Research Article

Appraisal of Different Tomato Genotypes against *Scirtothrips dorsalis* (Thysanoptera: Thripidae) Infestation with Reference to Morphological Plant Characters

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Abstract | *Scirtothrips dorsalis* is a devastating pest of tomato. The objective of this study was to screen commercially available tomato genotype and to identify the morphological plant characters responsible for resistance against *S. dorsalis*. For this purpose, five commercially cultivated tomato genotypes (Riogrande, Riogrande H, Bombino, Roma VF and Roma) were evaluated against thrips (*S. dorsalis*) at A.R.I. Tarnab, Peshawar, Pakistan during spring 2017 in randomized complete block design with three replications. Trichome study was also carried out to know the type of trichomes responsible for resistance. Results revealed that genotypes differed significantly in response to *S. dorsalis* populations. *S. dorsalis* infestation started on April 3rd and peak population (11.73±0.55) was noted on May 1st on Bambino then population declined in the proceeding weeks, no *S. dorsalis* were recorded after June 22nd. In general, Roma supported lowest no. (4.16±0.23) of *S. dorsalis* plant^{-1} and Riogrande supported the highest (4.89±0.25) *S. dorsalis* plant $^{-1}$ and were found comparatively resistant and susceptible respectively. There were more glandular trichomes than non-glandular trichomes on leaves. Among the glandular trichomes, Type IV was the most abundant followed by Type VI whereas Type I and VII were rarely found on the leaf of the tested genotypes. Among the non-glandular trichomes, Type V was most abundant compared to II, III VIII. RomaVF had higher trichome density (52.58±0.49 and 62.48±2.7 per mm^2) followed Bambino (48.60±1.95 and 49.71±71 per mm^2) and Roma (45.82±2.11 and 51.65±2.47 per mm^2) on adaxial and abaxial leaf surfaces respectively. Negative relationship between *S. dorsalis* density with trichome density and type was observed in the tested tomato genotype. Morphological plant characters like glandular trichomes taking part in resistance against *S. dorsalis* can be used as an important tool in an integrated pest management model.

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Introduction

Tomato (*Lycopersicum esculentum*) is an important cash crop ranked second after potato globally (Adalid et al., 2004). In Pakistan, tomato is cultivated on a total area of 52.3 thousand hectares with a total production of 530,000 tons. In 2016-2017, among the five provinces across the country, Khyber Pakhthunkhwa ranks third with a production of 9.8 tones (Anonymous, 2018).

In our country tomato yield is not satisfactory due to various biotic and abiotic factors. Among these, insect and diseases are the major constraints. Tomato crop is attacked by a number of insect pests including several species of thrips. *Scirtothrips dorsalis* (Thysanoptera: Thripidae) is minute polyphagous insect pest (Atakan, 2011) and both nymphs and adults feed upon the cellular content of leaves, resulting in white silvery spots (Koschier and Sedy, 2001). *S. dorsalis* infestation reduces photosynthesis which leads to shedding of flowers and fruits reducing fruit productivity. In case of severe infestation, the infested plant become curled wrinkled, dried and ultimately die (Kenedall and Capinera, 1987; Atwal, 1976).

Beside the direct damages, it is an important vector of many viral diseases e.g. tomato mosaic virus, tomato leaf curl virus, potato virus, cucumber mosaic virus, tomato yellow top virus, tomato spotted wilt virus and tomato ring spot virus in Pakistan causing 20-90% losses in different crops (Mughal, 1995; Hameed, 1995; Hogenhout et al., 2008). Virus infection is difficult to control (Persley et al., 2007). Therefore, management strategy should focus on vector control.

In Pakistan, farmers mostly rely on synthetic insecticides for the control of *S. dorsalis*. However, the use of these insecticides results in development of insect resistance to insecticide, residue problems on crops and also has adverse effect on human health and the environment. To overcome such problems associated with the use of synthetic insecticides for *S. dorsalis* control. Host plant resistance plays a vital role as it is safe and compatible with all other control measures in an IPM program. 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). Plant resistance to pests is influenced by morphological and biochemical plant factors specially the trichomes.

Trichomes are hairy structures originated from epidermal cells of plant and classified as glandular and non glandular (Glas et al., 2012). Glandular trichomes in tomato plant have been associated with the production of secondary metabolites or they may involve in the secretion of gummy or sticky exudates that hamper the insect (David and Eswaramoorty, 1988). While non glandular trichomes act as physical barrier that limiting insect contact with the host plant. Trichomes density and its distribution on leaf surface are the best predictors of many herbivores resistance including homopterous insects Heinz and Zalom (1995). Resistance in several tomato genotypes to *S. dorsalis* has been reported by (Kumar et al., 1995; Mirnezhad et al., 2010; Vosman et al., 2018) due to the presence of type IV glandular trichomes that release acylsugars which form a sticky net that may trap insects (Mirnezhad et al., 2010; Leckie et al., 2016).

In Pakistan, work on morphological antixenosis mechanism of resistance in tomato to *S. dorsalis* infestation is very limit. Hence, the present study is an attempt to explore the antixenosis resistance level of commonly grown tomato cultivar of Khyber Pakhthunkhwa to *S. dorsalis* infestation.

Materials and Methods

Healthy tomato seedlings of uniform size of each genotype (Riogrande, Riogrande H, Bombino, Roma VF and Roma) were transplanted on 25th of March 2017 at Agricultural Research Institute Tarnab (34.0123ºN, 71.7074ºE), Peshawar, Pakistan, in a Randomized Complete Block Design with three replications. Ten plants of each genotype were transplanted separately in experimental plot measuring 3 m x 1.5 m. Plant to plant and row to row distance were 45 cm and 90 cm respectively. Total experimental area was 12.5m x 10 m. All plots were exposed to natural infestation and no preventive measures were applied throughout the growing season. The data were recorded on the following parameters.

S. dorsalis population density plant^{-1}

S. dorsalis population (nymph and adult) was recorded on five randomly selected plants at each observation. Number of nymph and adult were counted by giving a strong shake to the plant. All fallen *S. dorsalis* nymph and adult onto a white paper placed beneath the plant were counted with naked eye. Data was recorded on weekly basis for eight weeks from April 3rd to June 22nd).

Total yield (kg ha^{-1})

Tomatoes after each picking from each plot were weighted separately and the total yield of tomato was obtained by adding the yield from all pickings for each plot and then was converted to yield kg ha^{-1}.

Trichome density and leaf area (cm²)

Ten leaf samples of each genotype were selected for trichome study. Trichomes were counted on 1mm² transverse leaf portion on both the adaxial and abaxial leaf surface under trinocular stereo zoom microscope 350X with 5 Mp Camera (NIKON, SMZ 745T). The same 10 leaves were selected for measuring leaf area with the help of leaf area meter (LICOR, LI-3100).

Statistical analysis

The data recorded on all the above parameters were subjected to analysis of variance and means were separated by using LSD test at 5% level of significance by using Statistix 8.5. Correlation analysis was also carried out between the *S. dorsalis* density with trichomes density to find out morphological factors responsible for resistance in the tested tomato genotypes.

Results and Discussion

Scirtothrips dorsalis population plant^{-1}

S. dorsalis plant^{-1} on different genotypes at weekly interval (April 3rd to May 22nd) were significant, varied from 0.06 to 11.73 plant^{-1}. *S. dorsalis* infestation started on April 3rd, However, Riogrande had lowest *S. dorsalis* population (0.33±0.14 plant^{-1}) than other genotypes (0.57±0.14 - 0.73±0.14 plant^{-1}) *(F= 10.67; df= 4; P= 0.002)*. *S. doralis* population significantly increased in the subsequent weeks and reached to the peak on 1st May where *S. dorsalis* population was significantly high on Bambino (11.73±0.55 plant^{-1}) and lowest on Roma VF (8.86±0.20 plant^{-1}) *(F= 17.98, df= 4; P= 0.0005)*. Afterward, population decline in the successive weeks and diminished on May 22nd with highest *S. dorsalis* density on Riogrande (0.66±0.13 plant^{-1}) and lowest on Bambino and Roma (0.13 ±0.14 plant^{-1}) respectively *(F= 26.38, df= 4; P= 0.0001)* (Figure 1).

Significant variation in average *S. dorsalis* population was recorded on different genotypes (F= 8.67; df= 4; *P* < 0.05). However, average seasonal population of *S. dorsalis* was significantly high (4.89±0.25 plant^{-1}) on Riogrande and low on Roma (4.16 ±0.23 plant^{-1}). Response of the remaining genotype Riogrande H (4.40±0.21 plant^{-1}) and Bambino (4.51 ±0.14 plant^{-1}) and Roma VF (4.33±0.33 plant^{-1}) were non significantly different from each other but significantly lower that Riogrande (Figure 2).

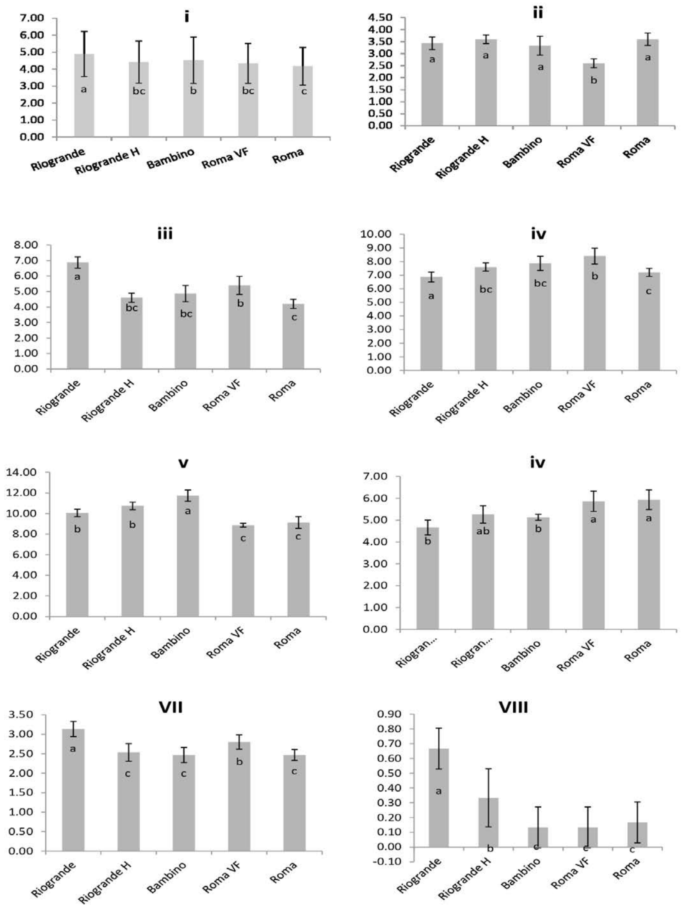

Figure 1: *S. dorsalis population plant^{-1} on tomato genotypes on different dates i: 3rd April; ii, 10th April; iii, 17th April; 24th April; v, 1st May; vi, 8th May; vii, 15th May; viii, 22nd May 2017. Bars marked with different letters are significantly different at (P<0.05).*

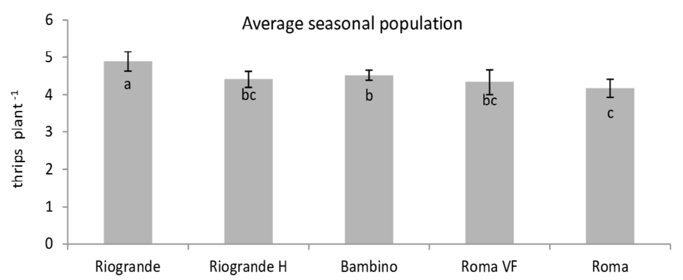

Figure 2: *Average seasonal S. dorsalis population on tomato genotypes during 2017 (3rd April to 22nd May). Bars marked with different letters are significantly different at (P<0.05).*

Trichomes density and leaf area

Significant difference in leaf area was observed in the tested genotypes. Bigger leaf area of 31.47±0.74 cm² (F= 14.04, df = 9, P = 0.001) was recorded in Riogrande H, followed by Riogrande, Bambino, Roma VF and Roma ranging from 28.04 to 23.64 cm² (Figure 3).

Trichome density on the adaxial and abaxial leaf surfaces was maximum in RomaVF followed by Bambino and Roma (Tables 1 and 2). In all genotypes, both the leaf surfaces possessed more glandular trichomes than non glandular. Glandular trichome on adaxial leaf surface was maximum in Roma VF (34.58±0.80) followed by Roma (31.75±1.41) and Bambino (30.94±0.94) while on abaxial leaf surface glandular trichome was highest in Roma (39.24±2.02) and Roma VF (38.64±2.01). Similarly, non glandular trichomes were highest on adaxial leaf surface of Roma VF (18±0.75) followed by Bambino (17.66±1.01) and on abaxial leaf surface it was maximum in Roma VF (23.84±0.85). Among the glandular trichome, Type IV was the most abundant on both the leaf surfaces followed by type VI while type I and VII glandular trichomes were very rare one on the leaves of selected genotypes. While Type V was the most abundant among the non glandular followed by type II while type III and VIII were the most rare one.

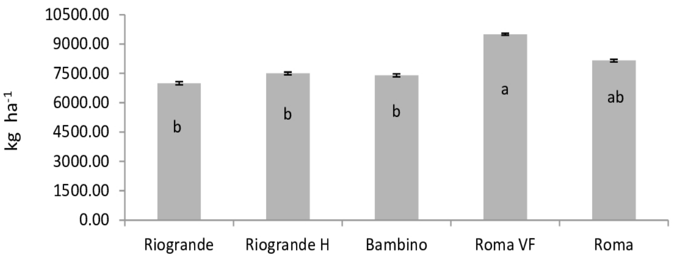

Figure 3: *Yield of tomato different genotypes during 2017. Bars marked with different letters are significantly different at (P<0.05).*

Correlation analysis revealed *S. dorsalis* density is significantly affected by the trichome density and type (Table 3). Total trichome density on both the upper and lower leaf surfaces is negatively correlated with *S. dorsalis* density (r = - 0.4710) and (r = - 0.4392) respectively. Negative correlation also existed among both the glandular and no glandular trichomes on both the leaf surfaces. All types of non glandular trichomes were negatively correlated with *S. dorsalis* density. However, among glandular trichomes all types were negatively correlated with *S. dorsalis* density except type VI which showed positive correlation with *S. dorsalis* density on both the adaxial and abaxial leaf surfaces.

Yield (Kg ha^{-1})

The highest yield was recorded for Roma VF (9504±147.22 kg ha^{-1}) followed by Roma with yield of 8156 ± 211.31kg ha^{-1}. The genotype Riogrande H, Bombino and Riogrande yielded 7499±213.62, 7404±233.25 and 7000±244.22 kg ha^{-1} respectively. These being non-significant from each other but significantly lower than Roma VF than Roma VF (Figure 4).

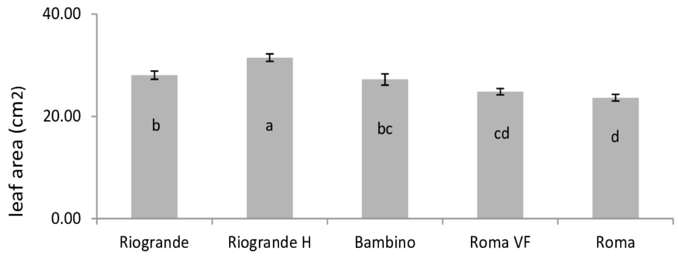

Figure 4: *Leaf area of different tomato genotypes during 2017. Bars marked with different letters are significantly different at (P<0.05).*

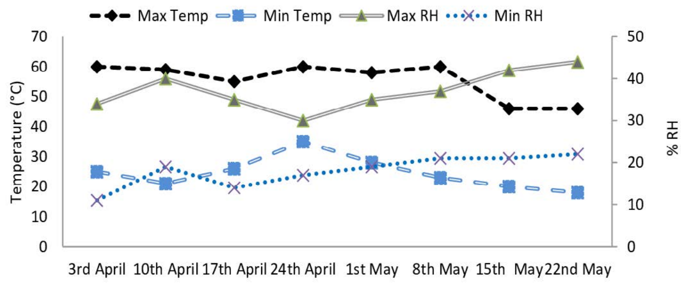

Figure 5: *Temperature and Relative humidity recorded during tomato cropping season in Peshawar during 2017.*

The genus *Lycopersicum* offers an array of defense traits against insect (Kennedy, 2003). *S. dorsalis* infestation varied significantly among Riogrande, Giogrande H, Bambino, Roma VF and Roma. Riogrande was found the most preferred host plant that had highest *S. dorsalis* infestation. Roma was found the least preferred plant and had lowest *S. dorsalis* infestation (Figure 2). Variation in the *S. dorsalis* infestation could be due to difference in physical as well as biochemical factors of the tested genotypes.

S. dorsalis incident was highest at flowering stage compared to vegetative or mature stages which was also observed by Ssemwogerere et al. (2013) who indicated that the primary characteristic in thrips locate a host plant using visual clues such as the colors blue, white, and yellow (Terry, 1997). Childers and Brecht (1996) and De Kogel and Koschier (2003) found 60 times more thrips density on plants with flowers than plants of the same age without flowers.

Present study found peak *S. dorsalis* density in Peshawar area in 1st week of May when plants were in flowering stage, when the max and min temperature was 17 and 30°C respectively with 35 - 55% RH with very low precipitation (Figure 5). Thrips population is strongly influenced by climatic conditions (Lewis, 1997). The drier weather encourages the onset of thrips damage and severe the symptoms can be observed (Dobson et al., 2002). We also observed high *S. dorsalis* populations during optimum temperature with low

Table 1: *Mean number of Trichomes (mm^{-1} ± SE) on adaxial leaf surface of different tomato genotypes.*

Genotypes/	Glandular			Non glandular		Total glandular	Total Non glandular	Total Trichomes density
	Type IV	Type VI	Others (I+VII)	Type V	Others (II +III+VIII)			
Riogrande	19.00±1.04c	3.28±0.15a	0.95±0.09c	7.24±0.82c	0.70±0.09 b	123.24±1.07c	7.95±0.90c	31.19±1.89c
Riogrande H	15.25±0.54d	2.07±0.12b	0.88± 0.10c	6.83±0.65c	0.78±0.11b	18.21±0.46d	7.62±0.58c	25.83±0.38d
Bambino	25.64±0.81b	3.28±0.14a	2.02± 0.13b	14.55±1.00a	3.10±0.06a	30.94±0.94 b	17.66±1.01a	48.60±1.95b
Roma VF	29.83±0.87a	3.12±0.14a	1.62± 0.06b	15.45±0.89a	2.54±0.21a	34.58±0.80a	18.00±0.75a	52.58±0.49a
Roma	26.34±1.25b	1.45±0.09c	3.96± 0.27a	11.44±0.67b	2.63±0.28a	31.75±1.41ab	14.08±0.71b	45.82±2.11b
$LSD_{(0.05)}$	2.917	0.458	0.411	1.725	0.608	3.013	1.683	3.692

Mean followed by different letters in each column is significantly different at 0.05 level of significance followed by LSD test.

Table 2: *Mean number of Trichomes (mm^{-1} ± SE) on abaxial leaf surface of different tomato genotypes.*

Genotypes	Glandular			Non glandular		Total glandular trichomes	Total non glandular trichomes	Total trichomes density
	Type IV	Type VI	Others (I+VII)	Type V	Others (II +III+VIII)			
Riogrande	23.73±0.58c	4.11±0.60a	1.74±0.15c	10.48±0.63cd	0.65±0.04c	29.60±0.72b	11.13±0.59cd	40.73±1.29c
Riogrande H	19.88±0.54c	2.79±0.39b	1.24±0.13c	9.27±0.11d	0.38±0.08c	23.91±0.58c	9.65±0.15d	33.57±0.71d
Bambino	25.57±0.88b	2.52±0.19b	2.46±0.48bc	15.56±0.40b	3.59±0.13b	30.56±1.08b	19.15±0.52b	49.71±1.59b
Roma VF	31.59±1.64a	3.72±0.12ab	3.33±0.42ab	18.88±0.68a	4.94±0.19a	38.64±2.01a	23.84±0.85a	62.48±2.71a
Roma	30.53±1.65a	4.24±0.51a	4.46±0.60a	11.87±0.52c	0.54±0.11c	39.24±2.02a	12.41±0.45c	51.65± 2.47b
$LSD_{(0.05)}$	4.181	1.282	1.306	1.669	0.420	4.860	1.830	6.452

Mean followed by different letters in each column is significantly different at 0.05 level of significance followed by LSD test.

Table 3: *Correlation analysis between Trichomes and thrips density of different tomato genotypes.*

	Glandular			Non Glandular		Total glandular	Total non glandular	Total trichomes density
Trichomes type /leaf surface	Type IV	Type VI	Others (I+VII)	Type V	Others (II+III+VIII)			
adaxial leaf surafce	-0.4735	0.6896	-0.6742	-0.4126	-0.5593	-0.4523	-0.4768	-0.4710
abaxial leaf surface	-0.5213	0.3418	-0.6797	-0.2782	-0.1604	-0.5240	-0.2389	-0.4392

and infrequent rains which probably favored *S. dorsalis* build-up on tomato. Nizamani et al. (2002) reported that the population of thrips reached to peak in last week of June and 1st week of July (avg temp 32ºC) then thrips population drastically decline up to 1st week of August (avg temp 28ºC). While Sewify et al. (1996) observed peak population during July, August and September. Whereas, Gupta et al. (1997) revealed that 4th week of July to 2nd week of August is the most favorable period for peak thrips infestation. In our country no work has been done on thrips in tomato. So the present findings cannot be sticky compared with findings of the earlier researchers. As *S. dorsalis* is polyphagous pest and distributed worldwide so the variation in density and peak infestation period could be due its polyphagous nature and temperature variations in different ecological conditions.

Resistance in tomato to different herbivores has been associated to the presence to both non glandular and glandular leaf trichomes. In addition to being a physical barrier, glandular trichomes release different chemicals which are associated with pest resistance (Gil and Alvarez, 2015). Trichome study showed that all the selected tomato genotypes exhibited both the glandular and non glandular trichomes. Significant variation in trichome density and types were observed in tomato genotypes. Trichomes on tomato foliage have been categorized as Type I, IV, VI and VII are glandular while Type II, III, V which are non glandular (Luckwill, 1943). Irrespective of the genotype, it has been observed that abaxial leaf surface had more trichomes than adaxial leaf surface. Type IV trichomes were the most abundant on both the adaxial and abaxial leaf surface found in this study as well as reported by

(Fernandez et al., 2003). Whereas Selvanarayanan and Naratanasamy (2006) reported that Type V trichome (non glandular) was the most abundant on tomato foliage. Such contradiction in trichome type could be possibility due to differences in genotypes and their genetic makeup of genotype. Type IV trichomes and Type I (which are rare on tomato leaves) are the source of acylsugur which combat insect attack by poising and stick insect (Weinhold and Baldwin, 2011). Furthermore, secretion of type VI trichome are the source of methyl ketones which are natural insecticides (Williams, et al., 1980) but methyl ketones has been reported in very low level in some tomato genotypes (Fridman, et al., 2005; Ben-Israel et al., 2009). Correlation analysis showed that trichome plays an important role in conferring resistance against *S. dorsalis.* Both glandular and non-glandular trichomes were observed to be negatively correlated with *S. dorsalis* density except type VI which was positively correlated with *S. dorsalis* density (Table 3). As type VI trichomes is the source of meth ketones is not predominantly found on tomato leaves of the tested genotypes used in this study might be one of the reason for positive correlation. Mirnezhad et al. (2010) clearly indicated resistance and susceptibility of tomato plant against thrips, is not influenced morphological plant character like by plant height toughness, leaves number and leaf area. Instead, resistance mainly influenced by chemistry of the glandular trichomes.

Significant difference among the tested genotypes was observed in term of yield. Such variation in yield may be due to genetic makeup of genotype. Present studies showed that genotypes with lower *S. dorsalis* infestation gave better yield. Such variation in yield among tomato genotypes due to insect pest has also been reported by (Rehman et al., 2000; Rida et al., 2002; Ahmad et al., 2007). Genotype Roma VF had less *S. dorsalis* density per plant gave maximum yield, while Bambino yielded minimum fruits had high *S. dorsalis* population. So under certain conditions, *S. dorsalis* may (along with other factors) contribute to yield. The absence of a strong correlation (r = 0.224) between *S. dorsalis* population and yield suggests that the *S. dorsalis* populations encountered in this study were not a major factor in causing variation in yield of tomato fruit. So further study is needed in absence of other major insect pest of tomato to clarify the extent of losses by *S. dorsalis* in tomato crop.

Conclusions and Recommendations

This study provides base line information of *S. dorsalis* density on tomato crop in Peshawar area. None of the tested genotype was free from *S. dorsalis* infestation. However, the genotype Roma was found to be the comparatively resistant and Riogrande was found to be susceptible to *S. dorsalis* infestation among the tested genotypes. Density of glandular trichomes was dominant over non glandular and *S. dorsalis* infestation was influenced by the trichome density and type. Investigating biochemical analysis of glandular trichomes of the tested tomato genotypes could be a step towards development of a *S. dorsalis* resistant variety that can be incorporated into an IPM strategy.

Novelty Statement

This is the first study which indicates the occurrence of *Scirtothrips dorsalis* (Thysanoptera: Thripidae) on tomato in Peshawar, Khyber Pakhthunkhwa and its relationship with morphological plant characters of tomato plant.

Author's Contribution

AU and RAS presented the basic idea and designed research. AK principle investigator. AU analyzed the data and wrote the manuscript. TI made critical correction in the first draft.

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