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Effect of Anatomical and Phytochemical Diversity of two Onion Cultivars on the Infestation with Onion Thrips (Thysanoptera: Thripidae)

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ABSTRACT

Two field experiments were conducted during two successive seasons 2013-2014 and 2014-2015 at the experimental farm, Faculty of Agriculture, Benha University, Egypt to study the effect of phytochemical composition and anatomical characteristics of two onion cultivars (Giza 20 and Red onion) on their susceptibility to infestation with *Thrips tabaci*. As well as, estimate the efficiency of different chemical and biochemical compounds in reducing the population density of *T. tabaci* on onion plants. The thrips population in two onion cultivars increased from the beginning of the experiment and reached the maximum population during the period from 1st March to 5th April in 2014 and from 15th February to 5th April in the second year of study 2015. Results also showed that Giza 20 cultivar was higher in its content of macro-elements, moisture and total protein than Red onion cultivar. On contrast, Red onion cultivar was higher in total carbohydrates, reducing and non-reducing sugars than Giza 20 cultivar. Also, the anatomical parameters (thickness of epidermis, thickness of Central tissue and number of vessels wood) of Red onion cultivar was higher than the same parameters of Giza 20 cultivar. In addition, results showed that Pyrthrin reduced lower of thrips infestation rate of two onion cultivars than other Radiant, Marshal and Confidor which gave higher reduction rates in thrips infestation on the two onion cultivars.

Key words: Onion, *Thrips tabaci*, anatomical characteristics, chemical composition, pesticides

Introduction

Onion (*Allium cepa* L.) is one of the most important vegetable crop worldwide, it is not highly nutritious but has useful properties partly that the onion bulb is rich in phosphorus, calcium and carbohydrates. It's nippy due to sulphuric compounds and it is an appetizer, stimulant and source of energy (Karar *et al*., 2014). Onion Thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) is a dangerous pest of onion plants (*Allium cepa* L.) found on all parts where onion grown causing direct and indirect damages (Khan *et al*., 2015). Nymphs and adults that live in the leaf sheath and stalk, have very distinguishable feeding behaviors by punching through the leaf surface and then sucking up the plant succulent causing loss of chlorophyll, reduced photosynthetic efficiency and significant yield loss (Gill *et al*., 2015). Damage appears as silvery patches, streaks on the leaves or tiny black "tar" spots, which is faeces from thrips (Boateng *et al*., 2014). Feeding on leaves also can create an entry point for plant pathogens (Orloff *et al*., 2008). Additionally, feeding by onion thrips results in plant stunting, reduced bulb weight as well as predisposes onion plants to various pathogens specially viruses that further decrease yield which leading to a complete crop failure (Diaz-Montano *et al*., 2011). Concerning onion response to thrips infestation, some onion cultivars are sensitive but others are resistant, there are no onion cultivars that are highly resistant to thrips, but they vary in resistance levels or can tolerate feeding the damage (Khan *et al*., 2015). Onion cultivars with waxy leaves and tight necks were more attractive to onion thrips compared to cultivars with glossy to semi-glossy leaf surfaces and an open neck (Diaz-Montano *et al*. 2012). Onion cultivars with glossy and semi-glossy leaves have lower levels ketone hentriacontanone-16 compared to other cultivars (Damon *et al*. 2014). The chemical composition of onion plants could affect the feeding rate, development and reproduction of *T. tabaci*. In this respect, Riefler and Koschier (2009) proved that the different concentrations of primary metabolites (sugars, proteins and carbohydrates) influence oviposition, feeding time, plant exploitation and consequently, the duration of each stage of their life. Also, volatiles and various allelochemicals viz. monoterpenes considered as chemical defense system against thrips through their deterrent activity and feeding inhibition (Koschier *et al*., 2000).

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The research aimed to study the effect of phytochemical composition and anatomical characteristics of two onion cultivars (Giza 20 and Red onion) on their susceptibility to infestation with *Thrips tabaci*. As well as, estimate the efficiency of different chemical and biochemical compounds in reducing the population density of *T. tabaci* on onion plants.

Material and Methods

Experiments were conducted during two successive seasons 2013-2014 and 2014-2015 at the experimental farm of Faculty of Agriculture, Moshtohor, Benha University, Qalubia, Egypt.

Onion cultivars

Seeds of two onion cultivars namely Giza 20 and Red onion were obtained from Field Crop Res. Inst., Agric. Res. Center, Giza, Egypt.

Field experiment

The experimental area was about 63 m^2, 31.5 m^2 for each cultivar. The experiment was designed in randomized complete block design with 3 replicates. All the recommended agriculture practices were carried out as needed. The experimental area was kept free from any pesticide treatment, as the plants were left to natural infestation. Temperature degrees and relative humidity at the two studied seasons were obtained from Central Lab. for Agric. Climate (C.L.A.C), Cairo, Egypt.

Determinations

Stereomicroscopy examination

Fifteen days after transplanting and during the growth stag (about 20 weeks), weekly randomized samples of ten onion plants for each replicate were picked, placed in a tightly closed paper bags and transferred to the laboratory in the same day to the survey and estimate the population density of *T. tabaci* by stereomicroscope as thrips count/plant leave.

Analysis of phytochemical components of two onion cultivars leaves

Leaves samples were collected after 85 days from transplanting, leaves of each cultivar were homogenized by Teflon tissue grinder using a glass cup surrounded by ice jacket. Distilled water was used as the homogenizing medium. The homogenate was centrifuged at 8,000 g for 15 min using a refrigerated centrifuge. The sediment was discarded and the supernatant was taken for the following biochemical determination:

Total carbohydrates and proteins were estimated as described by Crompton and Birt (1967) and Bradford (1976), respectively. As well as, the percentage of reducing sugar were estimated by using the methods of Sadasivam and Manickam (1991). Na^+ and K^+ concentrations were made on a radiometer FLM3 flamephotometer as described by Amin and El-halafawy (2002). Additionally, Moisture content, was calculated according A.O.A.C. (1970) as follows:

$$\% \text{ Moisture content} = \frac{fresh\ weight - dry\ weight}{fresh\ weight} * 100$$

Anatomical characters of two tested onion cultivars leaves

Samples of each cultivar leaves were picked and fixed in FAA solution (10 ml formalin + 5ml glacial acetic acid + 85 ml ethyl alcohol 70%). Then, sections in the leaves were made by using the method of Jackson (1976). The different measurements (in micron) of the thickness of upper epidermis, layer palisade tissue, spongy tissue and lower epidermis layer were determined using of compo eye, leaf and symptoms program (Rudall, 2007).

Efficiency of five compounds in reducing the population density of T. tabaci on onion plants

Five compound including chemical pesticides, bio-pesticide and natural pesticide were applied as mentioned in (Table 1) to estimate their efficiency in reducing the population density of *T. tabaci* infesting the two onion cultivars. All pesticides were applied using a 20 L knapsack sprayer with one nozzle. The amount of water was calibrated to obtain sufficient coverage of onion plants. Spraying was conducted early in the morning. Ten onion plants per replicate were picked at random, placed in a tightly closed paper bags and transferred to the laboratory in the same day to be microscopically inspected to determine the effect of the five tested compounds in reducing the population density of *T. tabaci* individual immediately before spraying and after 1,3,5,7,11,14 days respectively.

Table 1: Pesticides used in the present study

NO	Trade name	Concentration of A.I.	F	Common name	Rate of use/100 L water
1	Confidore®	20%	OD	Imidacloprid	50 ml
2	Marshal®	20%	EC	Carbosulfan	50 ml
3	Pelo®	50%	EC	Pyriadlyl	100 ml/fad.
4	Radiant®	12%	SC	Spinetoram	120 ml/fad.
5	Pyrethrum®	5%	EC	pyrthrin	440 ml/fad.

A.I.: Active ingredient *F: formulation* *OD: Oil dispersal*
EC: Emulsifiable concentration *SC: Suspension concentrate*

Statistical analysis

Data were analyzed by the computer, using ANOVA test with LSD at 5% level (Little and Hills, 1978).

Results and Discussion

Survey of *T. tabaci* on two onion cultivars at Qalubia Governorate throughout two successive seasons 2014 and 2015

Results graphically illustrated by Figs (1 & 2) show the survey of *T. tabaci* on two onion cultivars at Qalubia Governorate throughout two successive seasons 2014 and 2015 during the periods from 28th December to 17th May. Also, Figs (1 & 2) indicated that during 2014 Red onion plants have the highest thrips number/plant while Giza 20 plants gave the lowest number, respectively. On contrast, during 2015 the highest and the lowest thrips number/plant were recorded on Giza 20 and Red onion cultivars, respectively. Generally, higher population of thrips (individuals /plant) were recorded in 2015 than that recorded in 2014, this trend was observed on two onion cultivars. From data illustrated by Fig (1) we can observe that the first record of thrips/plants on two onion cultivars were observed in 28th December. Additionally, the thrips population in two onion cultivars was increased from the beginning of the experiment and reach the maximum population during the period from 1st March to 5th April, then decline to 8.1 and 4.3 thrips/plant on Giza 20 and Red onion cultivars, respectively in 17th May. This decline in thrips population due to the beginning of crop maturity and the dryness of leaves.

Regarding thrips population during 2015, Figs (2) showed that no thrips/plant were recorded on Giza 20 cultivar at the end of December, whereas, the first recorded of thrips/plant on Red onion cultivar was observed at 28th December (4.3 thrips/plant). Also, the population of the *T. tabaci* began to build up in early January and reached maximum during the period from 15th February to 5th April (104.7 – 133.4 thrips/plant) on Giza 20 cultivar. While, the population on Red onion cultivar reached to its maximum during the period from 22nd February to 5th April (115.7 - 129.7 thrips/plant). The population was declined to 8.2 and 8.9 thrips/plant on Giza 20 and Red onion cultivars, respectively at the end of crop life. This sudden drop in population may be due to maturation of crop, leaf dryness and migration of thrips to other crops.

Similar results by Hussain *et al*. (1997) who reported that population of the *T. tabaci* began to build up in early February and reached maximum during April. Also, Ullah *et al*. (2010) reported that the first record of thrips/plant was observed at 3rd of February and reached to its maximum during the last week of April. Then, the population was declined towards the end of May. Moreover, Diaz-Montano *et al*. (2010) evaluated forty-nine onion cultivars in relation to resistance to *T. tabaci* and found that eleven cultivars were resistant. Also, Loges *et al*. (2004) evaluated seven onion cultivars and stated that only one cultivar was resistant to *T. tabaci* owing lower number of insects/plant. Additionally, da Silva *et al*. (2015) evaluated seven onion cultivars for their ability to infested with *T. tabaci* and they found that three only cultivars were resistant. These results may be because of weather factors (temperature and relative humidity) that means unconsidered factors affecting the building up *T. tabci* population on onion plants. These results were in accordance with Gill *et al.* (2015) who reported that the hot and dry weather could lead to an increase in onion thrips populations and on the severity of thrips injury to onion. From another view, Karar *et al.* (2014) stated that accordance the leaf color the onion cultivars could classified to resistant or susceptible to onion thrips.

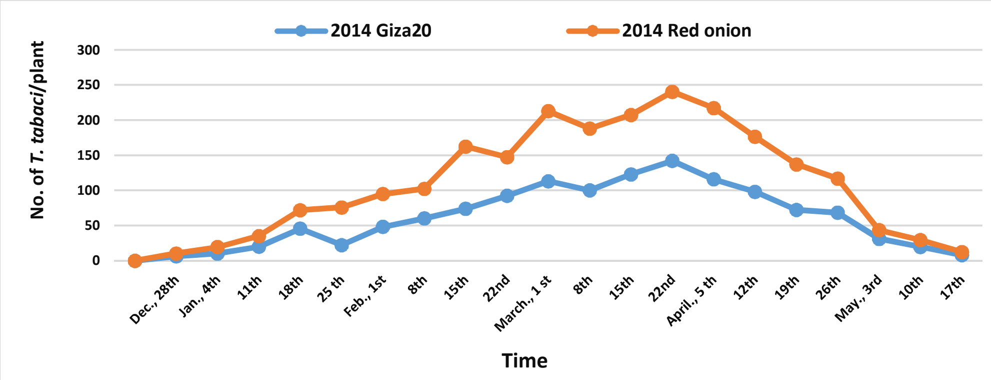

Fig. 1. Population development of thrips on two onion cultivars during 2014.

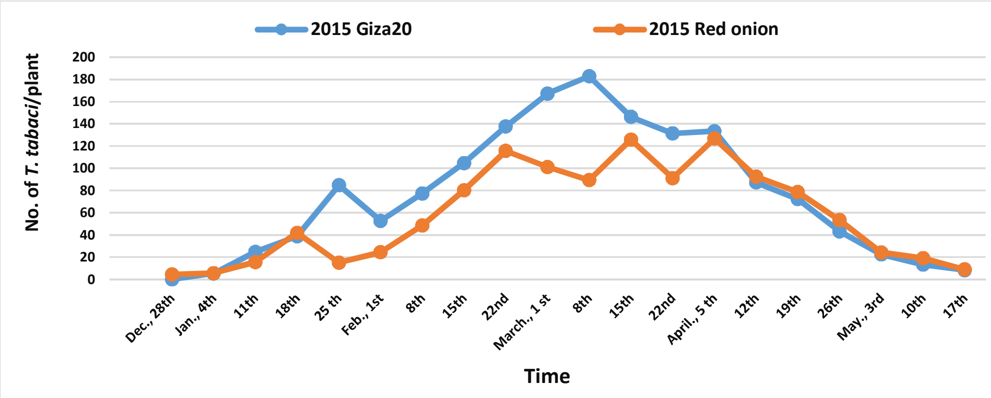

Fig. 2. Population development of thrips on two onion cultivars during 2015.

Phytochemical analysis of different onion cultivars and their effect on infestation rate with *T. tabaci*

Data in Table (1) indicate that Giza 20 cultivar was higher in its content of macro-elements, moisture and total protein than Red onion cultivar. On contrast, Red onion cultivar was higher in total carbohydrates, reducing and non-reducing sugars than Giza 20 cultivar. Similarly, Voorrips *et al.* (2008) reported that onions resistance to *T. tabaci* was related to the chemical characteristics of the plants. Also, Kibanyu (2009) indicated that the growth stage and chemical composition of onion plants were effect on onion thrips population rate, and there was an increase in the number of onion thrips from 27- 34 days after transplanting for all the onion varieties. The number of thrips recorded during this period was generally high compared to the rest of the season. Moreover, Waiganjo (2004) showed that during the early stages of onion growth there were generally low levels of infestation with thrips. The high susceptibility of onion cultivars might also be associated with their maturity stage where they remained attractive to the pests for a longer period especially during the most vulnerable onion growth stages (Boyhan et al., 2001).

The chemical composition of onion plants could affect the feeding rate, development and reproduction of *T. tabaci*. In this respect, Riefler and Koschier (2009) proved that the different concentrations of primary metabolites (sugars, proteins and carbohydrates) influence oviposition, feeding time, plant exploitation and consequently, the duration of each stage of their life. Also, volatiles and various allelochemicals viz. monoterpenes considered as chemical defense system against thrips through their deterrent activity and feeding inhibition (Koschier *et al.*, 2000).

Table 2: Phytochemical analysis of different onion cultivars and their effect on infestation rate with *T. tabaci*

Parameters		Giza 20	Red onion
Macro-elements (%)	N	3.20	3.02
	P	174.3	168.2
	K	3.41	2.85
Moisture (%)		90.94	90.82
Total Carbohydrates (%)		104.9	119.8
Reducing sugars (%)		26.5	34.42
Non-reducing sugars (%)		81.7	85.4
Total protein (%)		21.57	21.17

Anatomical characters of two tested onion cultivars leaves

Data presented in Table (3) and Photo (1) indicated that no significant differences were observed in the cuticle layer thickness in the two onion cultivars. In addition, the anatomical parameters (thickness of epidermis, thickness of central tissue and number of vessels wood) of Red onion cultivar was higher than the same parameters of Giza 20 cultivar.

Table 3: Anatomical characters of two onion cultivars leaves

Cultivars / Parameters (µm)*	Giza 20	Red onion
Thickness of cuticle layer	4.9	4.8
Thickness of epidermis	11.2	13.6
Thickness of central tissue	180.3	213.6
Diameter of vessels wood	7.3	6.4
Number of vessels wood	5.3	10

**All data were microscopy recorded at 100 x*

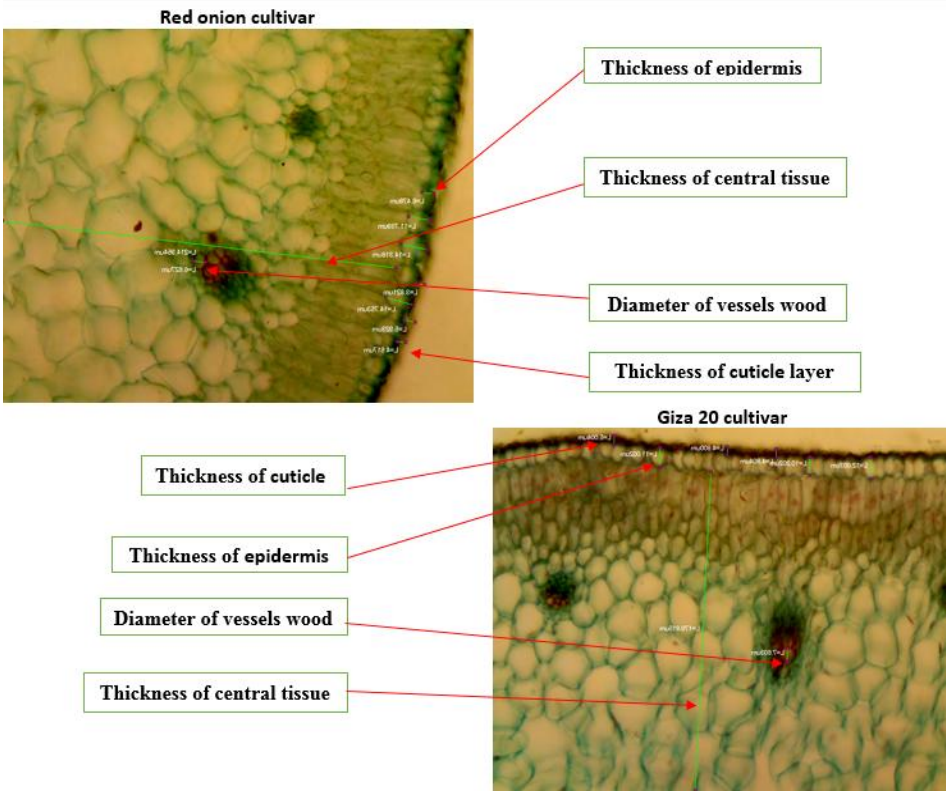

Photo 1: Anatomical characters of two onion cultivars leaves

On contrast, the thickness of cuticle layer and diameter of vessels wood was higher in Giza 20 leaves than in Red onion Leaves. Because of the previous characteristics, Red onion cultivar was resistant to thrips infestation than Giza 20 cultivar. Similar results were demonstrated by Voorrips *et al.* (2008) who reported that the most important morphological parameters responsible for resistance were the thickness and the rigidity of the cellular wall. Also, the distribution and the size of stomata and the rugosity of the leaf surface were effect on suitability of onion to thrips infestation (Morsello *et al*., 2008). Moreover, Mo *et al*. (2008) indicated that the composition and amount of wax accumulated on onion leave's surface as well as, the leaf shape and the central angle between the leaves had an influential role in onion plants suitability to thrips infestation. Additionally, Kibanyu (2009) proved that the mechanism for onion resistance to thrips infestation was most likely due to the morphological features of the cultivar.

Efficiency of five compounds in reducing the population density of *T. tabaci* on onion plants

Data in Table (4) indicated that the highest reduction of thrips infestation rate on Giza 20 after one and five days of treatment was observed when plants sprayed with Marshal with 87.4% and 90.0% reduction, respectively. Also, data indicated that during the period from 3 to 21 after treatment except after 5 days, the highest significant reduction rate was observed when Giza 20 cultivar plants sprayed with Confidor. On contrast, when Giza 20 plants sprayed with Pyrthrin, the lowest significant reduction in thrips infestation rate was observed. This trend of results was true during all treatment days. Concerning the effect of five compounds on thrips infestation rate of Red onion cultivar plants, data in Table (4) showed that the highest and the lowest significant reduction in thrips infestation rate were recorded when plants sprayed with Marshal and Pyrthrin, respectively. This trend of results was observed at all treatment days. Also, data in Table (4) indicated that Radiant gave higher reduction in thrips population after all days of treatment than Pleo except after 21 days of treatment on two onion cultivars. Additionally, the reduction rate was gradually increased from the first day after treatment to reach the maximum reduction rate after 21 days of treatment. This trend of results was true in two onion cultivars when sprayed with any compound.

Regarding the efficiency of five compounds in reducing the population density of *T. tabaci* on two onion cultivars during 2015, data in Table (5) showed that the Pyrthrin gave the lowest significant reduction in thrips infestation rate on two onion cultivars in all treatment. On contrast, the highest significant reduction rates of thrips/plant after all days of treatment except after 7 and 14 days were observed when Giza 20 plants were sprayed with Marshal. While, the highest significant reduction rate after 7 and 14 days were observed when onion plants

Table 4: Reduction (%) of thrips infestation rate on two onion cultivars during 2014 season.

Cultivars	Giza 20							Mean	Red onion							Mean
Days of treatments	1	3	5	7	11	14	21		1	3	5	7	11	14	21	
Confidor	73.8	91.7	76.6	83.7	85.4	76.2	53.8	77.3	75.4	78.0	74.3	65.9	59.2	43.3	47.7	63.4
Marshal	87.4	89.5	90.0	84.4	78.97	61.6	40.2	76.0	81.9	83.5	79.0	72.6	58.3	62.5	51.6	58.6
Pyrthrin	33.9	44.0	58.0	30.1	12.1	6.51	5.90	27.2	21.1	50.3	61.4	39.9	32.7	21.4	2.10	23.9
Pleo	48.3	50.1	66.9	61.1	53.6	46.9	45.7	53.2	50.9	56.9	67.4	53.4	43.3	42.7	10.6	36.8
Radiant	78.4	75.8	76.2	70.4	56.4	63.1	20.7	63.0	76.5	82.7	77.2	67.5	54.5	47.9	12.	48.8
L.S.D (0.05)	1.795	1.326	1.703	2.444	1.341	1.554	1.799		1.599	1.891	1.661	1.687	2.021	1.382	0.999	

Table 5: Reduction (%) of thrips infestation rate on two onion cultivars during 2015 season.

Cultivars	Giza 20							Mean	Red onion							Mean
Days of treatments	1	3	5	7	11	14	21		1	3	5	7	11	14	21	
Confidor	71.1	73.7	74.6	75.2	68.3	47.2	29.4	8.86	78.3	67.1	69.0	61.4	62.9	57.0	41.3	62.4
Marshal	85.8	87.1	85.7	77.5	68.7	40.8	29.7	62.8	86.9	85.5	87.9	76.3	62.9	60.6	29.7	69.9
Pyrthrin	25.7	34.0	47.6	33.9	17.3	6.8	2.7	67.9	26.6	36.7	44.9	29.5	24.2	11.3	5.3	25.5
Pleo	47.6	57.1	71.1	48.8	31.7	24.6	27.2	24.0	46.5	74.9	58.4	44.3	34.0	23.2	8.1	41.3
Radiant	80.6	77.1	77.5	83.8	64.3	45.7	18.7	44.0	78.7	87.3	80.4	74.3	70.5	57.8	21.4	67.2
L.S.D (0.05)	1.173	1.615	1.013	1.679	1.364	1.393	1.107		1.317	1.625	1.542	1.179	1.734	1.136	1.122	

sprayed with Radiant and Confidor, respectively. Also, no significant reduction rates after 11 and 21 days of treatment were observed when Giza 20 plants were sprayed Confidor and Marshal. Additionally, results indicated that the highest significant reduction rates after 1, 5 and 7 days after treatment were recorded when Red onion cultivar plants sprayed with Marshal, whereas, after 3 and 11 days of treatment, the highest reduction rate was observed when plants sprayed with Radiant. Whereas, Confidor gave the highest significant reduction rate on Red onion plants after 21 days of treatment.

Conclusion

From results of the current study, it was concluded that the thrips population in the two onion cultivars (Giza 20 and Red onion) was gradually increased and reach their maximum at the most vulnerable onion growth stages then decreased during the maturity stage. Also, Giza 20 cultivar was higher in its content of macro-elements, moisture, and total protein than Red onion cultivar. On contrast, Red onion cultivar was higher in total carbohydrates, reducing and non-reducing sugars than Giza 20 cultivar. Also, the anatomical parameters (thickness of epidermis, thickness of Central tissue and number of vessels wood) of Red onion cultivar was higher than the same parameters of Giza 20 cultivar, so these parameters had an important role in susceptibility or inconvertibility of plants to infestation with *T. tabaci.* It was clear that Pyrthrin reduced lower of thrips infestation rate of two onion cultivars than other Radiant, Marshal and Confidor which gave higher reduction rates in thrips infestation on the two onion cultivars. Based on that, results confirm that in onion farms, pesticides should form part of the integrated pest management strategy for the control of onion thrips where they were combined with other options such as host plant resistance and cultural practices.

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