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Screening of Onion (*Allium cepa* L.) Accessions for Susceptibility to *Thrips tabaci* L. (Thysanoptera: Thripidae) under Insecticide-free Field Conditions

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ABSTRACT

Thrips tabaci Lind. commonly called as onion thrips, is important foliage feeding pest of vegetables crops of Pakistan. For this research Ten onion accessions Early red, Phulkara, Chiltan, Saryab red, Swat-1, Hazara, Nasarpuri, Red imposta, VRIO-7, VRIO-8 were evaluated during *rabi* season of 2017-18 at Chak Shahzad, Islamabad (33° 40 N and 73° 08 E), for their susceptibility to onion thrips under field conditions. Seeds of different onion varieties were obtained from Ayub Agriculture Research Institute Faisalabad (AARI), National Agriculture Research Center Islamabad (NARC) and BARC Quetta. Experiments were planned as Randomized Complete Block Design (RCBD) which were replicated five times. The plot size was kept at 3.0 × 3.0 m, with ridge to ridge distance of 15 cm and 10 cm onion plant-to-plant distance on each ridge. Fertilization, irrigation, weeding and all other agronomic practices were carried out in onion experimental fields except thrips management practices. Results revealed that thrips incidence occur after 6th week of transplantation. Saryab red found relatively susceptible against thrips with maximum mean population of 52.41±15.42 individuals per plant while Red imposta was relatively resistant with 37.02±9.97 individuals per plant infestation. *Thrips tabaci* showed maximum activity at 24 °c which shows positive correlation between temperature and thrips development. Considering categorization of ten onion accessions against thrips, Red Imposta was found as highly resistrant, early red, Chiltan, Nasar puri as resistant cultivar whereas Swat 1, Virio7 and 8, Phulkara, Saryab red were found susceptible while Hazara grouped in highly susceptible category due to maximum thrips infestation. Visual assessments depicted that all resistant cultivars had yellowish-green leaf color whereas the cultivars with blue-green foliage showed susceptibility towards thrips infestation. The Red imposta had lowest thrips infestation suggesting strong antibiosis and antixenosis.

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Authors' Contribution
Quratulain conducted research trails. AM planned the study. MN conceptualized the study. GS planned layout. MKR wrote the manuscript. RM editing and reviewed the manuscript.

Key words
Onion thrips, *Thrips tabaci*, Promising cultivars, Onion varieties, Screening

INTRODUCTION

Onion condiment (*Allium cepa* L.) is economically important widely grown binnenial vegetable, consumed in daily culinary dishes as green leafy vegetable and dry bulb form (Shaikh *et al*., 2014). In the world ranking, Pakistan stand as 6th largest exporter of onion with the share of 3% in international market (Haider *et al*., 2014). It is cultivated on 130.6 thousand hectares of land in Pakistan with annual production of 1674.6 thousand tons (GOP, 2016). The onions vary in their characters such as shape, coloration and taste. Onion bulbs have a great variation in color (white, yellow, red) and shape (round or flattened). Onion is important due to its medicinal benefits and it is rich in phosphorus, calcium and carbohydrates.

In Pakistan onion production is facing a threat of sucking pests. The insect pests which damages onion field crop mainly include thrips, head borer, maggots, cutworm and leaf minors (Khan *et al*., 2015). *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) is most destructive and worldwide pest of *Allium cepa* causing direct and indirect damage to crop. It reduces 50 percent onion yield by sucking cell sap as direct damage while inflict indirect damage through spreading various diseases (Lewis, 1997). Epidermal cells of onion leaves are destroyed as a result of thrips feeding producing silvery blotches on leaves. Thrips act as a vector of various diseases, minute in size, highly fecunditive, phytophagous, multivolatine, polyphagous and cosmopolitan insect pest. It is capable of disseminating Tops virus and IYSV in onion young

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seedlings (Stuart *et al*., 2011). Thrips are 2mm long, slenderical shaped vegetable pest. Adults are brown in colour having asymmetrical mouthparts. *Thrips tabaci* life cycle consists of egg, two larval instars, prepupae and pupal stage and adult (Ghabn, 1948). High temperature favours the development of thrips while at low temperature its development slows down (Mound, 1997). It is a pest of more than 140 host plant. Synthetic pesticides are commonly used for thrips managment. Due to its rapid development and concealed habitat, *Thrips tabaci* develop resistance against conventional pesticides. The eco-friendly management practices are required to keep pest population below economic damages by assuring safe mode to beneficial insects (Khaliq *et al*., 2014).

Thrips tabaci is regular pest of alliums (onion and garlic). It occurs round the year on cultivated and wild plants like cotton, okra etc. Considerable efforts and expenditure is employed in its control. Feeding way of *T. tabaci* create problem due to its direct damage by removing cell contents. Scars of silver color on onion leaves visible due to empty cell cavities. Leaf damaged area unable to recover but escalates as plant grows.

Thrips gained importance worldwide due to rapid development, minute size and mobility over the years. Despite of intensive insecticides usage, the level of thrips management attained often remained deficient to overwhelm the economic damage of *T. tabaci* (Shelton *et al*., 2014).

The present study was planned to ascertain the susceptibility and resistance of ten locally used onion accessions against *Thrips tabaci in* Pakistan to devise alternative to chemicals methods for the management of this noxious pest of onion. This field experiment in a farmer field at Islamabad was aimed (1) to explore the comparatively resistant onion genotypes to thrips, (2) to evaluate the accession traits related to thrips infestation and (3) to ascertain the susceptibility of promising genotypes of Pakistani onion cultivars against onion thrips.

MATERIALS AND METHODS

Ten onion accessions Early red, Phulkara, Chiltan, Saryab red, Swat-1, Hazara, Nasarpuri, Red imposta, VRIO-7, VRIO-8 were evaluated during *rabi* season of 2017-18 at Chak Shahzad, Islamabad (33° 40 N and 73° 08 E), for their susceptibility to onion thrips under field conditions. Seeds of different onion varieties were obtained from Ayub Agriculture Research Institute Faisalabad (AARI), National Agriculture Research Center Islamabad (NARC) and BARC Quetta. Experiments were planned as Randomized Complete Block Design (RCBD) which were replicated five times. The plot size was kept at 3.0 × 3.0 m, with ridge to ridge distance of 15 cm and 10 cm onion plant-to-plant distance on each ridge. Fertilization, irrigation, weeding and all other agronomic practices were carried out in onion experimental fields except thrips management practices.

Observation recorded

The susceptibility of ten Selected onion accessions (Early Red, Phulkara, Chiltan, Saryab Red, Swat-1, Hazara, Nasarpuri, Red Imposta, VIRIO-7, VIRIO-8) against *Thrips tabaci* were assessed on the basis of thrips counts (Adults and Nymphs) per plant. Five onion plants were randomly selected from each experimental unit and thrips population was logged by examining the plant till to the harvest of the crop. Thrips population per plant was recorded randomly at weekly intervals from five week after transplantation from each experimental unit by using magnifying glass (11X) till maturity of crop (Maclytyre *et al*., 2005). Mean pest population was worked out and then statistical procedures were done. Yield components of onion (weight of onion plant, weight of onion bulb, height of plant, number of leaves, leaf length and chlorophyll contents) were recorded accordingly.

Varietal categorization for resistance

The onion varieties were categorized into four classes, (i.e. highly resistant, resistant, susceptible and highly susceptible) based on thrips counts per plant. For this purpose of categorization, individual genotype mean value ($\bar{x}_I$) was compared with mean of all genotypes ($\bar{x}$) and standard deviation (sd), following the scale used by Patel *et al*. (2012). Data retransformed were used for $\bar{x}$, $\bar{x}_I$ and standard deviation computation. The scales adopted for categorizing of different genotypes was as.

Categories of resistance	Scale for resistance
Highly resistant (HR)	$\bar{x}_I < \bar{x}$- sd
Resistant (R)	$\bar{x}_I > \bar{x}$ - sd $< \bar{x}$
Susceptible (S)	$\bar{x}_I > \bar{x} < (\bar{x} + sd)$
Highly susceptible (HS)	$\bar{x}_I > (\bar{x} + sd) < (\bar{x} + 2\ sd)$

Leaf damage

Leaf damage ratings caused due to onion thrips were recorded visually only once in onion growing season adopting a scale (ranges from 1 to 9). Damage on different crops due to different insect pest was measured by using similar scales. (Coudriet *et al*., 1979; Smith, 2005). Scales denoted as No damage= 1; Onion leaves 25% white or have blotches on leaves= 3; Onion leaves 50% white or having leaf blotches= 5; 75% of leaves turned white or with blotches on onion leaves= 7 and 9= completely

damaged onion plant (100% white leaves).

Data analysis

Means calculated from various treatments were parted by Tukey's Highly Significant Difference test (5% level of significance). Metrological data were taken from Metrological Department Rawalpindi, Pakistan. Data were statistically analyzed by Statistics 8.1 software.

RESULTS

Screening onion cultivars for Thrips tabaci

The initial count for *Thrips tabaci* was done at 35 days after transplantation of onion plants (DAT) and then data was taken at every seven days interval until 105 DAT for total of 12 counts. Figure 1 shows number of thrips on ten tested accessions and Red Imposta had minimum infestation. Cultivars 'Swat 1' 'Virio 8' 'Virio 7'and 'Phulkara' were taken as susceptible checks. At 83 DAT, significant differences were recorded in the cumulative number of thrips among onion cultivars ($F = 13.03$; $df = 9, 267$; $P < 0.001$) and at 90 DAT ($F = 14.31$; $df = 9, 267$; $P < 0.001$) (Fig. 1). The cultivar 'Red Imposta' had minimum number of thrips but no significant difference shown from 'Early Red', 'Chiltan' and 'Nasar Puri' at ninety DAT and 105 DAT (Fig. 1). *T. tabaci* population was very low (6.6 to7.23 thrips per plant) during the mid of January after 34 days of transplanting in different onion varieties (Fig. 1). Mean thrips population in the all ten onion accessions have no significant difference during screening test. While the cultivar Red Imposta registered the lowest thrips population 37.02±9.97 per plant and Hazara was found most infested by registering the maximum thrips population 53.68±17.97 per plant. Infestation of thrips reached the peak at 83 DAT and started to get down after 90 DAT (Fig. 1). The thrips population during 9th week and onwards started to diminish upto 12th standard week, due to constant reduction in average daily temperature (Fig. 1, Table I). The onion thrips reached to its second population peak, during standard week 13th (42.35 to 58.90 thrips/plant).

At 14th standard week, the thrips infestation gradually reduced upto negligible level due to low daily average temperature (Fig. 1). As for as the seasonal mean population of *T. tabaci* on various onion accession is concerned, the highest seasonal populations per plant recorded were on genotype Hazara 53.68 ± 17.97 followed by Saryab Red, 52.41± 15.42, Virio 7, 52.34± 16.65, Phulkara, 50.31±15.64, Virio 8, 49.71± 14.44, Swat 1, 49.06±15.17, Nasar Puri, 47.54±14.59, Chiltan, 43.64±13.34, Early Red, 43.33± 11.79 respectively and lowest population 37.02± 9.97 was recorded in Red Imposta (Fig. 1).

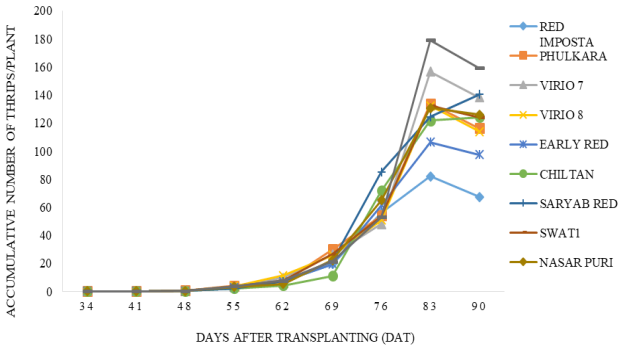

Fig. 1. Cumulative number of thrips population per plant on 10 onion cultivars.
Lines with different letters are significantly different ($P<0.05$, Tukey's test).

Weather effects thrips population

Study showed that *T. tabaci* population lowest and highest peaks 0.24±0.072 and 71.01±4.9 per plant respectively between Feb to March. Thrips populations was lowest 0.028±0.017 per plant during the winter, increasing rapidly during the spring with the increase in temperature, followed by an abrupt decrease in thrips numbers accompanying with senescence of onion plants. Thrips population dynamics with relation to weather factors on all ten varieties showed (Table I). Thrips population directly influenced by temperature and rain fall. Malik *et al*. (2004), Solomon and Morgan (1995) reported that temperature influence insect growth and development directly. Incidence of thrips occurred in the month of Feb after six weeks of transplantation at 4-6 leaf stage. Infestation starts in onion plants (0.028 thrips/plant) in seventh standard week when temperature start rising as 12.71 °c. In the month of Feb due to continuous rise in temperature mean thrips population rises to 15.78 thrips/plant. Population of thrips increases (129.89 thrips/plant) in the month of March with increase in temperature and peak was observed at maximum temperature (22.1 °c) in 13th standard week. It steadily declined to 10.41 thrips/plant due to intensive rainfall in the month of April. Haider *et al*. (2014) reported that rainfall had significantly negative impact on thrips population. After that thrips population declined drastically with increase in temperature.

Onion growth stage and population of Thrips tabaci

During the present experiment, incidence of thrips was observed on all varieties of onion. In initial stages of plant growth, all varieties showed similar response towards thrips infestation. Pest infestation was very low in the month of February when onion have 2-4 leaves/plant. In 7th standard week, infestation of thrips observed on

Table I. Effect of abiotic factors on thrips population.

Standard week	Avg. temp.(°c)	Avg. relative humidity (%)	Rainfall (mm)	Wind speed. km/hr	Thrips population/plant
06	11.64	56.79	7.89	58.26	0.0 ± 0.0E
07	12.71	73.50	37.92	35.98	0.028 ± 0.017 E
08	15.50	69.50	6.48	32.51	0.44 ± 0.045E
09	17.71	74.57	11.41	41.46	15.78 ± 1.25 DE
10	18.14	64.36		17.52	37.46 ± 3.15 C
11	18.21	65.79	10.17	35.48	111.94 ± 8.3 A
12	18.71	63.43		22.33	59.856 ± 3.6 B
13	22.21	57.64		39.52	129.892 ± 8.23 A
14	23.57	62.29	13.41	23.72	120.736 ± 7.94A
15	23.14	63.29	7.61	38.56	64.436 ± 3.84 B
16	20.07	71.93	13.06	23.53	23.84 ± 1.17 CD
17	24.93	46.21		30.03	10.416 ± 0.37DE

Columns having same letter are not statistically different (P≥0.05, ANOVA)

Table II. Categorization of ten different onion accessions for their susceptibility against *T. tabaci.*

Resistance category	Resistance scale	Varieties	Seasonal t. Tabaci population mean ($\bar{x}_i$)
1	**2**	**3**	**4**
Based on population of thrips/Plant: $\bar{x}$ = 47.91 and sd = 5.17			
Highly resistant (HR)	$\bar{x}_1$ < 42.74	Red imposta	37.02
Resistant (R)	$\bar{x}_1$ > 42.74 < 47.91	Early red	43.32
		Chiltan	43.64
		Nasar puri	47.54
Susceptible (S)	$\bar{x}_1$ > 47.91 < 53.08	Swat 1	49.06
		Virio 8	49.71
		Phulkara	50.30
		Virio 7	52.34
		Saryab red	52.41
Highly susceptible (HS)	$\bar{x}_1$ > 53.08 <58.25	Hazara	53.67

Phulkara was 0.16 thrips per plant, on Virio 7 it was 0.08 thrips/plant and on Virio 8 it was 0.04 thrips/plant. Population increased at 4-6 leaves/plant during 8th an 9th standard week. Hazara variety completed its vegetative growth with 12-14 leaves and pest population attained its peak level with 179.04 thrips per plant and 159.24 thrips per plant in Hazara variety during 13th and 14th standard week respectively. While Red imposta showed minimum population with 82.03 thrips per plant and 67.44 thrips per plant in 13th and 14th week, respectively. During bulb enlargement stage, thrips population declined gradually. During 15th standard week thrips population started declining and goes to negligible range in 16th and 17th week.

Concerning week wise pest infestation on different onion varieties; Saryab red showed maximum population of thrips per plant during the season (52.41±15.42 thrips/plant) followed by Virio 7 having mean population 52.34±16.65 thrips/plant. While minimum mean thrips population was observed on Red imposta (37.023±4.97 thrips/plant) followed by Early red (43.32±1.79 Thrips/plant) and Chiltan (43.64±13.34 Thrips/plant) as depicted in Table IV.

Categorization of Onion accessions for susceptibility and resistance against Thrips tabaci

The tested ten accessions *viz.*, Early Red, Phulkara, Chiltan, Saryab Red, Swat1, Hazara, Nasar puri, Red

Imposta, VIRIO 7, VIRIO 8 were categorized into four different groups i.e. highly resistant, resistant, susceptibility and highly susceptible. The evaluated onion accessions were categorized into above mentioned categories based on thrips count per plant and comparing the mean thrips population on individual genotype ($\bar{x}_1$) with thrips mean population of all accessions ($\bar{x}$) and SD (standard deviation) as depicted in Table I.

Based on the thrips population on onion accession, Red Imposta was found with lowest thrips population of 37.02±4.97 per plant which was categorized as highly resistant against *Thrips tabaci* (Table II). However, the onion accessions Early Red, Chiltan, and Nasar Puri were found resistant against *Thrips tabaci* with thrips populations, 43.32±1.79, 43.64±13.34 and 47.54±14.59 per plant, respectively which were less than 47.91 but more than 42.74 thrips population per plant. The cultivars Swat 1, Virio 8, Virio 7, Saryab Red, and Phulkara were susceptible to *Thrips tabaci* with more than 47.91±14.59 thrips/plant but less than 53.08±17.97 thrips per plant. On genotype Hazara thrips mean infestation was more than 53.08±17.97 thrips/plant and categorized as highly susceptible to *Thrips tabaci.*

Table III. Leaf damage ratings on ten different onion accessions due to thrips infestation.

Onion accessions	Leaf damage rating ± SE
Red Imposta	5.77 ± 0.11 ab
Phulkara	5.53 ± 0.27 ab
Virio 7	6.32 ± 0.26 a
Virio 8	5.49 ± 0.12 ab
Early red	5.22 ± 0.34 ab
Chiltan	5.19 ± 0.43 ab
Saryab red	4.91 ± 0.18 ab
Swat 1	5.39 ± 0.48 ab
Hazara	4.37 ± 0.34 b
Nasarpuri	5.38 ± 0.12 ab
Tukey's HSD@5%	0.4248
F-Value	2.90

Columns having same letter are not statistically different (P≥0.05, ANOVA).

Damage ratings for Thrips tabaci

T. tabaci leaf damage was visually rated at 89 (DAT). Results showed that onion accessions were significantly different ($F = 11.35$; $df = 9, 63$; $P < 0.001$) (Table III). Out of the 10 accessions, 02 accessions i.e., Hazara and Saryab Red damage ratings lies between 4.37±0.34 and 4.91±0.18 with 30 and 43% of onion leaf tissues damaged by *T. tabaci*. The cultivar 'Hazara' had significantly minimum damage (42% leaf damage) than many of the commonly cultivated commercial cultivars (e.g. 'Red imposta', 'Phulkara', 'Virio 7', 'Virio 8', 'Early Red') and had similar ratings to 'Saryab red'' (Table III). In experimental field, leaf damage was recorded at 87 DAT and it was 70% in 'Virio 7' as susceptible cultivar.

Characters of onion varieties

Results showed that there is no significant difference among varieties for number of leaves (Table IV). Saryab red contained relatively maximum cholorophyll contents 133.1±19.1 µg mL^{-1} with 18.16 no. of leaves, with relatively maximum leaf length (67.29 cm) followed by Virio-8 chlorophyll content 128.3 µg mL^{-1}, with 19.6 No. of leaves, with leaf length 51.95cm and plant height 60.05cm. Chiltan variety have chlorophyll content 124.1 µg mL^{-1}, with 18.24 No. of leaves, leaf length 59.84 cm, plant height 67.33cm. While Hazara have lowest cholorophyll contents 81.8 µg mL^{-1} with 17.44 No. of leaves, leaf length 54 cm and plant height 46.45 cm. Malik *et al*. (2004a) reported that onion varieties with more number of leaves, more length and height have maximum population of thrips. Saryab red was reported by Malik *et al*. (2004b) as a susceptible variety with maximum plant height and plant weight i.e., 75.71 cm and 204.96 gm, respectively. Similar results were reported by Kibanyu (2013) that thrips infestation is more on taller varieties than short length varieties. As compared to plant weight, Saryab red bulb size was 50.44 gm which shows its maximum vegetative growth and reduced bulb size. Phulkara shows maximum bulb yield with 5060kg/ha while Chiltan showed minimum mean bulb yield as 2248.88kg/ha as shown in Table VI. Colors and foliage attitude were also recorded during the study, various varieties show different characteristic (Table V). The accessions Red Imposta, Phulkara, Virio 7, Virio 8, Swat 1 and Nasar puri shown erected foliage attitude while Early red and Hazar shown intermediate, similarly Chiltan, and Saryab red exhibited prostrate attitude.

DISCUSSION

During this study thrips observed on all varieties of onion. In initial stages of plant growth, all varieties showed similar response towards thrips infestation. Pest infestation was very low in the month of February. Hussain *et al*. (1997) and Hyder and Shariff (1987) also observed almost similar results that thrips infestation start in the first week of February and attain peak in the month of April. Domiciano *et al*. (1993) observed similar situation in onion field.

Table IV. Performance of ten different onion accessions in respect of plant growth characters and yield parameters on thrips infestation.

Varities	Chlorophyll (µg ml^{-1})	No. of leaves/ plant	Leaf length (cm)	Plant height (cm)	Total population means
Red imposta	122.2±5.8 A	15.56±0.61 A	45.73± 0.78CD	53.54 ± 1.21CD	37.023 ± 9.97 A
Phulkara	121.3±8.86 A	17.32±1.09 A	39.63± 2.14D	51.33± 1.07CD	50.307 ± 15.64 A
Virio 7	116.9±9.28 A	17.76±1.05 A	44.90± 1.09CD	48.69± 4.33CD	52.337 ± 16.65 A
Virio 8	128.3±2.62 A	19.6±1.53 A	51.95± 5.5BC	60.05± 5.31BC	49.71 ± 14.44 A
Early red	121.7±1.26 A	15.44±0.78 A	45.62± 0.65CD	53.04± 1.08CD	43.327± 1.79A
Chiltan	124.1±3.77 A	18.24±1.92 A	59.84± 3.39AB	67.33± 3.29AB	43.64 ±13.34 A
Saryab red	133.1±19.5 A	18.16±1.24 A	67.29± 1.11A	75.71± 0.98A	52.41 ±52.41 A
Swat1	115.0±8.13 A	16.84±0.7 A	41.64± 0.8CD	50.47± 1.03CD	49.057 ± 15.17 A
Hazara	81.8±2.58 A	17.44±2.0 A	38.54± 1.16D	46.45± 0.54D	53.677±17.97A
Nasar puri	108.3±8.9 A	17.76±1.6 A	43.09± 1.09CD	51.69± 0.86CD	47.54 ±14.59A
Tukey's HSD@5%	15.403	1.59	3.35	3.48	6.36
F-Value	1.71	1.21	15.25	13.97	11.3

Columns having same letter are not statistically different (P≥0.05, ANOVA).

Table V. Leaf characters (foliage attitude and leaf color) of 10 onion accessions.

Varities	Foliage attitude	Leaf colour
Red imposta	Errect	Yellow green
Phulkara	Errect	Green
Virio 7	Errect	Light green
Virio 8	Errect	Yellow green
Early red	Intermediate	Yellow green
Chiltan	Prostrate	Green
Saryab red	Prostrate	Dark green
Swat1	Errect	Light green
Hazara	Intermediate	Dark green
Nasar puri	Errect	Green

Thrips population build up effects due to variation in rainfall and temperature. Onion thrips became active with increasing temperature in the spring. Population development and growth triggers up to the level when onion senescence begins (Lewis, 1997; Kirk, 1997). Thrips population build up and growth generally influenced by dry weather which favors thrips infestation. While cool and rainy environment significantly reduces thrips population due to high thrips mortality and reduced growth rates (Kirk, 1997). Elevated temperatures required to thrips for flight. Temperature (20 °C) favored the rapid growth of thrips when there was no rainfall. Positive correlation of thrips with temperature and negative correlation of thrips with humidity is also reported by Ullah *et al*. (2010).

Table VI. Mean plant weight and bulb weight of 10 onion accessions (Tukey's HSD@5% ± SD).

Varities	Plant weight (gm)	Bulb weight (gm)	Yield (kg/ha)
Red imposta	118.48±7.73 BCDE	66.92±5.3 ABCD	3717.7
Phulkara	153.00± 4.8BC	91.08 ± 5.4 A	5060.0
Virio 7	142.68± 10.8 BCDE	83.72 ± 7.03 AB	4651.1
Virio 8	162.0± 19.1AB	68.4 ± 5.6 ABCD	3800.0
Early red	104.08± 5.8DE	57.52 ± 2.1 CDE	3195.5
Chiltan	145.2± 7.3BCD	40.48 ± 9.3 E	2248.1
Saryab red	204.96± 15.5A	50.44 ± 3.7 DE	2802.2
Swat 1	124.48± 6.8 BCDE	78.52zxz±5.2 ABC	4362.2
Hazara	100.68± 8.9E	57±5.06 CDE	3166.6
Nasar puri	116.2± 9.6CDE	64.56±5.96 BCDE	3586.6
Tukey's HSD@5%	13.14	7.51	
F-value	11.49	8.5	

Columns having same letter are not statistically different (P≥0.05, ANOVA).

Our studies on onion varieties screening excavated that *T. tabaci* infestation was at peak during 8-10 leaf stage when plant height lies between 20-25 cm. While population shows reduction trend during bulbing stage. Ibrahim and Adesiyun (2009) reported that the onion plant height and number of leaves plays an important role in influencing the onion thrips that infest the onion plants. Critical height that attracts onion thrips probably lies between 22 and 26

cm which is similar to our results. Onion plant attained its maximum height between 7 to 9 weeks after transplantation (Umar *et al*., 2000). Rey *et al*. (1974) reported the similar results as onion plant got its maximum height at bulb formation stage, when 8-13 leaves seemed and 2nd or 3rd leave became desiccated. Young onion plants are unable to provide enough shelter from natural enemies to the thrips. Earlier results confirmed that thrips infestation is recorded more on 8-10 weeks older onion plants than in earlier and later stages. The variation in thrips population throughout the growing season is influenced by different factors like weather, plant structure, thrips population and population dispersation, behavior of insects and agronomic practices (Morsello *et al*., 2014). However, the present finding were in confirmation with Kisha (1977) that thrips breed only in the months of February and April.

Photosynthesis rate in leaves and production of dry matter are key factors that depends on chlorophyll contents of leaf (Mao et al., 2007; Ghosh et al., 2004). Maximum leaf chlorophyll content was recorded in Saryab red as 133.1µg mL^{-1} and 128.3 µg mL^{-1} in Virio 8 with maximum plant weight i.e. 204.96gm and 162gm, respectively at the end of growing season. Funayana et al. (1997) and Mary et al. (2006) findings indicated that photosynthetic concentration have variation due to environmental factors. Degradation of chlorophyll is a difficult phenomenon that often complements insect feeding damage to plants studied by Ni et al. (2001).

Ten onion varieties were analyzed for leaf damage due to thrips infestation. Leaf damage mean value of onion varieties were found significantly different for leaf damage. Results indicated that virio 7 is highly susceptible variety with leaf damage rating mean value 6.32 ± 0.26 a similar result showed by (Haider *et al*., 2014). Population of thrips in Virio 7 and Hazara were high with 66 % leaf damage and 41 % leaf damage respectively recorded at 89 days after transplanting. While Phulkara and Swat-1 have potential to withstand the pest attack. Among these varieties eight varieties showed no significant difference.

Hazara and Saryab red varities showed maximum thrips population as 53.6 thrips/plant and 52.41 thrips/plant during the growing season with dark green foliage. Dark green colour showed positive correlation to onion thrips population (Ellis *et al*., 1996; Sepahvand *et al*., 2009). Alimousavi *et al*. (2007) studied that leaf coloration is major factor in resistance to thrips damage. Yellowish green glossy foliage genotypes have lower leaf temperature than accessions with dark green foliage. This is due to more light absorption in dark green leaves resulting in high temperature in these leaf areas. While high temperature favors thrips infestation. Caudrict *et al*. (1979) reported that due to antixenotic and antibiotic characteristics of onion plants thrips population buildup influenced. Varieties with yellowish green leaves and open architecture, having wax layer and large leaf angles have less thrips infestation (Diaz-Montano *et al*., 2010; Molenar, 1984). Red imposta and Early red varieties with yellow green foliage showed minimum thrips population as 37.03 individual/plant and 43.3 individual/plant. Result shows that these onion varieties showed antibiosis and antixenosis resistance against onion thrips. More research will be needed to determine the resistance category.

CONCLUSION

The study suggests further research should analyze the accessions traits like leaf wax extracted from resistant and susceptible genotypes for determining the chemical composition of leaf waxes. Also, evaluation of other Pakistani genotypes for resistance to thrips and measuring other vital traits that may related to resistance to thrips should be studied in detail.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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