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Transplanting date, sticky traps and utilization of tolerant cultivars for integrated onion thrips, *Thrips tabaci* management in onion field

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Abstract
Thrips tabaci Lindeman (Thysanoptera: Thripidae), is a destructive pest of onion and other vegetables crops worldwide. Causing the crop both direct and indirect harm. In a two-year field trial in the Nile Delta region, were evaluate the transplanting dates (early – mid – late) growing seasons on *T. Tabaci* populations which attacks the onion crop (*Allium cepa* L.), evaluate the effect of mass trapping Furthermore, were evaluated for *T. tabaci* populations management in onion cultivars Ahmartantawy, Giza 20, and Giza 6. Results indicated that, Onion planting in early season reduces *T. tabaci* population density more than mid and late season. Blue sticky trap was consistently captured and detected adult thrips more than another sticky colored trap. Moreover, Ahmartantawy was the best variety to tolerance *T. tabaci* individuals infestation. The highest susceptible cultivar was Giza 6 cultivar since it possessed the highest number of individuals during both seasons of the study. This study highlighted critical management components that would be a milestone for designing Integrated Pest Management (IPM) program against *T. tabaci*.

Keywords: *Thrips tabaci*, mass trapping, tolerance, susceptible, Integrated Pest Management

Introduction
Onion (*Allium cepa* L.) is a crop that is widely grown around the world due to its nutritional value and affordable production [1]. Onion a crucial vegetable crop in Egypt, is cultivated in the Delta region. Onion exports rank fourth in Egyptian agricultural exports, with an estimated value of $187.26 million. Egypt ranks fourth globally in onion exports, with an average of 357.64 thousand tones [2]. Despite, its importance, onion cultivation currently faces various challenges that affect its productivity and quality. *Thrips tabaci* (*T. tabaci*) is among of the most destructive insect pests worldwide and the most harmful Thysanopteran pest that can cause serious damages to onion and other vegetable crop. it has been reported that *T. tabaci* can develop on several important host plants either from Alliaceae or other families [3]. *T. tabaci* is regarded as an indirect pest of onions since it feeds on leaves instead of the marketable bulb. Feeding symptoms on plants prevent photosynthesis, which lowers output. *T. tabaci* can significantly reduce crop yields in onion crops just by eating on them [4]. In Egypt, *T. tabaci* is the most destructive insect pest causes significant damage to seed heads and reduce onion seed crop production about 50% annually [5]. In New York, severe *T. tabaci* damage might result in yield reductions of between 30 and 36% [6]. The damage caused by the *T. tabaci* can cause an up to 60% reduction in onion output in Israel [7]**.** *T. tabaci* poses severe threat for approximate to cause losses of more than U.S. $1 billion worldwide each year [8].
Mass trapping and cultural control is the use of reliable agronomic techniques for avoiding or prevent pest infestations and destruction. Therefore, the current study was designed to cover the following aspects: to determine the preference of *T. tabaci* on differently colored sticky traps. Compare to transplanting date in management population density of *T. tabaci*. And evaluate the susceptibility of some domestic onion cultivars.

Materials and Methods
Experimental sites: The present study was carried out to cover various management aspects

of Thrips *tabaci*, in the Middle Delta region at Gharbia Governorate, Egypt. The study was extended for two successive seasons, 2019/2020 and 2020/2021. Field experiments were conducted in a private and commercial farm at Sammanoud city.

Transplanting date in management population density of *T. tabaci*: This experiment was showed, for two seasons 2019 - 2020 and 2020 - 2021. To know the efficacy the transplanting dates aiming to control the *T. tabaci* population individuals on onion fields, onion cultivars were used: Ahmartantawy from red onions. Seedlings of each cultivar was transplanted on three dates each year, the early transplanting date was done on 29th November (early transplanting date), the mid transplanting date was 13th December, and the late transplanting date was 27th December during two seasons. Seedlings were raised in the nursery in the field for 8 weeks in seedbeds before transplanting. Approximately 1050 m^2 was divided in three equal experimental plots for three transplanting date (350 ^{m2} for each) and each plot divided in four experimental plots (about 85 ^{m2} for each). After two weeks from transplanting, 5 plants from each replicate were randomly collected early [9]. Samples were taken weekly and placed in plastic bags then transferred the laboratory for counting the number of nymph and adult using binocular stereomicroscope. The means of the weekly counted *T. tabaci* individuals of the total seasonal numbers were used for comparing between transplanting dates.

Efficiency of five differently colored sticky traps: This experiment was carried out in a commercial farm during two seasons (3rd January) 2020 and (7th January) 2021. The farm area was two feddans and cultivated with onion Ahmartantawy during two seasons. The experimental filed area was divided into 20 equal plots 4 replicates of each colored sticky traps (CST)). Five differently colored sticky traps (CST) tested, blue sticky tarp (BST), yellow sticky trap (YST), with 20 × 10 cm in size were [obtained from Agriculture Research Center, Giza, Egypt] and the same size red sticky trap (RST), white sticky trap (WST) and black sticky trap (BcST) were made using red, white and black cardboard and coated with a thin layer of adhesive material. The edges of the traps were positioned 15–30 ^{cm} above the tops of the plants and fastened to a wooden pole. At intervals of seven days, the traps were checked and replaced. The colored sticky traps were removed, wrapped in transparent plastic cling film, and taken to the lab to calculate the quantity of thrips. Trapped *T. tabaci* adult were counted weekly After each count, sheets were removed and replaced by a new one. The means of weekly adults caught (adult/trap) were calculated to evaluate the efficiency of the Five differently colored sticky traps.

Susceptibility of some onion cultivars to infestation with *T. tabaci*: An area of 1200 ^{m2} in a private farm was chosen Delta region to accomplish the experiment during winter plantation for two successive seasons, 2020 and 2021. Three commercial onion cultivars included Giza 6 (red onion), Ahmartantawy (red onion) and Giza 20 (yellow onion). onion seeds were planted on 1st November and 13th November for two growing successive seasons 2019/2020 and 2020/ 2021. After about 8 weeks, plants were transplanted in the field on 2nd and 10th January 2020 and 2021 respectively. The experiment was performed in a randomized block design with four replicates (about 100 ^{m2}) in each treatment. The area was divided into 3 plots, one for each cultivar. After two weeks from transplanting, 5 plants from each replicate were randomly collected early. Samples were taken weekly and placed in plastic bags then transferred the laboratory for counting the number of nymph and adult using binocular stereomicroscope. The means of the weekly counted nymph and the adult *T. tabaci* individuals of the total seasonal numbers were used for comparing between cultivars. According to the (X) of the insects, each cultivar's susceptibility degree (SD) was classified, and the standard deviation (SD) was computed in accordance with [10]. The cultivars were classified as highly susceptible (HS) if their mean insect number was greater than X + 2SD, susceptible (S) if it was between X and X + 2SD, low resistant (LR), moderately resistant (MR), and highly resistant (HR) if it was between X -2SD and X -1SD.

Statistical analysis: Data were analyzed using MINITAB ® software program (version Minitab® 21.4.1). Analysis of Variance (ANOVA), and F- value were performed to compere means of different treatment including comparisons between differently colored sticky traps**,** transplanting date (early, mid, and late) and susceptibility of onion cultivars. ANOVA followed by means separation according to the Tukey's Honestly Significant Difference (Tuckey HSD) method and 95% confidence to identify differences and significances among treatments according to [11]. Means that don't share a letter are very dissimilar. Table and figure values are all means with standard errors.

Results and Discussion

Transplanting date in management population density of *T. tabaci:*

Winter season 2019- 2020: during season 2019-2020 (table 1), the differences among transplanting dates were significance (F – value =7.15, P-value = 0.000). The total number (±SE) of individuals / 5 plants were significantly greater population densities of *T. tabaci* during late season (689.1 individuals/ 5 plants) compared with mid-season (373.8 individuals/ 5 plants) and early season (205.1 individuals/ 5 plants). Relative abundant *of T. tabaci* in late season 54.3% of total followed by mid-season 29.5% and early season 16.2%. General seasonal mean of *T. tabaci* individuals counts were 12.8±2.7, 23.3±4.7 and 43.1±7.9 Individuals/ 5 plants for the early, mid, and late season during 2019- 2020 (Fig.1A).

Winter season 2020-2021: A similar trend was observed during 2020 - 2021 season (table 1). The differences among transplanting dates were significance increased (F-value = 15.5, P- value= 0.000), the total number (±SE) of individuals / 5 plants were significantly higher population densities of *T. tabaci* than throughout late season (952.8) compared to mid-season (635.1) and early season (296.3). Relative abundant of *T. tabaci* in late season 50.6% of total followed by mid-season 33.7 % and early season 15.7%. General seasonal mean of *T. tabaci* individuals counts was 18.5±4.0, 39.7±6.9 and 59.5±10.5 I/5P for the early, mid, and late season during 2021 season (Fig. 1B).

Generally, the early transplanting date caused the least mean number of *T. tabaci* individuals infestations, followed by the mid-transplanting date and the late transplanting date where the maximum number of infestations were created by the mean number of *T. tabaci* individuals. According to data from both onion growing seasons, the second season had a higher accumulative mean number of *T. tabaci* than the first season did for the (early, mid, and late) growing seasons. This could be a result of the weather conditions at the time and the movement of insects to the nearby crops that T. tabaci adults overwinter on. When warmer weather returns in the spring, the adults of thrips can fly to their preferred host species to lay eggs. In more variable climates, thrips overwinter as adults in weeds, grasses, plant detritus on the ground, and other protective places [12]. Early plantation has a lower incidence of *T. tabaci* populations than late transplantation, which may be caused by low temperatures and an incongruence between the crop's vulnerable stage and *T. tabaci* peak activity. Since the early transplanted onion reached maturity level in April, a second peak was not observed, which was consistent with Ullah *et al.,* (2010) [13] finding respecting of planting dates, it is obvious that the early planting season recorded the lowest liability of infestation. In India, Pandy *et al.,* (2018) [14] indicated that, that lowest mean *T. tabaci* population (4.7 nymphs/plant) were recorded in early season, which was found at par (7.7 nymphs/plant) were recorded mid-season. While highest mean *T. tabaci* population (13.7 nymphs/plant) was recorded in late planted season. The similar trend was also found by Sujay and Giraddi (2014) [15] That late-planted crop was vulnerable to severe insect pest infestation. Our results agree with the findings of in previous studies in Egypt, Awadalla *et al.*, (2017) [16] & Salem and Aref (2019) [17] showed that, the highest number and percentage of *T. tabaci* in the late transplanting date. While early season reduces the insect population by at least 50% or 100% when compared to mid or late season, and increases onion crop yield by 30 or 42%, depending on the stage. Likewise, in India, Raut *et al.*, (2020) [18] & Dwivedi *et al.*, (2022) [20] found that the highest population of nymph and adults of thrips was recorded on the late season, followed by mid-season and the lowest early season. Therefore, the early planting date caused the least mean number of *T. tabaci* individuals infestations.

Table 1: The total number (±SE) of *T. tabaci* individuals per 5 plants in the early, mid-, and late onion growing during winter plantation in 2019-2020 and 2020-2021 season at Gharbia Governorate.

Season	2019- 2020		2020- 2021	
	Total No. of *T. tabaci* individuals	% Relative abundant	Total No. of *T. tabaci* individuals	% Relative abundant
Early	205.1±7.7 c	16.2	296.3±8.5 c	15.7
Mid	373.8±9.2 b	29.5	635.1±11.1 b	33.7
Late	689.1±10.4 a	54.3	952.8±3.8 a	50.6
Total	1.268	100	1.884	100
F- value	7.15		15.5	
P- value	0.000		0.000	

.Means in the same column that do not share a letter are significantly different.

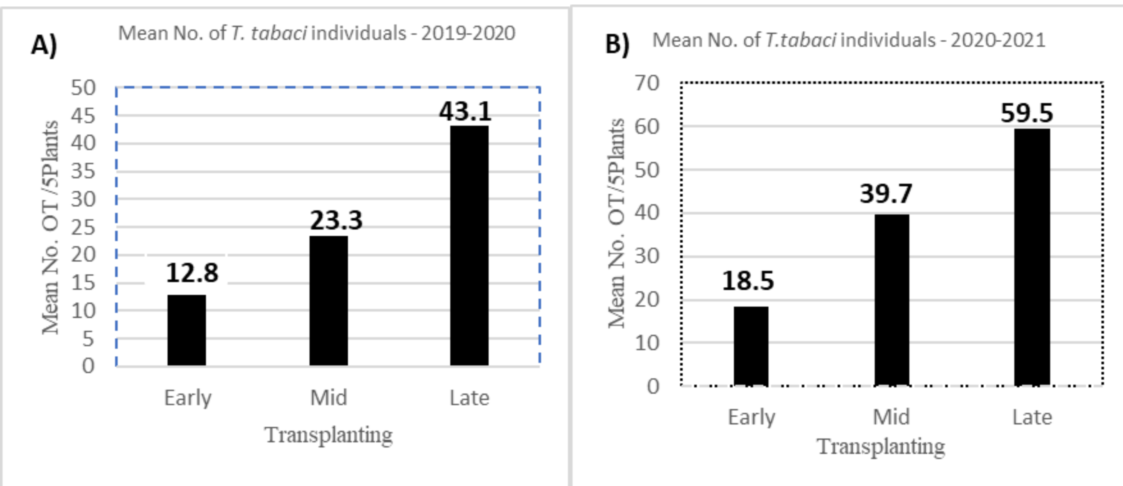

Fig 1: Mean seasonal numbers of *T. tabaci* individuals per 5 plants in the early, mid-, and late onion growing season at Gharbia Governorate A) during 2019- 2020 season B) during 2020-2021 season.

Efficiency of five differently colored sticky traps

The weekly mean numbers of captured adult using the five differently colored sticky traps are shown in (table 2). In 2020 season, the captured adult of *T. tabaci* began to show in the 2nd week of planting from 39.8±1.1, 29.5±2.3, 25,8±1.8, 19.5±1.9 and 17.8±1.0 adult/ trap in BST, YST, WST, RST and BcST, respectively. The population fluctuated to reach the maximum peaks in BST, YST and WST 146.8±4.5, 133.0±3.3 and 129.3±1.8 adult/ trap in weeks 16 after transplanting. The population fluctuated to reach the maximum peaks in RST and BcST 67.8±4.6 and 52.3±1.4 adult/ trap in weeks 15 after planting then the population size of *T. tabaci* decrease until harvesting. The seasonal adult population means using BST, YST, WST, RST and BcST were high significantly different (F-value = 16.77, P-value =0.000) where the recorded adult was 83.6±6.2, 73.3±6.0, 69.5±6.1, 37.0±3.6 and 28.6±2.5 during 2020 season.

Table 2: The weekly *T. tabaci* captured adult (mean ± SE) using five differently colored sticky traps," BST, YST, WST, RST and BcST", during winter plantation in 2020 season at Gharbia Governorate.

Plant age (weeks)	Card Sticky Traps					F – test	
	BST	YST	WST	RST	BcST	F- Value	P- Value
2	39.8±1.1 a	29.5±2.3 b	25.8±1.8 bc	19.5±1.9 cd	17.8±1 c	2.67	0.000
3	46.3±2.3 a	39.5±1 c	32.5±2.2 b	24.5±1.7 d	18±0.9 e	4.32	0.000
4	62.5±2.3 a	50.8±1.9 b	46.3±2.9 b	25.5±2.5 c	21.8±1.4 c	5.82	0.000
5	74.3±1.8 a	62.3±2.5 b	58.5±2.5 b	25.5±2.1 c	23.5±2.9 c	9.28	0.000
6	80.3±1.7 a	67±2 b	63.3±3.3 b	28.3±1.7 c	23.5±1.7 c	13.56	0.000
7	76.3±2.4 a	73.5±1 a	71.3±1 a	32.3±2.3 b	24.8±1.7 c	19.44	0.000
8	93±2.7 a	81.8±2.9 b	78.8±1.7 b	38.8±1.4 c	32.3±2.1 c	15.23	0.000
9	103.3±4.6 a	95±2.3 a	87.5±4.3 a	36.3±3.4 b	29.3±3.4 b	8.88	0.000
10	100.8±1.8 a	83.5±4.2 b	78.8±0.9 b	48.5±4.8 c	23.8±2.2 d	9.43	0.000
11	76.0±2.4 a	65.8±1.8 b	63.3±1.4 b	30.5±2.8 c	21±2 d	13.02	0.000
12	75.8±2.7 a	63.3±2.3 b	61.8±3.6 b	27.3±2.3 c	20.8±0.9 c	9.18	0.000
13	82±2.5 a	72.5±3.5 ab	69.5±1.5 b	44.3±1.3 c	37±2.5 c	6.54	0.000
14	105.3±3.5 a	94±2.5 a	90.5±2.5 a	63.3±8.7 b	40.3±3.6 c	3.08	0.000
15	123.5±5.1 a	115.8±3.6 a	112.8±4.8 a	67.8±4.6 b	52.3±1.4 b	6.08	0.000
16	146.8±4.5 a	133±3.3 ab	129.3±1.8 b	66.8±4.9 c	51.8±3.8 c	12.71	0.000
17	92.5±7.1 a	78.5±2.7 a	76.5±1.9 a	39.5±1.7 b	33.3±1.8 b	5.05	0.000
18	71.8±1.6 a	61.8±3 a	60.5±3.1 a	27±1.8 b	25.5±3.1 b	6.77	0.000
19	55.8±3.4 a	51.8±1.9 ab	44.3±1.3 b	20.8±1.3 c	19±1.8 c	7.12	0.000
Mean ±SE	83.6±6.2 a	73.3±6 b	69.5±6.1 c	37.0±3.6 d	28.6±2.5 e	16.77	0.000

Means in the same column that do not share a letter are significantly different.

In 2021 season (table 3), the captured adults of *T. tabaci* started to appear in the second week of planting from 36.5±3.1, 29.3±2.3, 24.3±2.0, 20.5±1.9 and 15±1.3 adult/ trap in BST, YST, WST, RST and BcST, respectively. The population fluctuated to reach the maximum peaks using BST (152.8±2.4 adult/ trap) in weeks 16 after transplanting and high significant different. On the other hand, the population fluctuated to reach the maximum peaks using YST, WST, RST and BcST (125.5±1.7, 122.3±4.9, 69.8±1.7 and 48.8±4.7 adult/ trap) in weeks 15 after transplanting, then the population size of *T. tabaci* decrease until harvesting. The weekly catches of adult by using five differently colored traps were high significantly different all over the season. The seasonal adult population means using BST, YST, WST, RST and BcST were high significantly different (F-value = 19.27, P- value = 0.000) where the recorded adult was 99.0±67.9, 82.3±6.3, 79.3±6.5, 41.5±3.5 and 30.1±2.4 adult/ trap during 2021 season. As a result of the two seasons, BST significantly higher than using YST, WST, RST and BcST respectively.

Table 3: The weekly *T. tabaci* captured adult (mean ± SE) using five differently colored sticky traps," BST, YST, WST, RST and BcST", during winter plantation in 2021 season at Gharbia Governorate.

Plant age (weeks)	Colored Sticky Traps					F – test	
	BST	YST	WST	RST	BcST	F- Value	P- Value
2	36.5±3.1 a	29.3±2.3 ab	24.3±2 bc	20.5±1.9 bc	15±1.3 c	1.39	0.000
3	44.8±2.2 a	40±1.5 ab	35.8±1.7 b	25.5±2.3 c	16.5±1.7 d	3.63	0.000
4	52±2.7 a	46.3±3.3 a	43.3±1.7 a	24±2.4 b	17.3±2.5 b	3.45	0.000
5	56.8±2.8 a	60.5±3.7 a	60±1.7 a	27±3 b	19.8±1.9 b	5.28	0.000
6	83±3.2 a	68.8±3.5 ab	57.3±2.9 b	26±2.3 c	24.8±4.9 c	5.61	0.000
7	88.3±3.3 a	76.5±2.3 b	71.5±3.1 b	31.8±2.3 c	20±1.5 d	13.55	0.000
8	101.5±3.8 a	88.8±3.9 ab	86.5±3.1 b	36.8±2.7 c	32.3±1.8 c	10.53	0.000
9	113.3±3.1 a	86.5±4.1 b	89.5±3.1 b	42.3±2.7 c	31.5±3.9 d	10.27	0.000
10	107±2.2 a	89.5±3.6 b	85,5±2.3 b	48±1.9 c	37.5±2.3 d	13.80	0.000
11	116.8±2.3 a	88.5±2 b	88.3±4 b	52,5±3.8 c	34.5±4.5 d	8.78	0.000
12	126.3±3.6 a	99±2.5 b	92.3±1.8 b	55.5±5.3 c	38.3±6.1 d	7.06	0.000
13	120.8±0.9 a	104±6.7 a	103±4.4 a	50.5±3.3 b	40.5±3.9 b	7.04	0.000
14	133.3±2.8 a	115.3±4.1 ab	117±4.2 b	63±3.6 c	44±5.2 d	9.14	0.000
15	128±1.8 a	125.5±1.7 a	122.3±4.9 a	69.8±1.7 b	48.8±4.7 c	12.47	0.000
16	152.8±2.4 a	119.3±4.4 b	117.5±2.4 b	61.3±3.3 c	38.8±2.4 d	23.03	0.000
17	130.3±3.8 a	90.8±2.9 b	86±3 b	43.3±3 c	30.3±3.6 c	15.13	0.000
18	105±2.7 a	82.3±2.6 b	79.5±2.1 b	35.8±2.5 c	27.3±1.8 c	19.85	0.000
19	86.8±4 a	70.3±1.9 b	67.5±1.6 b	34.3±2.8 c	25.3±3.2 c	8.46	0.000
Mean± SE	99.0±7.9 a	82.3±6.3 b	79.3±6.5 c	41.5±3.5 d	30.1±2.4 e	19.27	0.000

Means in the same column that do not share a letter are significantly different.

This agreed with results from Natwick *et al.*, (2007) [20] & Roth et al., (2016) [21] & Devi and Roy (2017) [22] & Pobozniak *et al.*, (2020) [23] who revealed that, blue traps were the most alluring to OT, followed by yellow and white ones, and might be utilized as an early detection method while monitoring thrips in pea fields. Also, Amutha (2022) [24] It was indicated number of OT captured in differed colored traps was significantly different, using the blue-colored sticky trap catching more *T. tabaci* followed by yellow.

In the contrast, Mesbah (2001) [25] & Murtaza *et al.*, (2019)

[26] reported that, yellow sticky traps were the most successful for observing and controlling thrips and whiteflies in cotton crops.

Susceptibility of some onion cultivars to infestation with *T. tabaci*

The result shown in (table 4) indicated that the seasonal mean and *T. tabaci* resistance standing of onion cultivars. Infestation during the seasons of 2020, the differences among cultivars were high significance (F- value = 271.6, P- value = 0.000). The highest significant seasonal mean number was recorded on Giza 6 cultivar (80.2±1.4 individuals/5plants), followed by Giza 20 (59.7±0.4 individuals/5plants). While, on the other hand, Ahmartantawy cultivar had the lowest mean numbers (49.1±0.7 individuals/5plants).

A similar trend was observed during 2021 season, the differences among cultivars were high significance (F- value = 225.2, P- value = 0.000). Ahmartantawy displayed the lowest number (56.1±1.2 individuals/ 5 plants), Giza 6 and Giza 20 had the largest numbers (96.0±1.9 and 68.1±0.6 individuals/ 5 plants, respectively).

The cultivars Giza 6 and Giza 20 had the highest *T. tabaci* densities (88.1±7.9 and 63.9±4.2 individuals/5 plants, respectively), on the other hand, Ahmartantawy had the lowest density (52.6±3.5 individuals / 5 plants), based to the general mean of two seasons. The investigated cultivars might be divided into two categories based on their susceptibility levels. Giza 6 appeared to be sensitive (S), while the cultivars Ahmartantawy and Giza 20 appeared to be low resistant (LR). We can be summarized as follows: the cultivar Ahmartantawy is more tolerant of infection with nymph and adults of *T. tabaci* than the Giza 6 and Giza 20 cultivars during both season of the study. The highest susceptible cultivar was Giza 6 since it possessed the highest number of nymphs during both season of the study.

Table 4: Seasonal mean numbers (±SE) of *T. tabaci* individuals (nymph+ adult) resistance status on three onion cultivars throughout winter plantation during year, 2020 and 2021 at Gharbia Governorate.

Cultivars	Season 2020	Season 2021	General mean of two seasons	Susceptibility degree
Ahmartantawy	49.1±0.7 c	56.1±1.2 c	52.6±3.5 c	LR
Giza 20	59.7±0.4 b	68.1±0.6 b	63.9±4.2 b	LR
Giza 6	80.2±1.4 a	96.0±1.9 a	88.1±7.9 a	S
F-value P-value	27.16 0.000	22.52 0.000		

Means in the same column that do not share a letter (a, b, c) are significantly different. LR= Low Resistance, S= Susceptibility

Ahmartantawy was observed to be very tolerance where overall *T. tabaci* individuals population were less than Giza 6 and Giza 20. On the basis of scales provided, different genotypes for onion cultivars' sensitivity to *T. tabaci* people were classified [27]. Several studies tested the susceptibility of the local onion cultivars to infestation with *T. tabaci* in Egypt, Awadalla *et al.*, (2017) [28] demonstrated that, the highest mean numbers of *T. tabaci* on Giza 6 were 316.6±36.6 and 286.4±34.1 nymphs during the 1st and 2nd season, separately. So, Giza 6 must be excluded from the factor of crop breeders and farmers due to its higher susceptibility for infestation. In addition, Embarak (2006) [29] & Salem and Aref (2019) [17] & Khozimy et al., (2021) [30] Improved that, The onion cultivar Giza 6 was more susceptible to *T. tabaci* infestation than Giza 20 and Ahmartantawy. Therefore, inclusion of resistant/tolerant cultivar (Ahmartantawy) in the integrated controlling of *T. tabaci* will increase the onion production, which may be sustainable and economically viable.

Conclusion

To conclude, we demonstrated that *T. tabaci* is a serious pest on onion crops at Delta Nile region. Which shows it is the highest *T. tabaci* population during the mid-March to mid-April at the end of winter season. Date of transplanting is one of important tactics in the controlling of *T. tabaci* in the onion field. Which shows the early transplanting date caused the least mean number of *T. tabaci* individuals infestations. the blue-colored sticky trap attracting more *T. tabaci* individuals followed by yellow. Host plant resistance (HPR) is a practical, affordable, and ecologically sound method of managing insect pests. Ahmartantawy (red onion) was the best variety to tolerate larval infestation of *T. tabaci* on onion plant. On the other hand, the highest susceptible cultivar was Giza 6 cultivar since it possessed the highest number of nymphs during both seasons of the study. This study revealed that the cultural practices such as transplanting date and the presence of *T. tabaci* tolerant onion cultivars approaches play important role in abundance, ecology, and management of *T. tabaci*.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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