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Assessment of Tolerance in Selected Onion Genotypes to Thrips Population in Bahawalpur, Pakistan

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Abstract. Onion thrips are one of the most significant pests of onion. Study was conducted during rabi season of 2022-23 to screen seven onion genotypes namely Nasarpuri, Phulkara, Sultan, VRIO-2, VRIO-3, VRIO-8 and VRIO-15 against thrips at experimental farm of Islamia University of Bahawalpur following randomized complete block design. Results showed maximum thrips on Nasarpuri (29.78) followed by 29.60 and 29.17 on VRIO-2 and Sultan respectively. Least population was on VRIO-8, VRIO-15 and Phulkara with 16.86, 15.40 and 13.35 thrips respectively. Study of plant morphological traits showed plant height, number of leaves per plant and leaf width was positively associated with thrips population. Among physiological traits more thrips were negatively associated with relative chlorophyll content, linear electron flow (LEF) and photosystem2 (Phi2) but positively associated with NPQt or energy dissipation. There was weak positive correlation between thrips population and bulb yield which instead showed tolerance against thrips attack in those genotypes particularly for Nasarpuri, VRIO-2 and Sultan. On the other genotypes VRIO-8, VRIO-15 and Phulkara showed resistance to thrips abundance. Knowledge about tolerant and resistant genotypes is important and can be utilized in future breeding programs for development of promising onion genotypes.

Keywords: screening, onion (*Allium cepa*), varieties, thrips (*Thrips tabaci*)

Introduction

The onion (*Allium cepa* L.), a biennial herbaceous plant, is a member of the Amaryllidaceae (Liliaceae) family. This is a significant bulbous condiment crop (Malik *et al*., 2010). Onion is the most economically important *allium* crop and is commercially significant as a vegetable crop worldwide. In Pakistan, onions are one of the important condiments (Malik and Bashir, 1994). Recent research indicates that the *Allium* genus comprises a minimum of 750 species and it is grown in around 170 countries of the world (FAO, 2014; Lannoy, 2001). Moreover, onions have a high nutritional potential for consumers as the bulbs are rich in calcium, magnesium, zinc and manganese (Chalbi *et al*., 2023).

Being the versatile vegetable, onions are consumed raw in salads and in a range of processed foods (Manohar *et al*., 2017). Because of their many health advantages, onions are being used increasingly often worldwide (Havey *et al*., 2004). It has been demonstrated that onions lower the risk of vascular and cardiovascular disorders, cancer, cataracts and DNA damage (Arung *et al*., 2011; Hamauzu *et al*., 2011; Jimenez *et al*., 2011). After tomatoes, onions are the world's second-most important horticultural crop. In the world, Pakistan stands as 6th main exporter of onion with the share of 3% in international market (Karar *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). However, Pakistani government reports that between 2021 and 2022, the output of onions decreased by 8.5% (GOP, 2022).

It has been demonstrated that several cultural practices including the growing environment, illnesses and insect pests can affect onion output (Shiberu and Mahammad, 2015; Melander and Rasmussen, 2001; Fournier *et al*., 1995). 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). The yield of crop is greatly reduced by these pests. Due to its notorious polyphagous feeding habits, *Thrips tabaci* (Thysanoptera: Thripidae) is a devastating insect pest that is widely distributed and a serious danger to a number of commercially significant crops, including

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onions, vegetables, fruits and flowers (Alston and Drost, 2008). *T. tabaci* is widely distributed, occurring in temperate zones as well as tropical and subtropical areas (Pourian *et al*., 2009). In recent years, *T. tabaci* has become a major global threat to the production of onions (Diaz-Montano *et al*., 2011). There is a temporal change in the abundance of both adult and nymph populations in April and May, with the highest levels observed in early April (Edelson *et al*., 1986).

T. tabaci has a cylindrical body that ranges in length from 0.06 inches to 1.15 mm and is coloured yellow to brown. Five to eight generations can occur annually and a whole generation takes three to four weeks during the summer. During its life, the female *T. tabaci* can deposit up to 80 little eggs in a cluster within the leaf epidermis. Adult females typically live between 19 and 30 days (Lall and Singh, 1968). The threshold level for thrips-tolerant cultivars is 30 thrips or higher per plant. The threshold point for thrips-sensitive cultivars is 15-30 thrips per plant (Cranshaw, 2004). Silvery dots appear on the leaves and flowers as a result of both adult and nymph piercing and sucking cell sap primarily from the young leaves. Feeding damage can cause onion yields to decrease by 34.5% to 43.5% (Fournier *et al*., 1995) and over 50% in cases with an extreme population (Diaz-Montano *et al*., 2011). Onion thrips are the primary vectors of the Iris yellow spot virus (IYSV) and thrips in general are tospovirus vectors (Kritzman *et al*., 2001). Thigmotactic activity, small size and rapid reproduction rates make thrips notoriously hard to control (Gerin *et al*., 1999). To reduce the use of broad-spectrum insecticides sustainable methods are employed to manage *T. tabaci* populations on a wide range of farmed crops, fruits and vegetables (Iglesias *et al*., 2021). Chemicals used to control the *T. tabaci* population can occasionally cause other pest populations to rise in response to their use (Gao *et al*., 2012). The use of pesticides to control insect populations has a negative impact on the environment, human health and natural enemies (Gogo *et al*., 2014; Mostafalou and Abdollahi, 2013).

Entomologists create new strategies to tackle the problem caused by thrips all over the world. Their primary goal is to steer clear of the chemicals sold as pesticides and to employ innovative alternative approaches to pest control. The antixerotic and antimicrobial traits of onion seedlings help them avoid thrips. There are less thrips in different types with unique characteristics such differing leaf angles, varied leaf colours and structural designs as well as wax coatings and layer shine. Some onion cultivars are susceptible to *T. tabaci*, while others are resistant to it based on the colour of their leaves (Diaz-Montano *et al*., 2010). Chemical control is an admired way for controlling thrips (Malik and Ali, 2002) however, it has harmful effects on both the environment and human health (Malik *et al*., 2003).

It's noticeable that not many researches have been conducted in Bahawalpur, despite the significance of studying the susceptibility of different onion cultivars to thrips infestations. The primary goal of the current study was to identify the onion variety that is most tolerant or resistant to thrips attacks in the Bahawalpur, Pakistan. Information on plant protection to lower environmental chemical levels and the use of resistant cultivars as a source of resistant germplasm in breeding programs may be helpful. Besides identifying the variety that is least susceptible to thrips attack could provide farmers in Bahawalpur and other regions with valuable variety for effective management of onion thrips.

Materials and Methods

The purpose of the current experiment was to test popular onion genotypes in the Bahawalpur region against thrips. For this, the seven local genotypes "Nasarpuri", "Phulkara", "Sultan", "VRIO-2", "VRIO-3", "VRIO-8" and "VRIO-15" were evaluated during rabi season of 2022-23. Seeds of onion genotypes were obtained from Ayub agriculture research institute in Faisalabad. Colour of all genotypes is light red except Sultan with dark red colour and VRIO-15 with white colour. The study was carried out at the Islamia University of Bahawalpur's faculty of agriculture and environment's experimental site (2925'5.0448" N, 7140'14.4660" E) using a randomized complete block design (RCBD). First, the experimental field area was prepared, and in the latter part of December 2022, the nursery was sown in seven distinct plots. Two months later, the seedlings were moved from the nursery to the experimental field area.

The plot was 28 by 6 feet in size. Each plot's ridges were used to transplant onion seedlings, with a spacing of 8 inches between plants and 12 inches between rows, respectively. There were three subplots in total, to support three replications. A rotavator was used to prepare the experimental plots and a plough was used to break up the soil clods. Weeds and stubbles throughout the crop were eradicated. Following the implantation of onion seedlings, the field was irrigated using a canal

water system at weekly intervals, taking into account crop requirements, weather patterns and crop conditions. Fertilization was done uniformly in plots first after 22 days of nursery transplantation with diammonium phosphate (DAP) @ 5 Kg/acre and then 28 days after nursery transplantation with Urea @ 5 Kg/acre dose rate. In onion experimental fields, weeding was done with the exception of thrips management techniques.

Screening for *T. tabaci* tolerance. The thrips counts (Adults and Nymphs) per plant were used to evaluate the susceptibility of the onion genotypes against *T. tabaci*. Up until the crop was harvested, five randomly selected onion plants from each experimental unit were inspected and the number of thrips was then noted. The thrips population in each experimental unit was counted at random every 10 days beginning in the fourth week after transplanting. Five plants from each treatment/ridge were chosen at random for observation and tagged with the objective for comprehensive data collection. The selected plants were gently shaken over a white cardboard paper facilitating the visual inspection of thrips population using a hand lens. The count of thrips was meticulously recorded during each observation. The data was recorded four times, twice each at vegetative and bulbous phases starting from 20.03.2023 (30 days after transplanting), 30.03.2023 (40 days after transplanting), 10.04.2023 (50 days after transplanting) and finally on 20.04.2023 (60 days after transplanting) when thrips population began to decline.

Morphological traits evaluated. Plant morphological data that were recorded throughout this time frame were plant height, leaf width and the number of leaves per plant. The width and length of the leaves were measured using a measuring tape. Onion yield (bulb weight) was also recorded.

Physiological traits evaluated. *Chlorophyll fluorescence and photosynthesis measurements.* Chlorophyll fluorescence and photosynthetic activity of onion leaves were measured using a pulse amplitude modulated portable (MultispeqVII, USA) device as described by Kuhlgert *et al*. (2016). Briefly on clear and cloudless days between 9:00 and 11:00 am in situ, top 3rd and 4th fully expanded leaves were selected for measurement of chlorophyll contents (SPAD), linear electron flow (LEF) and Photosystem II activity (Ph2). Non-photochemical quenching (NPQt) was measured to access the thermal energy dissipation in onion plant chloroplasts under insect attack stress conditions. PhotosynQ App was used in mobile by connecting with bluetooth for data storing. After taking measurements the data was transferred in laptop and was used for analysis.

Non-photochemical quenching coefficient (NPQt), relative chlorophyll, linear electron flow. The quantity of incoming light that is diverted from the photosynthetic process in order to limit damage to the plant is known as non-photochemical quenching. Green colour of leaves indicates the presence of relative chlorophyll content. It is correlated with different levels of nitrogen. It is assumed as same or decreased with increasing stress. This can be viewed as a rough estimate of how much energy is transferred during photosynthesis, or, more specifically, how much energy is transferred during exposure to light in chloroplasts. With an increase in stress, this is supposed to be decreased or unchanged (Ali *et al*., 2022).

Yield estimation. For yield parameters all the fruit were harvested from each unit plot. Roots as well as the leaves from harvested bulbs were removed when most of the leaves turned yellow and after attaining of full size of bulbs and bulbs were weighed using electrical weighing balance immediately before curing and the yield was converted to Kg/acre (Ali *et al*., 2016).

Statistical analysis. The data were analyzed using factorial ANOVA and the significance of the changes in treatment means was confirmed using the Tukey HSD test. The statistix 8.0 application was used to analyze the data. A correlation (Pearson) was also done between thrips population and selected plant morphological and physiological traits to see the relationship between thrips population and relevant traits in onion genotypes.

Results and Discussion

T. tabaci* population counts on different onion genotypes, their comparative morphophysiological traits and yield comparison. *Screening for thrips tolerance. The results indicated that when the average population of *T. tabaci* on different onion genotypes was compared, the genotype Nasarpuri had the highest average thrip population (29.78) followed by 29.60, 29.17 in VRIO-2 and Sultan in descending order. Significantly less population was 16.87, 15.40 and 13.35 in VRIO-8, VRIO-15 and phulkara respectively (Table 1; $F_{6, 83}$: 15.96; P<0.001). Effect of dates of observations showed maximum *T. tabaci* population was 28.22 on

30.03.2023 and least population was recorded 15.10 on 20.04.2023 (Table 2; $F_{3,83}$:20.0; P<0.001)

Plant height. Result showed that when plant heights for different onion genotypes were compared the maximum plant height was recorded 39.67 cm on genotype VRIO-2 followed by 37.98 cm and 37.78 cm respectively in VRIO-3 and Sultan in descending order. Significantly less plant heights were 32.58 cm for Nasarpuri and VRIO-15 followed by 32.02 cm and 30.95 cm in Phulkara and VRIO-8 respectively (Table 1; $F_{6,83}$:9.33; P<0.001). Effect of dates of observations showed plant height was maximum 43.00 cm on 20.04.2023 and minimum was 25.56 cm on 20.03.2023 (Table 2; $F_{3,83}$:72.98; P<0.001).

Number of leaves. The mean comparison for number of plant leaves on the different onion genotypes is displayed in Table 1. Maximum numbers of leaves were 5.70 in VRIO-2 followed by 5.65, 5.52, 5.15, 5.02 and 5.0 respectively in Sultan, VRIO-3, Nasarpuri, VRIO-8 and Phulkara which were significantly at par with each other. Significantly less numbers of leaves were 4.92 in VRIO-15 (Table 1; $F_{6,83}$:4.04; P:0.0015). Effect of dates of observation showed maximum number of leaves were recorded 5.68 on 20.04.2023 and minimum number of leaves were recorded 4.84 on 20.03.2023 (Table 2; $F_{3,83}$:8; P:0.0001).

Leaf width. Result showed that maximum plant leaf width was recorded 7.78 mm on genotype VRIO-2. It was followed by leaf width of 6.88 mm, 6.63 mm, 6.42 mm, 6.23 mm, 6.22 mm and 5.43 mm respectively in Sultan, VRIO-3, Nasarpuri, VRIO-15, Phulkara and VRIO-8 (Table 1; $F_{6,83}$:3.73; P:0.0027). Effect of date of observation showed maximum leaf width was recorded 7.92 mm on 20.04.2023 and minimum leaf width was recorded 4.87 on 20.03.2023 (Table 2; $F_{3,83}$:22.57; P<0.001).

Yield Kg/acre. Maximum bulb yield was recorded 3658.8 Kg/acre on genotype Nasarpuri. It was followed

Table 1. *T. tabaci* population on different onion genotypes and their comparative morphophysiological traits

Varieties	*T. tabaci* (Means)	Plant height (cm)	Number of leaves	Leaf width (mm)	Chlorophyll (SPAD)	NPQT	LEF	Phi2	Yield Kg/acre
Nasarpuri	29.78 A	32.58 B	5.15 AB	6.42 AB	8.3467 AB	2.4507 BC	303.27 B	0.4200 AB	3658.8 A
VRIO-2	29.60 A	39.67 A	5.70 A	7.78A	7.7883 B	2.8638 AB	332.37 A	0.4103 B	3114.5 A
Sultan	29.17 A	37.78 A	5.65 A	6.88AB	7.6117 B	2.4360 C	338.80 A	0.4318 AB	3194.4 A
VRIO-3	23.53 AB	37.98 A	5.52 AB	6.63 AB	8.0858 B	2.9850 A	313.38 AB	0.4009 B	3208.9 A
VRIO-8	16.87 BC	30.95 B	5.02 AB	5.43B	7.3422 B	3.0252 A	331.97 A	0.4059 B	3492.1 A
VRIO-15	15.40 C	32.58 B	4.92 B	6.22AB	8.7408 AB	2.4233 C	338.63 A	0.4479 A	3121.8 A
Phulkara	13.35 C	32.02 B	5.00 AB	6.23AB	9.6863 A	2.7653 ABC	326.19 AB	0.4263 AB	3325.1 A

The column's means that are denoted by the same letters are not significantly different from one another at P=0.05. NPQt; Non-photochemical quenching; LEF: Liner electron flow; Phi2: Quantum yield of photosystem 2

Table 2. *T. tabaci* population and plant morpho-physiological traits of onion genotypes on different dates of observation

Date	*T. tabaci* (Means)	Plant height (cm)	Number of leaves	Leaf width (mm)	Chlorophyll (SPAD)	NPQt	LEF	Phi2
20-03-2023 (30 DPP)	26.84 A	25.56 D	4.84 C	4.87 C	7.9652 A	1.9859 C	324.73 B	0.4767 A
30-03-2023 (40 DPP)	28.22 A	32.61 C	5.19B C	6.06 B	7.9237 A	2.3742 B	339.50 AB	0.4267 B
10-04-2023 (50 DPP)	19.95 B	38.01 B	5.41 AB	7.20 A	8.7874 A	3.1841 A	286.07 C	0.3920 C
20-04-2023 (60 DPP)	15.10 B	43.00 A	5.68 A	7.92 A	7.9237 A	3.2840 A	355.19 A	0.3864 C

The column's means that are denoted by the same letters are not significantly different from one another at P = 0.05. NPQt: Non-photochemical quenching; LEF: Liner electron flow; Phi2: Quantum yield of photosystem 2

by 3492.1 Kg/acre, 3325.1 Kg/acre, 3208.9 Kg/acre, 3194.4 Kg/acre, 3121.8 Kg/acre and 3114.5 Kg/acre with no significant difference in yield between different varieties (Table 1; $F_{6,104}$:0.60; P:0.7248).

T. tabaci* population on different onion genotypes and their comparative physiological traits. *Relative chlorophyll. Result showed maximum relative chlorophyll content was 9.6863 SPAD recorded on Phulkara variety followed by 8.7408 SPAD, 8.3467 SPAD respectively in VRIO-15 and Nasarpuri. Significantly less chlorophyll contents were 8.0858 SPAD, 7.7883 SPAD, 7.6117 SPAD and 7.3422 SPAD respectively in VRIO-3, VRIO-2, Sultan and VRIO-8 (Table 1; $F_{6,83}$:4.55; P<0.001). Regarding the effect of dates of observation, maximum relative chlorophyll was recorded 7.9652 SPAD on 20.03.2023, while the minimum relative chlorophyll was recorded 7.9237 on 30.03.2023 (Table 2; $F_{3,83}$:2; P:0.1213).

NPQt. Result showed that when the means regarding NPQt of different onion genotypes were compared, the maximum NPQT was recorded on VRIO-8 variety 3.0252 followed by 2.9850, 2.8638 and 2.7653 in descending order respectively in VRIO-3, VRIO-2 and Phulkara. Significantly less NPQt values were 2.4507, 2.4360 and 2.4233 respectively in Nasarpuri, Sultan and VRIO-15 (Table 1; $F_{6,83}$:7.20; P<0.0001). Effect of date of observation showed maximum NPQT was recorded 3.2840 on 20.04.2023 while the minimum NPQT was recorded 1.9859 on 20.03.2023 (Table 2; $F_{3,83}$:70.40; P: <0.0001).

LEF. Result showed that when different onion genotypes were compared regarding LEF, the maximum LEF was recorded 338.80 on Sultan. It was followed by 338.63, 332.37, 331.97, 326.19, 313.38, 303.27 respectively in VRIO-15, VRIO-2, VRIO-8, Phulkara, VRIO-3 and Nasarpuri (Table 1; $F_{6,83}$:4.67; P<0.0004). Under the effect of different dates of observation maximum LEF was recorded 355.19 on 20.04.2023 while the minimum LEF was recorded 286.07 on 10.04.2023 (Table 2; $F_{3,83}$:40.05; P:<0.0001).

***Phi2*.** Result showed that when the means of different onion genotypes were compared regarding Phi2, the maximum Phi2 was recorded 0.4479 on VRIO-15. It was followed by Phi2 values 0.4318, 0.4263 and 0.4200 in descending order respectively in Sultan, Phulkara and Nasarpuri. Significantly less Phi2 values were 0.4103, 0.4059 and 0.4009 respectively in VRIO-2, VRIO-8 and VRIO-3 (Table 1; $F_{6,83}$:4.20; P:0.0011). Effect of date of observation showed maximum Phi2 was recorded 0.4767 on 20.03.2023 while the minimum Phi2 was recorded 0.3864 on 20.04.2023 (Table 2; $F_{3,83}$:47.03; P:<0.0001).

Correlation (Pearson) of *T. tabaci* population with morpho-physiological traits of onion genotypes and yield. A positive correlation was seen for number of *T. tabaci* and plant growth attributes like plant height, number of leaves, leaf width. However, a negative correlation observed between *T. tabaci* population and plant physiological traits including chlorophyll contents, LEF and Phi2 but a positive correlation seen between *T. tabaci* population and NPQt. A very week positive correlation was also seen between *T. tabaci* population and bulb yield of onion (Table 3).

Results of this study showed that out of seven tested genotypes Nasarpuri had maximum thrips (29.78) per plant. It was followed by the thrips populations of 29.60, 29.17 and 23.53 on VRIO-2, Sultan and VRIO-3 respectively. However, VRIO-8, VRIO-15 and Phulkara genotypes had significantly less populations of 16.37, 15.40 and 13.35 respectively. This could be due to the variation in plant physio-morphic traits. According to our result when the plant height, number of leaves and leaf widths were more the thrips population was also more. It is in agreement with earlier studies about screening of some prominent onion genotypes against thrips attack (Ali *et al*., 2016).

Table 3. Correlation (Pearson) of *T. tabaci* population with plant morpho-physiological traits in onion and yield

Correlation		Plant height (cm)	Number of leaves	Leaf width (mm)	Chlorophyll (SPAD)	NPQt	LEF	Phi2	Yield Kg/acre
T. tabaci	(r)	0.6791	0.7854	0.6963	-0.5364	0.2098	-0.2977	-0.2614	0.0506
	(P)	(0.0934)	(0.0364)	(0.0822)	(0.2145)	(0.6516)	(0.5168)	(0.5712)	(0.9141)

Correlation is significant at P≤0.05; non-significant at P≥0.05. NPQt: Non-photochemical quenching; LEF: Liner electron flow; Phi2: Quantum yield of photosystem

These findings are partially in agreement with studies of Shah and Khan (2015) which showed that onion cultivar Trichmer had greater number of leaves/plant (13.07) and had also maximum thrips population/plant (10.99) while a cultivar Granada with smaller number of leaves per plant showed less thrips 7.66/plant. Additionally, our research findings can be compared with studies of Karar *et al.* (2014), who found that cultivars with stage of 5-8 and 8-12 leaves had the highest thrips population.

Plant physiological traits are affected negatively due to stress like insect. In our results, verities with more thrips had lower chlorophyll and LEF value which are related to each other. While phi2 value also decreases due to punching energy dissipate or NPQt value increase.

Chlorophyll is necessary for photosynthesis, the process by which plants convert light energy into chemical energy to sustain their growth and development (Anderson and Fu, 2024). The plants' reaction to the stress brought on by the thrips feeding is responsible for the positive link found between the thrips population and non-photochemical quenching (NPQ). Plants use non photochemical quenching (NPQ) as a defense mechanism to release excess light energy received as heat and shield the photosynthetic machinery from harm (Muhammad *et al*., 2021). Plants respond to stress by activating defense mechanisms, such as thrips eating on them, which lessens the damage. Plants that are fed by thrips may experience physiological stress, which will cause NPQt to activate as a defense mechanism (Dai *et al*., 2009). Plants may upregulate NPQ in response to thrips damage in order to withstand the stress induced by thrips population growth and increased eating. Consequently, the positive relationship between NPQt and thrips population indicates that plants activate NPQt as thrips populations increase (Wood, 2023).

The adverse effects of thrips feeding on plants' photosynthetic apparatus provide an explanation for the negative association observed between thrips population and photosystem II (PSII) activity (Dai *et al*., 2009). A vital part of the photosynthetic process, photosystem II is in charge of absorbing light energy and starting the electron transport cycle. Thrips physically harm and compromise the integrity of cells as they feed on plant tissues. This injury may directly affect PSII's ability to function, which could result in a decrease in activity (Cheaib and Killiny, 2024). Furthermore, feeding by thrips can cause plants to react to stress by producing reactive oxygen species (ROS), which can impede PSII function even more and result in photoinhibition. Thrips' increasing numbers and more intense feeding habits can cause cumulative damage to plant tissues (Wu *et al*., 2021).

The deleterious effects of thrips feeding on plants' photosynthetic machinery can be the reason for the negative association observed between the population of thrips and linear electron flow during photosynthesis. Electrons are transmitted through a sequence of protein complexes in the thylakoid membrane during the basic process of photosynthesis known as linear electron flow (Kindt *et al*., 2003). This process produces ATP and NADPH, which are necessary for carbon fixation and the creation of organic compounds. Thrips physically harm and compromise the integrity of cells as they feed on plant tissues (Wood, 2023). The photosynthetic pigments, protein complexes and electron carriers are examples of the elements immediately impacted by this damage that are engaged in linear electron transport. Consequently, the photosynthetic electron transport chain's electron transfer efficiency is decreased (Mirkovic *et al*., 2017).

These results shown by correlation values, thrips attack or population is negatively correlated with value of chlorophyll, LEF, Phi2 but positively associated with energy dissipation (NPQt). The effect of dates of observation showed that thrips population was more in earlier dates e.g., in March then in April which might be due to high temperature and when onion plants were turning mature.

Maximum bulb yield was recorded 3658.8 Kg/acre in Nasarpuri. It was followed by 3492.1 Kg/acre in VRIO-8, 3325.1 Kg/acre in phulkara, 3208.9 Kg/acre VRIO-3 and least was 3114.5 Kg/acre in VRIO-2. According to correlation analysis there was weak correlation between onion bulb yield and thrips population and yield was also non significantly different in seven onion genotypes. This is in agreement with earlier research (Ali *et al*., 2016) that found a stronger relationship between bulb yield and plant height, number of leaves and leaf width but a weaker correlation between thrips and yield.

Conclusion

It is suggested that genotypes VRIO-8, VRIO-15 and Phulkara which were resistant to abundance should be recommended for onion growers and breeders and these

genotypes should be further investigated for the presence of traits that support their lower infestation and/or injury levels.

Conflict of Interest. The authors declared that they have no conflict of interest.

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