1.89 larvae) was recorded on genotype Chinar. The average of two years data revealed that significantly minimum number of larvae/plant was recorded on genotypes Chinar (1.52 larvae), Mission 102 (1.60 larvae) and RK 101 (1.61 larvae). The genotype R 165 had significantly higher larval population/plant (2.10 larvae). Response of different genotypes towards larval population has been the focus of many researchers. Similar kind of study has also been reported by Ahmed (1994), Khanam *et al*. (2003), Sajjad *et al*. (2011) and Ashfaq *et al.* (2012) who assessed genetic susceptibility of tomato genotypes different from those in the present study.

The variation in the larval population may be due to differences in various physical plant factors. The fruits skin particularly the pericarp toughness has been reported responsible for resistance to fruit borer (Rath and Nath, 1995). Ashfaq *et al.* (2012) found negative correlation between thickness of leaf lamina with fruit infestation and larval population. Clissold *et al.* (2006) reported that tough leaves prohibit feeding of early larval instars and reduce their development. Trichome density could be another physical plant factor attributed to resistance. The leaves pubescence restricts *H. armigera* larval movement (Ramalho *et al.*, 1984; Gerard, 1978). Glandular trichomes on tomato leaves release certain sticky and toxic chemicals that cause mortality of the larvae (Srinivasan and Uthamasamy, 2005). Gurr and McGrath (2002) reported negative correlation (r = -0.96*) between trichomes density and larval population. Comparatively, oviposition, larval and moth population was higher in 2010 than in 2009 because of variation in abiotic factors (*e.g.,* temperature, humidity, rain fall and wind speed). The present findings are comparable to that of Srivastava *et al.* (1992) and Sharma *et al.* (2012), who found positive relationship between the larval and moth population.

Screening of tomato genotypes on the basis of fruit weight loss

Table II revealed that during 2009 the genotype Chinar had significantly lowest fruit weight loss (17.74%) and R 165, GS 5575 and Riogrande had significantly highest fruit weight loss *viz.,* 34.25, 33.97 and 33.50%, respectively (all being non significant from each other). During 2010, again genotype Chinar along with Sourabh and Sultan had minimum fruit weight loss (20.22, 21.55 and 22.60%) while R 165 showed significantly maximum fruit weight loss (40.55%). The mean results for 2009-2010 showed significantly lowest fruit weight loss in Chinar (18.98%) and Sourabh (21.01%). *H. armigera* damage was highest on genotypes GS 5575 (36.16%) and R 165 (37.40%). On weight basis, *H. armigera* fruit damage was comparatively low in 2009 than in 2010.

Table II.- Mean fruit weight loss by *H. armigera* larvae feeding on 14 tomato genotypes during 2009-2010.

Genotype	Mean fruit weight loss (%)		
	2009	**2010**	**Overall mean (2009-2010)**
GS 5575	33.97 a	38.35 ab	36.16 ab
R 165	34.25 a	40.55 a	37.40 a
027	31.22 ab	34.19 b-d	32.70 cd
Sourabh	20.48 ef	21.55 f	21.01 i
Sultan	21.17 ef	22.60 f	21.88 hi
T 7008	32.85 ab	35.03 bc	33.94 bc
Chinar	17.74 f	20.22 f	18.98 i
Mission 102	22.54 e	29.35 de	25.95 fg
RK 101	24.22 de	25.30 ef	24.76 gh
Super Classic	30.61 a-c	37.19 ab	34.26 bc
Bambino	29.28 bc	30.72 c-e	30.00 de
Riogrande	33.50 a	33.09 b-d	33.29 b-d
Roma VF	27.36 cd	31.08 cd	29.22 ef
Roma	31.95 ab	33.69 b-d	32.82 b-d
LSD $_{(0.05)}$	**3.8095**	**5.4943**	**3.4279**
Years			
2009			27.93 b
2010			30.93 a
Significance level			**
Interaction		Significance level	
Year x Genotype			ns

Means in columns following similar letters are not significantly different at α = 0.05 (LSD Test).
** Significant at P ≤ 0.01
ns Non significant

Screening of tomato genotypes on the basis of number of damaged fruits

In 2009 significantly minimum number of fruits (20.32%) of genotype Chinar, was damaged while maximum number of fruits damaged was of

GS 5575 (37.95%). In 2010 also, lowest number of damaged fruits (22.47%) were recorded for genotype Chinar, while the highest number of damaged fruits was for R 165 (45.29%). Mean number of fruits damaged for the two years (2009 and 2010) was significantly lower in Chinar (21.40%) and Sourabh (23.87%), whereas significantly highest in R 165 (40.74%) and GS 5575 (39.43%) (Table III).

Table III.- Mean fruit number damage by *H. armigera* of 14 tomato genotypes during 2009-2010.

Genotype	Mean number of damaged fruits (%)		
	2009	**2010**	**Overall mean (2009-2010)**
GS 5575	37.95 a	40.92 a-c	39.43 ab
R 165	36.20 ab	45.29 a	40.74 a
027	36.70 ab	36.24 cd	36.47 b-d
Sourabh	21.92 de	25.82 fg	23.87 gh
Sultan	22.90 de	27.95 f	25.42 fg
T 7008	34.59 ab	40.63 a-c	37.61 bc
Chinar	20.32 e	22.47 g	21.40 h
Mission 102	27.53 c	37.33 b-d	32.43 e
RK 101	25.00 cd	30.45 ef	27.72 f
Super Classic	33.63 b	40.22 bc	36.93 bc
Bambino	33.86 ab	36.74 b-d	35.30 c-e
Riogrande	35.46 ab	40.84 a-c	38.15 a-c
Roma VF	33.31 b	34.33 de	33.82 de
Roma	34.02 ab	41.42 ab	37.72 a-c
LSD $_{(0.05)}$	**4.2278**	**4.7914**	**3.0600**
Years			
2009			30.96 b
2010			35.76 a
Significance level			**
Interaction		Significance level	
Year x Genotype			ns

Means in columns following similar letters are not significantly different at α = 0.05 (LSD Test).
** Significant at $P \leq 0.01$
ns Non significant

The present results revealed that none of the tested genotypes were completely resistant to the attack of *H. armigera*. Some earlier researchers had screened tomato genotypes for resistance against *H. armigera* and found none of the genotypes were completely free from *H. armigera* attack (Khanam *et al.,* 2003; Selvanarayanan and Narayanasamy, 2006a,b; Sajjad *et al.,* 2011). Genotypes with minimum fruit damage had lowest larval population because of dense trichomes that reduced larval feeding and restricted movement of the neonate larvae (Satpute *et al*., 1994). Negative correlation of dense trichomes has been reported with larval feeding (Selvanarayanan and Narayanasamy, 2006b). The presence of phenols and acidity of tomato fruits due to their antibiotic effects also contributes to the host plant resistance against *H. armigera* (Kashyap and Verma, 1987; Banerjee and Kallo, 1989; Selvanarayanan and Narayanasamy, 2006 b).

Table IV.- Mean marketable yield (kg/ha) of 14 tomato genotypes during 2009-2010.

Genotype	Mean marketable yield (kg/ha)		
	2009	**2010**	**Overall mean (2009-2010)**
GS 5575	10684 f	10418 f	10551 e
R 165	10061 f	10632 ef	10346 e
027	13617 d	12458 e	13038 d
Sourabh	18150 bc	16994 bc	17572 bc
Sultan	19412 ab	18438 ab	18925 b
T 7008	13287 de	12438 e	12862 d
Chinar	21677 a	19826 a	20752 a
Mission 102	18430 bc	15055 d	16743 c
RK 101	16756 c	16212 cd	16484 c
Super Classic	11161 ef	10571 f	10866 e
Bambino	10110 f	8983 f	9546 e
Riogrande	11519 d-f	9638 f	10578 e
Roma VF	10757 f	9752 f	10254 e
Roma	13787 d	12426 e	13106 d
LSD $_{(0.05)}$	**2298.5**	**1829.0**	**1365.6**
Years			
2009			16.93 a
2010			14.89 b
Significance level			**
Interaction		Significance level	
Year x Genotype			**

Means in columns following similar letters are not significantly different at α = 0.05 (LSD Test).
** Significant at $P \leq 0.01$

The genotype GS 5575 and R 165 proved to be relatively more susceptible for having significantly maximum fruit damage. Lack of trichomes and the presence of high nitrogen content (Minkenberg and Ottenheim, 1990) and high non reducing sugar content, low phenols and acidity (Selvanarayanan and Narayanasamy, 2006b) and low ascorbic acid (Sharma *et al*., 2008) are considered responsible for susceptibility of tomato genotypes. Some earlier researchers have reported varied degree of fruit damage in both resistant and susceptible tomato genotypes (Ferry and Guthbert, 1973; Lal, 1985; Sajjad *et al*., 2011). Variation in fruit damage may be due to differences in tomato genotypes and their genetic potential that resists *H. armigera* attack. Fruit infestation by *H. armigera* was comparatively high in 2010 than in 2009 due to high pest infestation in 2010. Our results are in conformity with those of Srivastava *et al.* (1992) and Singh and Sachan (1993) who found positive correlation between *H. armigera* egg and larval population and pheromone trap catches.

Table V.- Correlation among *H. armigera* larval population/plant, damaged fruit and yield parameters during 2009-2010

Parameters	Correlation coefficient (r value)		
	2009	2010	Cumulative
Larval population/plant vs. % Fruit damage (weight basis)	0.8810**	0.8734**	0.9263**
Larval population/plant vs. %Fruit damage (number basis)	0.8815**	0.8334**	0.9062**
Larval population vs. Yield	-0.8282**	-0.8784**	-0.8887**
% Fruit damage (weight basis) vs. % Fruit damage (number basis)	0.9641**	0.9812**	0.9846**
% Fruit damage (number basis) vs. Marketable yield	-0.8463**	-0.9021**	-0.8955**
% Fruit damage (weight basis) vs. Marketable yield	-0.7725**	-0.9255**	-0.8723**

** Significant at $P \leq 0.01$
* Significant at $P \leq 0.05$
ns Non significant

Screening of tomato genotypes on the basis of yield (kg/ha)

The genotype Chinar gave significantly higher fruit yield of 21677 kg/ha, while genotype R 165 gave significantly lower fruit yield of 10061 kg/ha. In 2010 also significantly higher tomato yield was obtained in genotype Chinar (19826 kg/ha), whereas lower yield was observed in genotype Bambino (8983 kg/ ha). The mean yield for the two years was significantly higher for genotype Chinar (20752 kg/ha) and lower for Bambino (9546 kg/ha). In general the yield of tomato crop in 2009 was comparatively higher than that of 2010.

Variation in tomato yield was observed among the tested genotypes. Although such variation may be due to genetic yield traits, but this may also be due to the response of these genotypes to *H. armigera* attack. In the present study, the genotypes with lower pest population gave higher yield. Yield variation is usually reported among tomato genotypes (Rehman *et al*., 2000; Khan *et al.*, 2001; Rida *et al.*, 2002; Ahmad *et al.*, 2007). Biotic and abiotic factors are usually considered important for yield variation. Genotype Chinar had less larval population per plant and gave maximum yield, while Bambino yielded minimum because of high larval population. Similar findings were also reported by Heinrichs (1994) and Ashfaq *et al.* (2012) who showed that that resistant genotypes show high yield than susceptible genotypes.

Correlation among H. armigera *larval population, damaged fruit and yield parameters during 2009-2010*

Mean values of correlation among pest and host parameters are given in Table V. In 2009, larval population was positively correlated with loss of fruit weight (r = 0.8810) as well as with number of fruits infested (r = 0.8815). Correlation was positive for 2010 (r = 0.8734 and r = 0.8334) as well as mean for the two years (r = 0.9263 and r = 0.9062, respectively).

Highly significantly positive correlation was found between damaged fruits on weight loss and number of fruits infested for both 2009 (r = 0.9641) and 2010 (r = 0.9812) and means for the two years (r = 0.9846).

Larval population was significantly negatively correlated with tomato yield in both 2009 and 2010 (r = - 0.8282 and - 0.8784, respectively), and also for mean of 2009 and 2010 collectively (r = -0.8887). Correlation was significantly negative between yield and fruit damage on weight as well as number basis for both the years.

The present results revealed a positive effect of larval population on tomato fruit losses in both years (r = 0.9263**). Similar positive correlation between larval density and fruit damage has also been reported by Zahid *et al.* (2008). Fruit weight loss and number of fruits damaged both contribute to fruit damage, usually with reportedly positive correlation (Kashyap and Verma, 1984, 1987; Sahu *et al.*, 2005). The present results also showed similar trend as reported by earlier researches.

Significantly negative correlation (r = 0.8887**) between larval population and tomato yield was observed. Our results are comparable to that of some previous researchers (Khanam *et al.*, 2003; Sahu *et al.*, 2005). Since *H. armigera* moth population in 2010 was higher and resultantly the oviposition and larval population were higher in 2010 compared to 2009, so the tomato yield was comparatively higher in the latter year. This showed that *H. armigera* population negatively affects tomato yield (Stavridis *et al.*, 2008).

CONCLUSIONS

The present study revealed that none of the tested genotypes were free from *H. armigera* infestation. However, based on the mean fruit weight loss (%) by *H. armigera* larvae (2009-2010), the genotypes Chinar, Sultan and Sourabh were found to be comparatively resistant, while genotype R 165 and GS 5575 were found to be most susceptible to *H. armigera* infestation. The larval population per plant was negatively correlated with fruit damage on weight as well as on number basis. The fruit damage on weight basis and on number basis showed positive correlation with each other, while both were negatively correlated with yield. The above genotypes performed better in the field and need to be further explored. In this context, investigating the physical and biochemical plant characters of the studied genotypes from a view point of host plant resistance to *H. armigera*, would be useful contribution towards development of a resistant variety that can be incorporated into an IPM strategy.

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