Pest Management in Horticultural Ecosystems
Vol. 28, No.2 pp 48-52 (2022)

DOI Number: 10.5958/0974-4541.2022.00037.6

Preferential response of melon fruit fly, *Zeugodacus cucurbitae* (Coquillett) (Diptera: Tephritidae) to major tomato hybrids

R. VIJAY[1], G. KESHAVAREDDY[1*] and K. R. VASUDEVA[2]

[1]Department of Agricultural Entomology, University of Agricultural Sciences, GKVK, Bengaluru-560065, Karnataka, India

[2] Department of Post Harvest Technology, College of Horticulture, Bengaluru

*** E-mail:** keshavaa_reddy@rediffmail.com

Abstract: The five major tomato hybrids were evaluated to check the preferential response of melon fruit fly, *Zeugodacus cucurbitae*. All the five tomato hybrids were selected based on highest number of seedlings sold in a year by different nurseries in Kolar and Chikkaballapur districts during 2019. The field studies indicated that Abhinav was the most susceptible hybrid for melon fly infestation followed by Saaho, US-448 and Alankar. Meghdoot was relatively resistant hybrid among five major hybrids. The correlation studies indicated that large pedicel diameter, high total soluble sugar (TSS) content and low phenol contents are the major factors responsible for highest fruit infestation by melon fruit fly on tomato.

Key words: Hybrid, infestation, tomato, *Zeugodacus cucurbitae*

Introduction

Tomato (*Solanum lycopersicum* L.) is an important edible and widely grown vegetable in the world (Ganeshan and Chethana, 2009). It belongs to the botanical family *Solanaceae*. It is an herbaceous plant with woody stem which can grow up to 1–3 m. As a true fruit it is botanically classified as berry and its soft tissue consists of pericarp walls with a thin layer of epicarp. Tomato is the third most preferred vegetable after potato and onion in India and ranks second after potato in the world. It is a commonly used vegetable in the Indian culinary. It is a healthy vegetable and minimizes the risk of heart diseases, diabetes as well as cognitive function disorders due to its antioxidant, anti-inflammatory and anti-carcinogenic property. Lycopene and bioflavonoids in tomatoes are considered as cancer fighting agents (Wu *et al*., 2011). Ripened red tomato contains powerful antioxidant. Lycopene and vitamin-E prevent low density lipoprotien oxidation effectively. This vegetable helps in rapid skin cell replacement because of its unique vitamin-C content and used for sunburn treatment (Bhowmik *et al*., 2012).

Tomato is grown across the world covering the area of 4.76 mha with a production of 182.25 mt. India is the second largest tomato growing country in the world after China and being grown in area of 0.79 mha with the production of 19.37 mt and productivity of 24.65 t/ha (Anonymous, 2018). Karnataka is the third major producer after Andhra Pradesh and Madhya Pradesh with an area of 64,250 ha, production of 20.81 lakh tonnes and average productivity of 34.3 t/ha which is much higher than national average (Anonymous, 2018). Kolar and Chikkaballapur are the major tomato growing districts of Karnataka state (Anonymous, 2017).

The insect pests have been potential threat in tomato production, particularly due to emerging and invasive pests. The incidence of insect pests varies from season to season and crop growth stages. The fluctuation of insect pests are largely governed by different weather factors during crop growing period and season. Many insect pests feed on tomato starting from germination to harvesting resulting in reduction of yield and fruit quality. But the incidence of fruit flies was unheard of. Melon fruit fly, *Zeugodacus cucurbitae* is an emerging pest in tomato ecosystem and is causing serious economic threat to tomato production as well as quality. The tomato fruits become increasingly susceptible to fruit fly attack at close to harvest and even more when the rainy season starts. The melon fruit fly cause peculiar mode of infestation in tomato, where adult female fly starts laying eggs under the pedicel of tomato making use of visual and olfactory cues. Immediately after egg hatching, larvae of fruit fly penetrate into the fruit and feed on the internal content of the fruit without any external symptoms of damage. Infested fruits start to rot, liquid oozes out from the fruits, as the larvae completely feeds on the fruit, the infested fruits drop off and pupation takes place in soil (Brevault and Quilici, 2007). In this view, the current study on the preferential response of melon fruit fly to major tomato hybrids was carried to bring out the relatively resistant hybrid which prevents/ resist the attack of *Z. cucurbitae* on tomato.

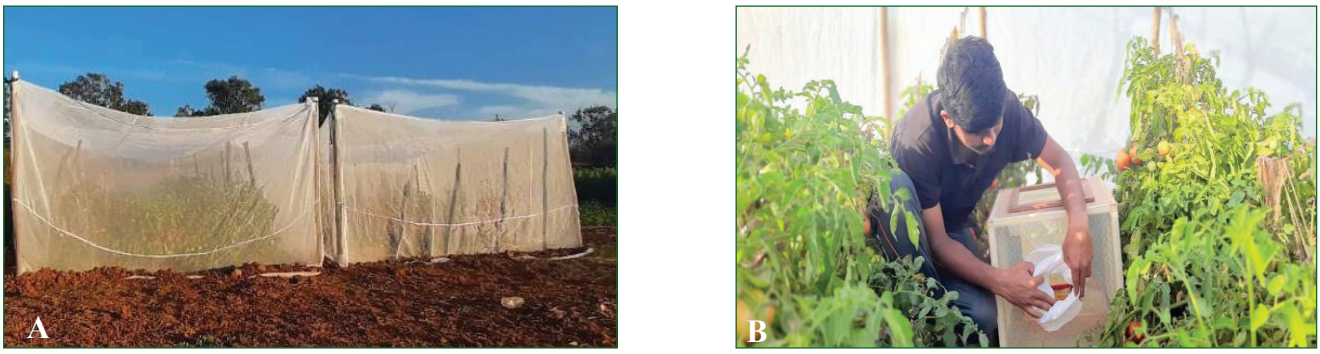

Fig. 1: **A**: Experimental plots covered with nylon mesh before the release of fruit flies (*Z. cucurbitae*);
B: Flies released into experimental plot covered by nylon mesh

Materials and methods

Study area

The experiment was conducted in the research fields of All India Network Project on Agricultural Acarology, Zonal Agricultural Research Station (ZARS), UAS, GKVK, Bengaluru. The study was conducted during *rabi* season of 2019-20. The research farm is located in between 77°34′17″ E long. 13°04′55″ N lat. at an average elevation of 920 m above mean sea level.

Climate details

The climate of UAS, GKVK, Benagluru comes under eastern dry zone of Karnataka. It receives mean average rainfall of 86.32 mm rainfall during *rabi* season. The mean minimum and maximum temperature is 27.58^{0}C and 17.2^{0}C respectively. The mean maximum and minimum relative humidity is 91% and 57.2% respectively during the cropping period. The meteorological data for the study period was collected from Department of Meteorology, UAS, GKVK, Bengaluru.

Visit to various nurseries to record on sale of tomato seedlings

The survey was conducted on the sale of varieties/ hybrids wise tomato seedlings to farmers in one year by making visits to the selected nurseries in both the districts during 2019. Later based on maximum number of seedlings sold to farmers in a year, a total of five major tomato hybrids that are widely cultivated by farmers in both the districts have been selected for further studies like per cent fruit infestation and fruit fly preferential studies.

Field experiment

Field study on preferential response of fruit fly to five different tomato hybrids was conducted in a Randomized Block Design (RBD) method. Each hybrid with four replications was maintained. Each replication consists of three plants of each hybrid and a total of fifteen plants. The plot size of each replication was 3×4 meter and was completely covered with nylon mesh to prevent the damage to tomato crop by other insect pests (Figure 1A). At the fruit maturity and ripening stage (75 DAT), seven days old hundred adult melon fruit flies with sex ratio of 1:1 were released into each nylon mesh (Figure 1B). Later, the observations on per cent fruit infestation was recorded at 7 days time intervals, up to 21 days. At different time intervals, per cent fruit infestation in each plant was recorded by dividing number of infested fruits with total number of fruits observed. Later, total per cent fruit fly infestation was calculated for each treatment.

Insect culture

Melon fruit fly, *Z. cucurbitae* infested tomato fruits were collected from tomato fields of Kolar and Chikkaballapur districts of Karnataka state and were kept on plastic trays with 5 cm thick sterilized fine sand and kept inside acrylic rearing cages in laboratory for pupation. Later, pupae were separated from sand carefully and kept in petri plates for adult emergence. The emerged adults were allowed to mate and used to maintain culture in the laboratory.

Lab experiment

The per cent fruit infestation by fruit fly was correlated with different physical and biochemical fruit parameters like fruit diameter, pedicel diameter, fruit shape, pericarp and epicarp thickness, pH and total soluble sugars (TSS) of fruit juice, total phenols and lycopene content of the fruits of different tomato hybrids. The physical and biochemical parameters of tomato fruits of different hybrids were derived at Department of Post Harvest Technology, College of Horticulture, Bengaluru. The following different procedures were followed to calculate the above parameters

Table1. Hybrid/variety wise seedlings sold by different nurseries in Kolar and Chikkaballapur Districts during 2019

Sl. No.	Hybrid/Variety	Total no. of seedlings sold in a year
1.	Abhinav	51.5 lakhs
2.	US- 448	34.2 lakhs
3.	Alankar	15 lakhs
4.	Saaho	14.25 lakhs
5.	Meghdoot	12.5 lakhs
6.	Rishika	4.5 lakhs
7.	Ansal	4 lakhs
8.	Samarth	2.5lakhs
9.	Siri plus	2 lakhs
10.	TO-6242	1.5 lakhs
11.	Prabha	1.5 lakhs
12.	Madan	1 lakh
13.	Virang	1 lakh
14.	TO-1057	0.3 lakh
15.	US-440	0.3 lakh

a) Assessment of fruit shape of different tomato hybrids

Fruit shape of different tomato hybrids were determined using descriptors for tomato developed by International Plant Genetic Resource Institute.

b) Assessment of fruit diameter, pedicel diameter, pericarp and epicarp thickness

Three randomly selected tomato fruits from each hybrid were collected in paper covers and taken to the Department of Post Harvest Technology, College of Horticulture. Different fruit parameters like fruit diameter, pedicel diameter, pericarp and epicarp thickness were noted using electronic digital caliper (Gadget hero's digital LCD vernier caliper 0–150 mm). Later, the mean values of three fruits was calculated.

c) pH of fruit juice

pH of fruit juices of different hybrids were measured using digital pH meter of Contech Instruments Ltd.

d) Total soluble sugars of fruit juice

Total Soluble Sugars (TSS) of fruit juice was recorded with digital pocket refractometer (Atago - 0 to 53 ^{0}B) and expressed in Brix (^{0}B).

e) Estimation of total phenol content of different tomato hybrids

Total phenol content of different tomato hybrids were estimated using the following steps and procedure. 5.0 g of tomato sample was crushed with 20 ml of 80% ethanol in a pestle and mortar and the volume was made up to 50 ml. From the extracted volume, 0.5 ml of aliquot was taken in a test tube and 0.2ml of Folin-Ciocalteau reagent was added to aliquot, 3.3 ml of distilled water was added and mixed well. After 2 min, 1ml of 2.0% Na_2CO_3 solution was added into each tube and allowed to stand at room temperature for 30 minutes, the absorbance was recorded in a spectrophotometer at 700 nm. Using absorbance value total phenol content was estimated with following formula (Singleton and Rossi, 1965).

Total phenol content

$$(\text{mg gallic acid equivalents/100 gm}) = \frac{\text{Absorbance} \times \text{Std. value} \times \text{Total volume of extract (ml)} \times 100}{\text{Assay volume (ml)} \times \text{Weight of tissue (gm)} \times 1000}$$

f) Estimation of lycopene in different tomato hybrids

Fruits were randomly sampled from the experimental plots with minimum sample size of 10 gm, the pulp was repeatedly extracted with acetone using pestle and mortar until the residue become colourless. Acetone extracts were pooled and transferred into a separating funnel containing 30 ml petroleum ether. 20 ml of 5% sodium sulphate solution was added, mixed gently and left the solution to settle for few minutes. The above layer with lycopene mixed petroleum ether was extracted and absorbance was recorded in a spectrophotometer at 503nm. The total lycopene content was calculated using following formula (Lichtenthaler, 1987).

$$\text{Lycopene (mg in 100g sample)} = \frac{31.206 \times \text{Absorbance}}{\text{Wt of sample (g)}}$$

Statistical Analysis

The data was subjected to single factor Analysis of Variance (ANOVA). The critical difference (CD) at 5% probability level was used as the test criterion.

Results and discussion

Visit to various nurseries on sale of tomato seedlings

A preliminary survey was conducted on the sale of tomato seedlings to farmers for the year 2019 by making visits to the selected nurseries in both Kolar and Chikkaballapur Districts. Among fifteen different tomato hybrids/ varieties sold by various nurseries, five major hybrids were selected for further studies. These hybrids were selected exclusively based on maximum number of seedlings sold by the nurseries to the farmers in a year. Among them Abhinav (51.5 lakh seedlings) was the

Table 2. **Physical, biochemical parameters and % fruit infestation of five tomato hybrids**

Sl. No.	Tomato hybrid	Fruit shape	Fruit diameter (mm)	Pedicel diameter (mm)	Stalk length (mm)	Epicarp thickness (mm)	Pericarp thickness (mm)	TSS (°B)	pH	Phenols (mg of gallic acid in 100gm)	Lycopene (mg in 100gm)	Per cent fruit infestation
1	Saaho	Slightly flattened	53.59	8.30	10.30	1.51	7.03	4.37	4.48	54.94	7.48	20.60 (44.29)[c]
2	US-448	Slightly flattened	55.59	9.93	10.77	1.00	5.42	4.50	4.19	56.69	7.50	20.13 (43.57)[c]
3	Alankar	Slightly flattened	52.52	9.20	11.07	1.29	6.40	4.00	4.43	60.38	5.80	14.34 (37.00)[b]
4	Meghdoot	Rounded	51.01	6.97	11.03	1.23	6.20	3.37	4.49	66.59	7.70	9.04 (29.43)[a]
5	Abhinav	High rounded	50.52	10.67	11.67	0.67	5.46	4.57	4.53	42.03	7.21	26.61 (51.01)[d]
											Sem±	**1.84**
											CD	**5.68**
											CV	**8.98**

*Values in the parentheses are Arc sine transformed.

major tomato hybrid that is being grown predominantly by farmers followed by US-448 (34.2 lakh seedlings), Alankar (15 lakh seedlings), Saaho (14.25 lakh seedlings) and Meghdoot (12.5 lakh seedlings) (Table 1).

Field experiment

The results of the preferential studies of fruit fly, *Z. cucurbitae* under open field conditions revealed that the per cent fruit infestation vary among different hybrids of tomato. Abhinav was the most susceptible hybrid among five hybrids with 26.61 per cent infestation followed by Saaho (20.60%), US-448 (20.13%), Alankar (14.34%). Meghdoot was found resistant among five hybrids with only 9.04 per cent fruit infestation (Table 9). The variation in per cent fruit infestation of five hybrids were subjected to correlation analysis with biochemical and physical parameters and are presented in Table 2.

The correlation studies revealed that the per cent fruit infestation by fruit fly had significant positive correlation with total soluble sugars (+0.94) and pedicel diameter (+0.83). The per cent fruit infestation showed significant negative correlation with total phenol content of fruits (-0.96, P=0.05) (Table 3). Abhinav fruits have more total soluble sugars (TSS) 4.57 ^{0}B. This may be the one reason for fruit fly preference to infest Abhinav fruits when compared to other major hybrid fruits which have relatively less total soluble sugars.

Present preferential investigation results also supported by Nehra *et al.* (2019) who reported that total soluble sugars had significant positive correlation with fruit fly infestation in round gourd varieties, whereas total phenol content had negative correlation with fruit fly infestation.

Haldhar *et al.* (2013) found significant positive correlation (r = 0.97) between larval density per fruit and per cent fruit infestation during the evaluation of eleven genotypes of musk melon against melon fruit fly. Further, they also reported that total sugars, reducing sugars, non-reducing sugars and pH were consistently high in susceptible genotypes and were low in resistant ones. On the other hand, total phenol content of fruit was highest in resistant lines but was low in susceptible genotypes. These results are corroborated with our present investigation on preferential studies of fruit fly on tomato hybrids.

The per cent fruit infestation showed non-significant negative correlation with epicarp thickness (-0.56). There was no significant correlation between per cent fruit infestation and pH of fruit juice, pericarp thickness, lycopene content, fruit diameter and stalk length. The fruit shape of all the five major hybrids were determined using descriptors for tomato developed by International Plant Genetic Resource Institute and found that Abhinav fruit was high rounded, Alankar, Saaho, US-448 fruits were slightly flattened whereas of Meghdoot fruit was round shape. It was found that the fruit shape was also have an impact on fruit fly infestation. Abhinav with high rounded fruit shape was found highly susceptible to fruit fly infestation when compared with other hybrids. Dhillon *et al.* (2005) also reported that per cent fruit infestation and larval density per fruit vary with fruit shape, size and toughness of the fruits in bitter gourd genotypes. Bitter gourd fruits with deep ribs were highly susceptible to melon fruit fly infestation.

Table 3. Correlation co-efficient (r) between fruit fly infestation and different physical-biochemical parameters of five tomato

	pH	TSS	Epicarp thickness	Pericarp thickness	Lycopene	Total phenol	Pedicel diameter	Fruit diameter	Stalk length	% infestation
pH	1.00									
TSS	-0.29	1.00								
Epicarp thickness	0.06	-0.41	1.00							
Pericarp thickness	0.41	-0.32	0.92	1.00						
Lycopene	-0.07	-0.01	-0.11	-0.15	1.00					
Total phenol	-0.20	-0.82	0.67	0.40	-0.04	1.00				
Pedicel diameter	-0.27	0.85	-0.72	-0.64	-0.27	-0.82	1.00			
Fruit diameter	-0.87	0.41	0.29	0.01	0.08	0.17	0.16	1.00		
Stalk length	0.33	0.01	-0.83	-0.67	-0.23	-0.45	0.46	-0.69	1.00	
% infestation	-0.01	0.94*	-0.56	-0.36	0.10	-0.96*	0.83*	0.10	0.22	1.00

* Significant at P= 0.05

Conclusion

Use of resistant cultivars is one of the most important component in managing insect pest in agriculture ecosystem as the other methods incur huge burden on farmers. Among five major tomato hybrids examined for preferential response of melon fruit fly, Abhinav was the most susceptible hybrid with highest per cent fruit infestation and Meghdoot was relatively resistant. These results were supported by correlation analysis with various physical and biochemical parameters of tomato fruits. With this, farmers can be suggested to go for Meghdoot rather than Abhinav hybrid in order to resist/ reduce the attack of fruit fly on tomato.

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MS Received: 12 October 2022
MS Accepted : 08 December 2022