Entomology

Screening of tomato cultivars against major insect pests

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Abstract

The experiment was carried out under polyhouse conditions at the College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India. Ten tomato cultivars were evaluated to identify the resistant source, among them, the cultivars GS 600 (0.86 nymphs/2 cm2 and 1.95 adults/ leaf) were categorized as resistant to whitefly. Whereas, the cultivars Omnia, Emerald, Arka Rakshak, Arka Samrat, and Arka Abhedh (1.75, 2.08, 2.32, 2.66, and 2.80 live mines/ leaf, respectively with 14.54, 15.79, 17.21, 18.90 and 19.87 % leaf infestation) were categorized as moderately resistant to leaf miner. Further, the cultivars viz., Omnia, Emerald, and Arka Rakshak (0.91, 0.77, and 1.12 mines/ leaf with 18.02, 16.16, and 20.28 % blotch miner/ tomato pinworm infestation) were categorized as moderately resistant to tomato pinworm.

Keywords: cultivars, resistant, whitefly, tomato pin worm, leaf miner

Introduction

Tomato is a rich source of vitamin A and C, also known as "poor man's orange" it adds a variety of colours to the food. Lycopene imparts red colour to the ripe tomatoes. It is also reported to possess anti-cancerous properties. Tomato fruit contain water 93 per cent, protein 1.9 per cent, fat 0.3 g, fibre 0.7 per cent, carbohydrates 3.6 per cent, calorie 23, vitamin 'A' 320 IU, vitamin 'B1' 0.07 mg, vitamin 'B2' 0.01 mg, vitamin 'C' 31 mg, nicotinic acid 0.4 mg, calcium 20 mg, phosphorus 36 mg and iron 0.8 mg. (Kachave *et al.*, 2020) [9]. The major insect pests includes whitefly, *Trialeurodes vaporariorum* (Westwood), serpentine leaf miner, *Liriomyza trifolii* (Burgess), South American leaf miner *Tuta absoluta* (Meyrick), thrips, *Scirtothrips dorsalis* (Hood), aphid *Aphis gossypii* (Glover), jassid, *Amrasca devastans* (Distant) and fruit borer, *Helicoverpa armigera* (Hub.) are major species according to Mandloi *et al.* (2015) [10]. Among the key insect pests, whitefly (*T. vaporariorum*), leaf miner (*L. trifolii*) and tomato pin worm (*T. absoluta*) are the most dangerous pests having a pandemic distribution and damaging many vital crops including vegetables, tubers, fiber crops and ornamentals from tropics and sub-tropics to temperate climates in crops grown under open and protected environment (Anu *et al.*, 2020) [2]. The wide range of geographical distribution with varieties of host range make them difficult to control. *T. vaporariorum*, which sucks the phloem sap of growing tomato plant, also transmits tomato yellow curl viruses. The larvae of *L. trifolii* feed on mesophyll and reduce chlorophyll content of leaves. Adults puncture leaves to feed and oviposit (Zhang *et al.*, 2017) [30]. Tomato pin worm has been responsible for losses of 80-100 per cent in tomato under both protected cultivation and open fields. Yield and fruit quality are both considerably impacted by direct feeding of the pest as well as secondary pathogens entering host plants through wounds made by the pest (Michailidis *et al.*, 2019) [11]. Hence, the investigation was undertaken to study the screening of different genotypes against major pests infesting tomato under polyhouse condition.

Materials and Methods

The study was conducted during 2019-20 at College of Horticulture, Mudigere in polyhouse condition. The experiment was conducted with 10 treatments replicated thrice in Randomized Complete Block Design (RCBD).

Nursery raising and transplanting

Ten tomato cultivars were selected for the study (Table 1). Seeds of tomato cultivars were sown separately in portrays filled with coco peat, treated with Trichoderma. No insecticide sprays were taken during seedling stage. Beds were prepared by ploughing the soil three times to a depth of 40 cm. All the weeds, stubbles, stones, *etc.* were removed entirely, and the land was brought into a fine tilth. Raised beds of 2.5 m × 1.5 m × 45 cm height were prepared with walking space of 30 cm between the beds. Twenty-eight days old seedlings of each cultivar/ hybrid were transplanted in the main field in a plot with a spacing of 40 × 60 cm. Irrigation was provided with drippers. Depending upon soil moisture and weather conditions, the beds were watered to keep the soil moderately moist.

Table 1: List of tomato cultivars used in the experimentation

Sl. No.	Cultivars	Source
1.	HTM 2466	Syngenta, Ind. Ltd.
2.	Madhura	Neo seeds India Private Ltd.
3.	PKM 01	Sri Krishna hybrid seeds
4.	GS 600	Advanta seeds, India
5.	Arka Vikas	IIHR, Bengaluru
6.	Arka Samrat	IIHR, Bengaluru
7.	Arka Abhedh	IIHR, Bengaluru
8.	Arka Rakshak	IIHR, Bengaluru
9.	Emarald (Sakata)	Green top agro centre Chikkamagaluru
10.	Omnia	Green top agro centre Chikkamagaluru

Observation

The observations were recorded on five randomly selected plants from each plot at fifteen days intervals from 30 to 135 days after transplanting (DAT). Both nymphs and adults of whitefly was counted on fully opened randomly selected top, three leaves. Observation on whitefly adults were recorded in early morning hours, whereas, the nymphal population was counted per unit area (2 cm^2) under a stereo-zoom binocular microscope at 10 X magnification. In case of leaf miner and tomato pin worm number of mines per leaf was counted on fully opened randomly selected three leaves at fifteen days intervals. Per cent leaf miner and tomato pin worm infestation was calculated using the following formula. Standard scoring procedure for whitefly adult, leaf miner and tomato pin worm infestation on tomato cultivars is given in table 2.

$$\text{Per cent leaf miner infestation} = \frac{\text{No. of leaf miner infested leaves}}{\text{Total no. of leaves observed}} \times 100$$

$$\text{Per cent blotch miner/ tomato pin worm infestation} = \frac{\text{No. of tomato pin worm infested leaves}}{\text{Total no. of leaves observed}} \times 100$$

Morphological and biochemical parameters

The trichome density of different tomato cultivars were counted at 90 DAT by marking one cm^2 area at the region near midrib on both abaxial and adaxial surface of a fully developed leaf by observing under the stereo binocular microscope. Plant height was measured at monthly intervals with the help of a measuring scale, and also the plant canopy was measured after the appearance of primary and secondary branches at monthly intervals. Leaf characters were checked *viz.*, whether it is glabrous or hairy by examining under the magnifying lens. The stem character of each cultivar was tested by gently pressing the stem against fore and middle finger, *i.e.*, soft or compact. The chlorophyll content in leaves were measured at 90 days after transplanting by using dimethyl sulfoxide (DMSO) method given by Shof and Lilum (1976) [24]. The sugar content in different tomato cultivars was also measured at 90 days after transplanting by using DNSA (Dinitro salicylic acid) reagent method given by Ranganna, 1979 [19].

Table 2: Standard scoring procedure for whitefly adult, leaf miner and tomato pin worm infestation on tomato cultivars

Score (0-4)	Whitefly population (no. / leaf)	Per cent infestation (leaf miner)	Per cent infestation (pin worm/ blotch miner)	Remarks
0	No population	No symptoms	No symptoms	Immune
1	0-2 adults per leaf	1-10 per cent infestation	1-10 per cent infestation	Resistant
2	2 -4 adults per leaf	11-20 per cent infestation	11-20 per cent infestation	Moderately resistant
3	4 -6 adults per leaf	21-30 per cent infestation	21-30 per cent infestation	Susceptible
4	> 6 adults per leaf	>31 per cent infestation	>31 per cent infestation	Highly susceptible

Results and Discussion

Response of tomato cultivars against whitefly, *Trialeurodes vaporariorum*

The data presented in table 3 revealed that none of the cultivars were found to be immune to whitefly under polyhouse condition. Of the ten cultivars, GS 600 recorded lesser whitefly adults (1.95/ leaf) and nymphs (0.86/ 2cm^2) which was categorized as resistant. Further, the genotypes Arka Samrat, Arka Rakshak, Madhura and Arka Vikas recorded moderate whitefly adults (2.07, 2.64, 3.44 and 3.82/ leaf, respectively) and nymphal population (1.01, 1.13, 1.33 and 1.47/ 2cm^2) which were categorized as moderately resistant. Whereas, Emarald, HTM 2466 and Omnia recorded higher whitefly adults (4.57, 4.84 and 5.36/ leaf, respectively) and nymphs population (1.65, 1.95 and 2.28/ 2cm^2, respectively) which were categorized as susceptible. However, Arka Abhedh and PKM 01 recorded very high population of whitefly adults (6.34 and 6.58/ leaf, respectively) and nymphs (2.58 and 2.88/ 2cm^2,

respectively) which were categorized as highly susceptible (Table 3). The present study is in accordance with Zeshan *et al.* (2016) [29] who reported that out of twenty seven varieties three were highly susceptible, six were susceptible, four were moderately susceptible, six were moderately resistant and eight cultivars were resistant. No cultivars were recorded as highly resistant or immune against whitefly. Jamuna *et al.* (2017) [8] who reported that, out of the six tomato cultivars were screened against whitefly, least population of adult whitefly was observed in Vybhav (1.50 adults/ 3 leaves) followed by Arka Samrat and Arka Rakshaka which recorded 3.25 and 3.50 adult whitefly per three leaves, respectively. Whereas, Arka Ananya, PTR 6 and PTR 4 recorded 4.00, 6.00 and 6.25 adult whitefly per three leaves, respectively which support the present findings. The present findings were also in conformity with Mishra *et al.* (2019) [12] who reported the average minimum and maximum whitefly population during cropping season were observed on Vaishnavi and PKM-1, respectively. Further, the mean whitefly population indicated that, the highest resistance was found in Vaishnavi followed by Suruchi, TMT-685, Shivaji, TMT-507, Abhimanyu and PKM-1.

Response of tomato cultivars against leaf miner, *Liriomyza trifolii*

The results indicated that, none of the cultivars were found to be immune or resistant to leaf miner under polyhouse condition. Out of the ten cultivars evaluated against leaf miner on tomato cultivars, Omnia, Emarald, Arka Rakshak, Arka Samrat and Arka Abhedh, (14.54, 15.79, 17.21, 18.90 and 19.87 %, respectively) recorded moderate leaf miner infestation and were categorized as moderately resistant source. Whereas, the cultivars, Madhura, Arka Vikas, PKM 01 and HTM 2466 recorded higher leaf miner infestation (21.79, 23.38, 25.78 and 28.43 %, respectively) and were categorized as susceptible once. Further, the cultivar GS 600 (30.15%) recorded very high leaf miner infestation and categorized as highly susceptible. Similarly, the cultivars Omnia, Emarald, Arka Rakshak, Arka Samrat and Arka Abhedh recorded moderate number of live mines (1.75, 2.08, 2.32, 2.66 and 2.80 live mines/ leaf, respectively) and they were categorized as moderately resistant source. Whereas, the cultivars, Madhura, Arka Vikas, PKM 01 and HTM 2466 recorded higher number of live mines (2.94, 3.14, 3.34 and 3.48 / leaf, respectively) and were categorized as susceptible. Further, the cultivar GS 600 (3.84 live mines/ leaf) recorded very high number of live mines and they were categorized as highly susceptible (Table 3). The present study is in line with Deepak *et al*. (2013) [5] who reported that only nine test cultivars, out of twenty one cultivars were found to be moderately susceptible. No cultivar was found highly susceptible against leaf miner under open conditions.

The present findings were also in agreement with the finding of Sarkar *et al.* (2017) [22] who reported that out of six tomato cultivars screened against leaf miner, the cultivar, Patherkuchi was found less susceptible and others were moderately susceptible (Ruby, Roja cherry, Romeo and Priya). Whereas, NS 501 cultivar recorded as highly susceptible. Likewise, Mohan and Anitha (2018) [13] who reported that among the tomato cultivars evaluated against *L. trifolii*, Arka Abha recorded the least damage with lower number of mines and number of larvae per plant. Whereas, Manulekshmi, Arka Alok and Hissar Lalith were in the category of moderately tolerant and hybrids like Arka Rakshak, Arka Samrat and Vellaryani Vijai were classified as susceptible ones. Further, Swaraksha and NS-538 hybrids were included under highly susceptible group.

Response of tomato cultivars against tomato pin worm, *Tuta absoluta*

The results indicated that, none of the cultivars were found to be immune or resistant to pin worm under polyhouse condition. Out of the ten cultivars evaluated against tomato pin worm on tomato, Emarald, Omnia and Arka Rakshak recorded medium pin worm infestation (16.16, 18.02 and 20.28 %, respectively) which were categorized as moderately resistant source. Further, the cultivars Arka Samrat, Arka Abhedh, PKM 01 and Arka Vikas recorded higher tomato pin worm infestation (22.58, 24.37, 27.46 and 29.88 %, respectively) and were categorized as susceptible. Whereas, the cultivars, Madhura, GS 600 and HTM 2466 recorded very high pin worm infestation (31.60, 33.14 and 34.67 %, respectively) and were categorized as highly susceptible (Fig 2). Similarly, Emarald, Omnia and Arka Rakshak recorded medium number of mines (0.77, 0.91 and 1.12 mines/ leaf, respectively) and were categorized as moderately resistant source. Further, the cultivars, Arka Samrat, Arka Abhedh, PKM 01, Arka Vikas and GS 600 recorded more number of mines (1.26, 1.39, 1.61, 1.79 and 1.99 / leaf, respectively) were categorized as susceptible. Whereas, the cultivars, Madhura and HTM 2466 recorded very high number of mines (2.00 and 2.26 / leaf, respectively) and were categorized as highly susceptible (Table 3). The present findings are in line with Oliviera *et al.* (2008) [16] who reported that, *T. absoluta* adults examined and evaluated at weekly intervals for number of mines/ leaf and per cent of leaves mined at 60, 75 and 90 days after planting showed low infestation. Whereas, accessions HGB-674 and HGB-1497 appeared as most promising for leaf miner. The present findings are in line with Darbain *et al.* (2016) [4] who reported susceptibility of certain tomato cultivars to infestation with *T. absoluta* which showed that the most susceptible cultivars were Alissa F1 and Super strain B while Logain cultivars was the least susceptible one. The present finding are also in conformity with Bitew (2018) [3] who reported that the accession LA 1777, LA 1718 and LA 716 were most resistant to *T. absoluta* but LA 1401 and LA 1139 were the most susceptible. The resistance of this genotype was related to the presence of trichome type I and IV.

Morphological basis of resistance to whitefly, leaf miner and tomato pin worm

Trichome density

The variation in whitefly adult and nymphal population in tomato genotypes may be attributed to morphological characters of the plants. During the present investigation, Arka Rakshak, Arka Samrat and GS 600 (41.06, 34.34 and 25.19 no./ cm2, respectively) recorded more number of trichomes per unit area which harbored more whitefly incidence. Whereas, the cultivar, that showed higher incidence of whitefly in PKM 01 (15.59 no./ cm2) which possessed lower trichome density (Table 4). Thus, the results indicated trichome density was significantly correlated with whitefly population. The present findings are in line with Ramazeame *et al.* (2015) [18] who

reported that there was a positive correlation between trichome density with cultivars resistance to whitefly. Higher the trichome density, higher the plant resistance to whitefly infestation. The present findings are also in accordance with Sachin *et al.* (2019) [21] who reported that tomato accessions with high density of trichomes are correlated with the higher level of whitefly repellence. The present findings are also in agreement with Oriani and Vendramim (2010) [17] who reported that the glandular trichome density was positively correlated with the mortality of whiteflies. The non-glandular trichome density was negatively correlated with the number of whitefly and positively with oviposition of whitefly. In the present investigation, Emarald (28.69 no./ cm2) and Omnia (30.23 no./ cm2) showed comparatively higher mean number of trichomes which were moderately resistant to leaf miner. Whereas, cultivar GS 600 (25.19 no./ cm2) and HTM 2466 (17.41 no./ cm2) showed comparatively lower trichomes which were susceptible to leaf miner. Thus, the result indicated that trichome density was significantly correlated with leaf miner infestation. The present findings are in accordance with Selvanarayanan and Muthukumaran (2005) [23] who reported that the density of non-glandular and glandular trichomes and phenol content in the foliage, lycopene and ascorbic acid content in the tomato fruits were the major factors of resistance. Whereas in case of pin worm, Arka Rakshak (41.06 no./ cm2), Emarald (28.69 no./ cm2) and Omnia (30.23 no./ cm2) which harbored lesser number of mines possessed considerably higher trichome densities. Whereas, the cultivars, that showed higher incidence of tomato pin worm were Madhura (19.39 no./ cm2), GS 600 (25.19 no./ cm2) and HTM 2466 (17.41 no./ cm2) and they possessed considerably lower trichome densities. The present results indicated that trichome density is significantly correlated with tomato pin worm infestation. The present study is in line with Sohrabi *et al.* (2016) [25] who reported that higher density of leaf trichomes in cultivars Raha and Quintini would be possible reasons of resistance to *T. absoluta*. The present investigation is also in accordance with Sridhar *et al*. (2019) [27] who reported that out of six genotypes of tomato, LA-1940 showed resistance both under choice and no choice bioassays with a higher number of type IV trichomes, highest total flavonoids and phenols.

Plant height, plant canopy and leaf character

In the present investigation, lower plant height and plant canopy with glabrus leaves were noticed in PKM 01 (115.45 cm and 60.80 cm, respectively) which showed maximum number of whiteflies. Whereas, the cultivar GS 600 recorded with higher plant height and plant canopy with hairy leaves (210.24 cm and 110.15 cm, respectively) showed lesser incidence of whiteflies (Table 4). Thus, the results indicated that plant height and canopy were negatively correlated. Whereas, laminar hair density was positively correlated with whitefly population. The present findings are in accordance with Huma *et al.* (2017) [7] who reported that plant height had negative correlation with whitefly adult and nymphs population. Whitefly adult population exhibited negative response with gossypol glands on leaf lamina, midrib and vein and with plant height. Likewise, Emarald and Omnia with higher plant height (230.70 cm and 172.10 cm, respectively) and canopy spread (118.40 cm and 90.26 cm, respectively) showed higher incidence of pin worm than the cultivars Madhura which showed lower plant height and canopy spread (120.30 cm and 64.35 cm, respectively). The results indicated that plant height and canopy spread was significantly correlated with pest incidence. The present study is in line with Gharekhani and Salek-Ebrahimi (2013) [6] who reported that the total mines on the cultivars as well as terminal buds infestation indicated positive and significant correlation with growing characteristics of them, which signify on attractiveness of the cultivars along with increasing of height and leaflets. The present findings are in accordance with Ambule *et al*. (2015) [1] who reported that the correlation of plant height, branches per plant and fruits per plant with infestation of *H. armigera* were significantly positive correlated.

Biochemical basis of resistance to whitefly, leaf miner and pin worm

Total sugars

In the present investigation, considerably lower amount of total sugars was noticed in Arka Samrat (3.12 mg/ g.fr.wt), Arka Rakshak (3.37 mg/ g.fr.wt) and GS 600 (4.63 mg/ g.fr.wt) which harbored lesser whitefly. Further, Emarald (3.52 mg/ g.fr.wt) and Omnia (4.33 mg/ g.fr.wt) which showed lesser incidence of leaf miner and pin worm. Whereas, the cultivars, that showed higher incidence of whitefly, leaf miner and pin worm were, Madhura, HTM 2466 and PKM 01 (5.45, 6.21, and 6.39 mg/ g.fr.wt, respectively) which exhibited higher total sugar content (Table 4). Thus, the results indicated that there is a direct relationship between total sugar content with insect pest incidence. The present findings are in accordance with Neiva *et al.* (2013) [15] who reported that tomato plants with normal acyl sugar levels showed resistance to whitefly population. Allelochemical rich lines exhibited pest resistance, whereas the controls did not, and the allelochemical rich lines did not differ significantly from each other in the level of resistance. The present study is in line with Somato *et al.* (2018) [26] who reported that free amino acid and total soluble sugar content had positive correlation whereas, total phenol had negative correlation with the population of whitefly and per cent leaf curling. The present findings were also in conformity with Rasheed *et al.* (2018) [20] who reported that the correlation between the reducing sugars and infestation of *T. absoluta* on leaflets, fruits and number of larvae per compound leaf was positive and significant, which indicated that increase in reducing sugar increased the infestation of *T. absoluta.*

Total Chlorophyll

In the present investigation, the cultivars Emarald (1.28 mg/ g.fr.wt), Omnia (1.53 mg/ g.fr.wt) and Arka Rakshak (1.50 mg/ g.fr.wt) recorded lower content of total chlorophyll showed moderate population of leaf miner and tomato pin worm. Whereas, the cultivars like HTM 2466 (2.21 mg/ g.fr.wt) and Madhura (2.01 mg/ g.fr.wt) showed higher incidence of pest population (Table 4). Thus, the results indicated that there is a direct relationship between chlorophyll content with incidence of leaf and pin worm. The present findings are in accordance with Mwila *et al.* (2017) [14] who reported that high peroxidase and tannin are closely associated to lower whitefly and damage indicating the two biochemicals protected the plant against whitefly. The present findings are also in line with Tabassum *et al.* (2019) [28] who reported that the population of

leafhoppers, aphids and thrips were negatively correlated with phenols and tannin content in the leaves of treated plants, but positive correlation was observed between pest population and reducing sugars in leaves.

Table 3: Performance of tomato cultivars for overall mean population/per cent infestation of major insect pests

Sl. No.	Cultivars	Mean No. of whitefly nymphs/ 2cm^2	Mean No. of whitefly adults/ leaf	Mean No. of live mines/leaf (*Liriomyza trifolii*)	Mean No. of mines/ leaf (*Tuta absoluta*)	Per cent leaf infestation (*Liriomyza trifolii*)	Per cent tomato pin worm infestation (*Tuta absoluta*)
1	HTM 2466	1.95 (1.56)	4.84 (2.31)	3.48 (1.99)	2.26 (1.66)	28.43 (32.20)	34.67 (36.09)
2	Madhura	1.33 (1.35)	3.44 (1.98)	2.94 (1.85)	2.00 (1.58)	21.79 (27.83)	31.60 (34.20)
3	PKM 01	2.88 (1.83)	6.58 (2.60)	3.34 (1.95)	1.61 (1.45)	25.78 (30.53)	27.46 (31.63)
4	GS 600	0.86 (1.16)	1.95 (1.56)	3.84 (2.08)	1.99 (1.57)	30.15 (33.34)	33.14 (35.12)
5	Arka Vikas	1.47 (1.40)	3.82 (2.07)	3.14 (1.90)	1.79 (1.51)	23.38 (28.93)	29.88 (33.15)
6	Arka Samrat	1.01 (1.22)	2.07 (1.60)	2.66 (1.77)	1.26 (1.32)	18.90 (25.77)	22.58 (28.39)
7	Arka Abhedh	2.58 (1.75)	6.34 (2.61)	2.80 (1.81)	1.39 (1.37)	19.87 (26.49)	24.37 (29.60)
8	Arka Rakshak	1.13 (1.27)	2.64 (1.77)	2.32 (1.67)	1.12 (1.27)	17.21 (24.50)	20.28 (26.78)
9	Emarald	1.65 (1.46)	4.57 (2.25)	2.08 (1.60)	0.77 (1.12)	15.79 (23.42)	16.16 (23.73)
10	Omnia	2.28 (1.66)	5.36 (2.42)	1.75 (1.50)	0.91 (1.18)	14.54 (22.38)	18.02 (25.10)
S.Em ±		0.11	0.13	0.07	0.08	1.01	0.98
CD @ 5%		0.35	0.39	0.24	0.26	3.05	2.94

Note: values in the parenthesis are √x+0.5 transformed for mean no. of pest population; angular transformed for per cent infestation.

Table 4: Morphological and biochemical parameters of tomato cultivars

Sl. No.	Cultivars	Parameters								
		Leaf character	Stem character	Plant height (cm)	Plant canopy (cm)	Trichome density/ cm^2			Total Chlorophyll (mg/g.fr.wt)	Total sugar (mg/ g.fr.wt)
						Abaxial surface	Adaxial surface	Average		
1	HTM 2466	Glabrus	Soft	180.23	93.20	25.30	9.53	17.41	2.21	6.21
2	Madhura	Glabrus	Soft	120.30	64.35	28.28	10.51	19.39	2.01	5.45
3	PKM 01	Glabrus	Soft	115.45	60.80	22.08	9.10	15.59	2.35	6.39
4	GS 600	Hairy	Compact	210.24	110.15	35.22	15.17	25.19	1.19	4.63
5	Arka Vikas	Hairy	Compact	164.17	85.30	36.12	16.10	26.11	1.61	5.04
6	Arka Samrat	Hairy	Compact	150.15	78.07	42.40	26.28	34.34	1.33	3.12
7	Arka Abhedh	Glabrus	Soft	195.40	100.12	30.40	13.20	21.80	1.75	5.29
8	Arka Rakshak	Hairy	Compact	142.28	74.19	53.02	29.10	41.06	1.50	3.37
9	Emarald	Hairy	Compact	230.70	118.40	39.20	18.18	28.69	1.28	3.52
10	Omnia	Hairy	Compact	172.10	90.26	40.31	20.15	30.23	1.53	4.33

Conclusion

From the present study it can be concluded that the cultivars GS 600 (0.86 nymphs/2 cm^2 and 1.95 adults/ leaf) was categorized as resistant to whitefly. Whereas, the cultivars Omnia, Emarald, Arka Rakshak, Arka Samrat and Arka Abhedh (1.75, 2.08, 2.32, 2.66 and 2.80 live mines/ leaf, respectively with 14.54, 15.79, 17.21, 18.90 and 19.87 % leaf infestation) were categorized as moderately resistant to leaf miner. Further, the cultivars *viz.,* Omnia, Emarald and Arka Rakshak (0.91, 0.77 and 1.12 mines/ leaf with 18.02, 16.16 and 20.28 % blotch miner/ tomato pin worm infestation) were categorized as moderately resistant to tomato pin worm.

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References

1. Ambule AT, Radadia GG, Patil DL, Toke NR. Morphological characters of tomato in relation to resistance against tomato fruit borer, *Helicoverpa armigera* (Hubner). International Journal Plant Protection, 2015; 8(1):152-156.
2. Anu BC, Saha T, Kumari SAK. Screening of tomato genotypes for tolerance or susceptibility against sucking pests under field condition. Journal of Entomology and Zoology Studies, 2020; 8(2):742-745.
3. Bitew MK. Significant role of wild genotypes of tomato trichomes for *Tuta absoluta* resistance. Journal of Plant Genetics and Breeding, 2018; 2(1):01-13.
4. Darbain SALEM, Emam AK, Helmi A, El-Badawy SS, Moussa S. Susceptibility of certain tomato cultivars to infestation with *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in relation to leaflet trichomes. Egyptian Journal of Agricultural Research, 2016; 94(8):829-840.
5. Deepak R, Singh AK, Sushil SN, Singh RK, Jha SK, Tyagi MP. Evaluation of promising tomato cultivars against American serpentine leaf miner (*Liriomyza trifolii*, Burgess) in North West plain of Uttar Pradesh, India. International Journal of Science Research, 2013; 3(4):01-06.
6. Gharekhani GH, Salek-Ebrahimi H. Evaluating the damage of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on some cultivars of tomato under greenhouse condition. Archives of Phytopathology and Plant Protection, 2013, 01-08.
7. Huma K, Abu Bakar MR, Muhammad A, Muhammad AA, Muhammad SK, Muhammad MM. Effects of plant morphology on the incidence of sucking insect pests complex in few genotypes of cotton. Journal of the Saudi Society of Agricultural Sciences, 2017; 16:344-349.

8. Jamuna B, Bheemanna M, Hosamani AC, Timmanna, Naveen R. Screening of tomato cultivars (hybrids/varieties) for whitefly, *B. tabaci* in field condition. International Journal of Current Microbiology and Applied Sciences, 2017; 6(7):903-908.
9. Kachave DR, Sonkamble MM, Patil SK. Population dynamics of major insect pests infesting to tomato, *Lycopersicon esculentum* (Miller). Journal of Pharmacognosy and Phytochemistry, 2020; 9(3):344-348.
10. Mandloi R, Pachori R, Sharma AK, Thomas M, Thakur AS. Impact of weather factors on the incidence of major insect pests of tomato (*Solanum lycopersicon* l.) cv. H-86 (Kashi Vishesh). The Ecoscan, 2015; 8(1):7-12.
11. Michaelides G, Seraphides N, Pitsillou M, Sfenthourakis S. Susceptibility of cypriot *Tuta absoluta* populations to four targeted insecticides and control failure likelihood. Journal of Applied Entomology, 2019; 143(5):508-517.
12. Mishra SK, Saraf RK, Gupta V, Tiwari A. Screening of tomato hybrids against whitefly, *Bemisia tabaci* (Gen.) under field condition. Journal of Entomology and Zoology Studies, 2019; 7(4):479-481.
13. Mohan M, Anitha N. Evaluation of tomato cultivars for field tolerance to American serpentine leaf miner, *Liriomyza trifolii* (Burgess). Journal of Entomological Research, 2018; 42(2):163-166.
14. Mwila N, Rubaihayo PR, Kyamanywa S, Odong TL, Nuwamanya E, Mwala M, *et al*. Biochemical factors associated with cassava resistance to whitefly infestation. African Crop Science Journal, 2017; 25(3):365-385.
15. Neiva IP, Andrade Júnior VCD, Maluf WR, Oliveira CM, Maciel GM. Role of allelochemicals and trichome density in the resistance of tomato to whitefly. Ciência e Agrotecnologia, 2013; 37(1):61-67.
16. Oliveira FA, Da Silva DJH, Leite GLD, Jham GN, Picanco M. Resistance of 57 greenhouse-grown accessions of *Lycopersicon esculentum* and three cultivars to *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Scientific Horticulture, 2008; 119(2):182-187.
17. Oriani MAG, Vendramim JD. Influence of trichomes on attractiveness and ovipositional preference of *Bemisia tabaci* (Genn.) B biotype (Hemiptera: Aleyrodidae) on tomato genotypes. Neotropical Entomology, 2010; 39(6):1002-1007.
18. Ramazeame L, Maheswari S, Vindyashree M. Varietal preference of whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae) on tomato. Trends in Biosciences, 2015; 8(22):6184-6194.
19. Ranganna S. Handbook of analysis and quality control for fruit and vegetable products. Tata Mc Graw Hill publishers, Delhi, 1979, p405-415.
20. Rasheed VA, Rao SK, Babu TR, Murali T, Krishna BV, Naidu GM. Biophysical parameters of different tomato genotypes responsible for resistance/ susceptibility to South American tomato leaf miner, *Tuta absoluta* (Meyrick). Journal of Pharmacognosy and Phytochemistry, 2018; 7(6):1130-1136.
21. Sachin US, Venkateshalu B, Fakrudin B, Kotikal YK, Raghavendra KM, Hadimani HP, *et al*. Influence of trichomes types on occurrence of whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) population on minicore accessions of tomato (Solanum lycopersicum L.). International Journal of Entomological Research, 2019; 5(1):06-12.
22. Sarkar P, Chakraborti S, Chakraborty D. Field screening of some tomato genotypes against leaf miner under west Bengal conditions. International Journal of Advanced Research in Biological Sciences, 2017; 7(3):490-494.
23. Selvanarayanan V, Muthukumaran N. Insect resistance in tomato accessions and their hybrid derivatives in Tamil Nadu, India. Communications in agricultural and applied biological sciences, 2005; 70(4):613-624.
24. Shoaf JW, Lium BW. Improved extraction of chlorophyll a and b from algae using dimethyl sulfoxide Limnol. Oceanogr, 1976; 21:926-927.
25. Sohrabi F, Nooryazdan1 H, Gharati1 B, Saeidi Z. Evaluation of ten tomato cultivars for resistance against tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) under field infestation conditions. Entomologia Generalis, 2016; 36(2):163-175.
26. Somato RG, Jat BL, Choudhary MD. Varietal screening of chilli, *Capsicum annum* L. against major sucking insect pests. Journal of Entomology and Zoology Studies, 2018; 6(1):995-999.
27. Sridhar V, Sadashiva AT, Rao VK, Swathi P, Gadad HS. Trichome and biochemical basis of resistance against *Tuta absoluta* in tomato genotypes. Plant Genetic Resources, 2019; 1(5):1479-2621.
28. Tabassum N, Nadagouda S, Beldhadi RV. Influence of biochemical parameters in the plants treated with PGRs on sucking insect pests population in Bt cotton. Journal of Entomological Research, 2019; 43(1):1-6.
29. Zeshan MA, Khan MA, Ali S, Arshad M. Phenotypic evaluation of tomato germplasm for the source of resistance against tomato leaf curl virus disease. The Journal of Animal & Plant Sciences, 2016; 26(1):194-200.
30. Zhang XR, Xing ZL, Lei ZR, Gao YL. Recent status of the invasive leaf miner *Liriomyza trifolii* in China. South Western Entomologist, 2017; 42(1):301-304.