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Variability of western flower thrips *Frankliniella occidentalis* (Thysanoptera: Thripidae) infestations on some Solanaceae and Cucurbitaceae crops

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Abstract

Western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) was an important pest that is adapted to utilize numerous plant-feeding sources, it has recently a main pest on vegetable crops. Since it was initially recorded in Egypt, it has spread throughout all regions. While relatively little information on behaviour and population and damages is available for vegetables like pepper, eggplant, squash cantaloupe, cucumber, and snake-cucumber. The current study focused on studying the variability of this pest infestation on these tested crops throughout two summer seasons 2022 and 2023. The present data proved that the population density of *F. occidentalis* was recorded as a high infestation on the tested six host plants after mid-May through two seasons. Moreover, snake-cucumber harboured a high infestation of *F. occidentalis* (7.91 individuals) followed by cantaloupe (6.49 individuals), but both cucumber and pepper were exposed to the lowest infestation (4.69 and 4.92 individuals, respectively). The Solanaceae crops harboured lower damages caused by *F. occidentalis* individuals on flowers than cucurbitaceae crops (Squash, cantaloupe, cucumber, and snake-cucumber). Between two/or three peaks of *F. occidentalis* at flowering and fruiting stages were detected through May-June. The injurious caused by *F. occidentalis* were up to 27.6%. Among three colour sticky traps (Red, yellow, and blue), blue sticky trap appeared to be the most attractive of *F. occidentalis* and *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) adults and can be used to enhance the effectiveness of tactics for thrips controlling in Solanaceae and Cucurbitaceae cultivations. Moreover, eggplant and pepper crops were less attractive to *F. occidentalis* individuals on flowers than cucurbit crops. The presented results indicated that the susceptibility degree of this tested crop to the *F. occidentalis*

infestation was limited to susceptible and low resistance. The two investigated Solanaceae crops had a low resistant, but squash and cucumber in cucurbit crops was a low resistance to *F. occidentalis* infestation. While cantaloupe and snake-cucumber in cucurbit crops were susceptible to *F. occidentalis* infestation in both two tested seasons. Mirid bug predator, *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae) associated with *F. occidentalis* and *T. tabaci* was slightly higher on Solanaceae than Cucurbitaceae plants, in spite of, the presence of thrips was high in cantaloupe and snake-cucumber. The level of flavonoids, alkaloids and phenoloxidase contents was the increase with increasing of *F. occidentalis* infestations as like a positive relation.

Introduction

Western flower thrips (WFT) *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) was an important pest insect that is adapted to utilize numerous plants feeding sources, it is mainly worldwide pest on horticulture crops (Kirk and Terry, 2003). WFT was first recorded on vegetables in Mediterranean regions in Turkey (Tunç and Göçmen, 1995). Within one year, it rapidly proliferation and spread to the Eastern Mediterranean region (Atakan *et al.,* 1998). *F. occidentalis* has been recorded on different crops including pepper, *Capsicum annuum* L. (Teulon *et al.,* 2014 and Shalaby, 2015), eggplant, *Solanum melongena* L. (Burgio *et al.,* 2004), cantaloupe, *Cucumis melo*, cucumber, *Cucumis sativus* L. and squash, *Cucurbita pepo* L. (Hanafy, 2015). Additionally, not only, *F. occidentalis* caused damage due to the sucking of plant juice, but also transmitted a large-scale serious plant virus as tomato spotted wilt virus (TSWV) and impatiens necrotic spot wilt virus (TNSWV) to several crops (Elimem *et al*., 2014 and Khalifa *et al*., 2021). Recently, *F. occidentalis* was the most common thrips species infesting several crops due to this insect being very small in size, so it is difficult to detect. Also, it has strong proliferation, productivity and even parthenogenetic. In addition, it has developed cross-resistance to large-scale of common insecticides (Jensen, 2000 and Cloyd, 2009). This insect pest attacks several vegetable crops (Kirişik and Erler, 2017).

In Egypt, Hanafy (2015) reported the different susceptibility degrees and host preferences of cucumber, squash, eggplant, and kidney bean crops against *F. occidentalis* under field conditions. In pepper crops, the population fluctuation of *F. occidentalis* on pepper flowers under greenhouse (Shalaby, 2015). Otherwise, the development of WFT population on pepper plants at seedling and flowering stages in the laboratory was studied by Yang *et al*. (2023). However, a banker plant system was used to be reduce multiple pests in greenhouses through the study of the variation in susceptibility degrees of four ornamental pepper cultivars to *F. occidentalis* (Kumar *et al*., 2020). On cucumber, the performance of an omnivore, *F. occidentalis* on cucumber plants studied to understand the ecology of the more complex relationships among plants and pest organisms (Pappas *et al*., 2018).

In fruit trees, El-Wakkad (2007) recorded *F. occidentalis* on the flowers of different fruit crops, guava, apple, grape, mango, and citrus crops. However, in ornamental plants, Abd El-Wahab *et al*. (2011) recorded this pest on 27 species of ornamental plants. Challenges in sustainable Cucurbitaceae and Solanaceae management are finding more knowledge about western flower thrips, *F. occidentalis* in Egypt to find the suitable methods to manage this pest on these two plant families.

Therefore, the current study herein focused on studying the variability of this pest infestation on some Solanaceae and Cucurbitaceae crops throughout two summer seasons 2022 and 2023 with relation to the enzyme activity of phenoloxidase and phytochemical components, flavonoids and alkaloids that help to put and implement a novel decision support system against *F. occidentalis* infestation on Solanaceae and Cucurbitaceae cultivations.

Materials and methods

Field experiments were carried out during summer seasons in 2022 and 2023 at a private farm at El-shahid Fekri village, Birket El-Saba Province, Menofia, Egypt, in order to estimate the infestation rate of *Frankliniella occidentalis* on two Solanaceae i.e. hot pepper, *Capsicum annuum* L (Orly Al-Mahsen cultivar) and black eggplant *Solanum melongena* L. (Romy, Black C_5F_1 cultivar) and Cucurbitaceae crops i.e. squash, *Cucurbita pepo* L. (Aziad cultivar), cantaloupe *Cucumis melo* (Yathrib 7 cultivar), cucumber *Cucumis sativus* L. (Good France (Eilo) cultivar) and snake-cucumber *Cucumis melo* L. subsp. *melo* Var. *flexuosus* (L.) (Balady cultivar). All experimental areas received standard agricultural practices according to each crop without any use of insecticides. The experimental area was 2100 m^2 divided into 6 plots (Each plot was 350 m^2). The seedling of all investigated cultivars was planted on 1st March in a completely randomized block design for distributing crops in the experimental area. Three replicates of each crop were performed.

Samples of 10 flowers/ replicate were randomly collected at three-day intervals from 2nd April to 18th June in two tested seasons. The mean numbers of *F. occidentalis* individuals (Nymphs and adults /10 flowers) were weekly recorded throughout the inspection period, using a whitish plastic plan sheet (21 cm width × 29 cm length) as a plate of inspection. To avoid insects escaping, this plate was sprayed with water. Also, the associated mirid bug predator, *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae) was recorded. In addition, random samples of 50 flowers were taken from each replicate during the investigated period in the two seasons to estimate the flower damages on all studied plant hosts caused by this pest. Three selected colour sticky traps (Blue, red and yellow) were used for attracting both *F. occidentalis* and *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) adults during both seasons in all investigated crops. (Each cultivar contained 3 traps from each colour). The sticky sheet (18 cm width × 28 cm length) had a sticky material on both sides, and it was weekly replaced. The sheet trap was made from sensitive plastic. The mean numbers of two attracted thrips per sheet were counted.

The relation between the plant enzyme activity (Phenoloxidase), phytochemical content (Flavonoids and alkaloids) and the infestation rate of *F. occidentalis* on flowers was studied. The

level of phenoloxidase, flavonoids and alkaloids were extracted and determined according to Fehrman and Dimond (1967), Huang *et al.* (2004) and Dalli and Al-Hakim (1987) at Agriculture Faculty, Menofia Univ., respectively. The susceptibility degree of each crop to the infestation with *F. occidentalis* on flowers was as classified dependent on the mean number of this insect ($\bar{X}$) and the standard deviation (SD) according to Chiang and Talekar (1980). The host plant that had mean numbers more than $\bar{X}$ +2SD, was a highly susceptible (HS); between $\bar{X}$ and $\bar{X}$ +2SD, susceptible (S); between $\bar{X}$ and $\bar{X}$ -SD, low resistance (LR); between $\bar{X}$ -SD and $\bar{X}$ -2SD, moderate resistance (MR) and less than $\bar{X}$ -2SD, was considered high resistance (HR). The obtained data were statistically analyzed by using SAS program (SAS, 2003) including f-test and ANOVA analyses. The least significant differences (LSD) were used to compare the obtained data at a 0.05 level of probability.

Results and discussion

Weekly inspections for flowers of tested vegetable crops throughout the first season (2022) showed that the infestation rate of *F. occidentalis* individuals started on 16th April and extended to the end of the inspection period (2nd April - 18th June). Data revealed that the population fluctuation of *F. occidentalis* recorded three peaks in squash and cantaloupe flowers, but it was recorded two peaks on the other four vegetable crops during season 2022 (Table 1). In Solanaceae crops, eggplant, and pepper, two peaks were observed: the first peak was lately started on 28th May (7.56 individuals/ 10 flowers) on eggplant, but early began on 30th April by few mean numbers being 3.25 individuals/ 10 flowers on pepper. The second peak was late noticed on 11th June (9.92 individuals/ 10 flowers) on eggplant and the last inspection (8.83 individuals/ 10 flowers) on pepper through the summer season 2022 (Table 1). In cucurbit crops, snake-cucumber and cucumber plants also had harboured two peaks which concentrated after 15th May during the summer season 2022, however, three peaks were recorded on squash and cantaloupe. At the beginning of April, only one peak was observed on cantaloupe flowers on 9th April 2022 (8.47 individuals/10 flowers).

Throughout the summer season of 2023, three peaks were observed on all tested crops except on snake-cucumber which was exposed to two peaks on 21st May (15.22 individuals/10 flowers) and 18th June (20.14 individuals/10 flowers) throughout 2023. In view of Table (1), the first peak of *F. occidentalis* on all tested crops was noticed through April, but the other two peaks were distributed through May and June during 2023. All observed peaks did not exceed 10 individuals/10 flowers in all crops except snake-cucumber which was exposed to infestation of *F. occidentalis* up to 17.81 individuals/10 flowers during the summer season of 2022.

On the other hand, the highest peaks appeared on all compared vegetable crops was than 10 individuals/ 10 flowers except on squash which was up to 9.86 individuals/ 10 flowers on 11th June 2023. During both two tested seasons, the population density of *F. occidentalis* was recorded higher infestation on these six tested host plants after mid-May through seasons, 2022 and 2023.

Table (1): The population fluctuation of *Frankliniella occidentalis* individuals (Adults and nymphs) on some vegetable crops.

Insp. D.	The population fluctuation of *Frankliniella occidentalis* individuals (adults and nymphs)/10 flowers											
	Summer season 2022						Summer season 2023					
	Eggplant	Pepper	Squash	Cantaloupe	Cucumber	Snake-cucumber	Eggplant	Pepper	Squash	Cantaloupe	Cucumber	Snake-cucumber
2nd April	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
09th	0.00	0.00	0.00	8.47	0.00	0.00	1.67	1.67	1.67	9.14	1.67	1.67
16th	0.58	1.47	3.06	1.86	0.28	0.61	2.92	3.81	5.39	4.19	2.61	2.94
23rd	1.50	0.89	3.89	2.64	1.19	1.86	3.83	3.31	6.14	4.97	3.61	3.94
30th	1.06	3.25	7.58	3.75	1.56	2.33	2.89	5.08	9.42	5.58	3.39	4.17
7th May	4.44	2.33	2.33	3.67	0.89	2.78	6.44	4.33	4.33	5.67	2.89	4.78
14th	6.00	3.00	3.56	6.33	3.67	3.89	8.00	5.00	5.56	8.33	5.67	5.89
21st	7.00	5.00	5.69	8.72	5.25	12.89	9.33	7.33	8.03	11.06	7.58	15.22
28th	7.56	6.50	5.39	8.72	8.28	12.06	9.89	8.83	7.72	11.06	10.61	14.39
4th June	6.72	6.97	6.75	6.81	6.78	13.14	9.06	9.31	9.08	9.14	9.11	15.47
11th	9.92	8.81	7.53	7.89	8.47	15.69	12.25	11.14	9.86	10.22	10.81	18.03
18th	9.44	8.83	6.42	7.61	7.97	17.81	11.78	11.17	8.75	9.94	10.31	20.14
Mean	4.53 b	3.92 b	4.35 b	5.54 ab	3.69 b	6.92 a	6.50 b	5.91 b	6.33 b	7.44 ab	5.69 b	8.89 a
±SE	±1.07	±0.93	±0.77	±0.87	±1.00	±1.96	±1.19	±1.05	±0.90	±0.97	±1.11	±2.07
Susc.D.	LR	LR	LR	S	LR	S	LR	LR	LR	S	LR	S
F value	3.09						2.51					
LSD	1.918						2.096					

Means signed by the same letter in the same row during the season was not significant at 0.05 probability level. Insp. D. = Inspection dates Susc. D.= Susceptibility degree LR. = Low resistant S.= Susceptible

Data in Figure (1) showed the highest infestation recorded on snake-cucumber (7.91 mean numbers of individuals/ 10 flowers) followed by cantaloupe (6.49 mean numbers of individuals/ 10 flowers) without significant difference between them (LSD = 1.998 at 0.05 probability level). However, the other crops, eggplant, pepper, squash, and cucumber harboured low infestation with *F. occidentalis* extended from 4.69 to 5.52 without significant difference between them (LSD = 1.998 at 0.05 probability level) (Figure 1). In cucurbit crops, cucumber was exposure to the lowest infestation of *F. occidentalis* (4.69 individuals/ 10 flowers), also pepper plant had low infestation in Solanaceae crops (4.92 individuals/ 10 flowers). The presented results indicated that the susceptibility degree of this tested crop to the *F. occidentalis* infestation was limited to susceptible (S) and low resistant (LR) according to Chiang and Talekar (1980) (Table 1). The two investigated Solanaceae crops had a low resistance during tested summer seasons, 2022 and 2023. In addition, squash and cucumber in cucurbit crops were classified as low resistant to *F. occidentalis* infestation. While cantaloupe and snake-cucumber in cucurbit crops were susceptible to *F. occidentalis* infestation in both two tested seasons (Table 1).

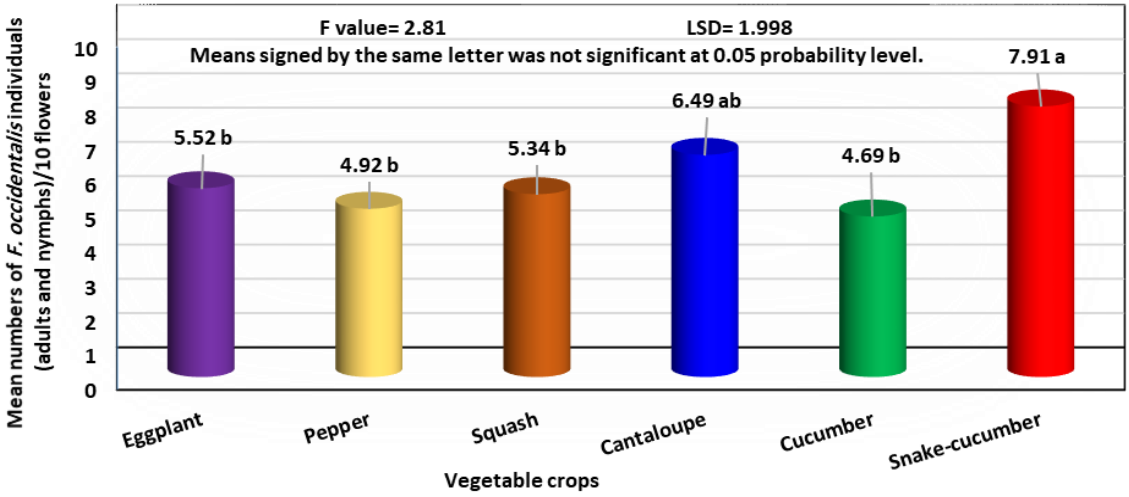

Figure (1): Average of *Frankliniella occidentalis* individuals (Adults and nymphs) on some vegetable crops during two tested seasons, 2022 and 2023.

The damages on flowers caused by *F. occidentalis* individuals were recorded per 10 flowers per replicate on the six tested vegetable crops during two seasons 2022 and 2023 (Table 2). Through the 1st season, 2022, the highest damage caused by *F. occidentalis* individuals was observed on snake-cucumber followed by cucumber (1.00 and 0.69 mean numbers of damaged flowers/ 10 flowers, respectively). However, the lowest was once recorded on eggplant (0.40 mean numbers of damaged flowers/ 10 flowers) (Table 2). Data showed non-significant differences represented between the investigated crops during 2023, but the caused injuries were higher than in the first season in 2022. The *F. occidentalis* damages ranged from 2.13 to 2.76 mean numbers of damaged flowers/ 10 flowers on all six crops (Table 2). Generally, the overall mean number of the injuries caused by *F. occidentalis* individuals was classified into three groups; the first was signed by "a" with snake-cucumber (1.88 mean numbers of damaged flowers/ 10 flowers), the intermediated case was signed by "ab" with squash, cantaloupe, and cucumber. The lowest case

of injuries caused by *F. occidentalis* individuals reported with Solanaceae crops, eggplant, and pepper plants (Table 2). In view of Table (2), the injurious caused by *F. occidentalis* were extended from 4-10%, 21.3- 27.6% and 12.7- 18.8% during seasons 2022, 2023 and altogether two seasons, respectively. The Solanaceae crops (Eggplant and pepper) harboured lower damages caused by *F. occidentalis* individuals on flowers during seasons, 2022 and 2023 than cucurbit crops (Squash, cantaloupe, cucumber, and snake-cucumber). Therefore, management of this pest should be aimed to coincide just before this critical period of increased abundance for WFT, to reduce the infestation and their damage to Solanaceae and Cucurbitaceae crops.

Table (2): Mean numbers of damages caused by *Frankliniella occidentalis* individuals on vegetable crops.

Crops	Mean numbers of damages caused by *Frankliniella occidentalis* individuals (Adults and nymphs)/ 10 flowers (Mean±SE)		
	Summer season 2022	Summer season 2023	Overall mean of damages
Eggplant	0.40 ±0.12 b	2.13 ±0.32a	1.27 ±0.86b
Pepper	0.53 ±0.15 b	2.29±0.36 a	1.41 ±0.88b
Squash	0.56 ±0.15b	2.30 ±0.36a	1.43 ±0.87ab
Cantaloupe	0.66 ±0.16b	2.39 ±0.37a	1.53 ±0.87ab
Cucumber	0.69 ±0.17ab	2.47 ±0.39a	1.58 ±0.89ab
Snake-cucumber	1.00 ±0.22a	2.76 ±0.41a	1.88 ±0.88a
F value	3.15	0.83	1.57
LSD	0.32	0.651	0.463

Means signed by the same letter in the same column was not significant at 0.05 probability level.

Three colour sticky traps (Blue red and yellow) were tested for the attractiveness of *F. occidentalis* and *T. tabaci* adults on six investigated vegetable crops for two summer seasons 2022 and 2023. Initially, among three colour sticky traps, the blue trap attracted the highest cumulative both *F. occidentalis* and *T. tabaci* collection per trap through the two tested seasons. The total catches of adults were insignificant value with red and yellow traps during season 2022, but it was significant value with blue trap on all investigated crops (Table 3).

Data was reported that *F. occidentalis* and *T. tabaci* adult catches were more aggregated on eggplant which extended from 21.72 to 34.89 adults / trap during the first season. The catches of thrips adults ranged from 19.44 to 34.89 adults/ trap in all investigated crops during 2022. Throughout the summer of season 2023, the thrips catches were higher in the second season than the first season (Ranging from 17.67 to 53.06 adults/trap). The cumulative attractiveness of thrips was significantly decreased with red sticky traps in comparison with yellow and blue traps with significant differences between them during 2023 (Table 3). In Solanaceae crops, the three tested sticky traps recorded significant differences between them, but no significant difference was observed between red and yellow sticky traps in four cucurbit crops during both tested two seasons (Table 3).

Table (3): Attractiveness *Frankliniella occidentalis* and *Thrips tabaci* adults in colour sticky traps on vegetable crops.

Host plant	Traps	Season 2022			Season 2023			Overall Mean		
		Mean ±SE/ trap	F value	LSD	Mean ±SE/ trap	F value	LSD	Mean ±SE/ trap	F value	LSD
Eggplant	Blue	34.89 ±5.94 a	11.82	7.18	53.06±7.82 a	27.43	9.48	43.97±9.08 a	20.52	8.13
	Red	18.17 ±3.78 b			17.67±3.79 c			17.92±0.25 c		
	Yellow	21.72 ±3.58 b			34.61±5.28 b			28.17±6.44 b		
Pepper	Blue	32.11±5.37 a	9.86	6.62	48.42±7.05 a	25.61	8.51	40.26±8.15 a	18.81	7.27
	Red	18.42±3.63 b			17.75±3.33 c			18.08±0.33 c		
	Yellow	20.36±3.30 b			31.72±4.91 b			26.04±5.68 b		
Squash	Blue	32.69±5.50 a	6.68	7.35	51.81±8.13 a	18.41	9.94	42.25±9.56 a	12.66	8.39
	Red	21.56±4.79 b			21.44±4.80 c			21.50±0.06 b		
	Yellow	20.44 ±3.46 b			34.97±5.11 b			27.71 ±7.26b		
Cantaloupe	Blue	33.06 ±6.37 a	7.54	8.03	51.42±8.60 a	20.03	10.52	42.24±9.18 a	14.48	9.03
	Red	18.11±4.84 b			17.97±4.85 c			18.04±0.07 b		
	Yellow	21.36±3.74 b			32.19±5.67 b			26.78±5.42 b		
Cucumber	Blue	28.81±4.82 a	5.06	6.38	48.53±7.43 a	22.84	8.78	38.67±9.86 a	14.5	7.38
	Red	19.00±3.72 b			19.00 ±3.72c			19.00 ±0.01 b		
	Yellow	21.39±3.47 b			29.58±4.61 b			25.49±4.10 b		
Snake-cucumber	Blue	33.28±5.86 a	8.64	7.45	47.75±7.69 a	16.7	9.75	40.51 ±7.24 a	12.94	8.28
	Red	20.08±4.62 b			19.33±4.23 c			19.71±0.38 b		
	Yellow	19.44 ±3.33b			33.42±5.54 b			26.43 ±6.99 b		

Means signed by the same letter in the same column in each crop was not significant at 0.05 probability level.

In Figure (2), the highest catches were recorded in blue trap (32.47, 50.16 and 41.32 adults) followed by yellow trap (20.79, 32.75 and 26.77 adults) and red trap (19.22, 18.86 and 19.04 adults) (F value= 8.44, 23.29 and16.23, LSD= 6.99, 9.11 and 7.87 during season 2022, 2023 and altogether two seasons, respectively). Generally, blue sticky trap in our study appeared to be the most attractive colour of *F. occidentalis* and *T. tabaci* adults and can be used to enhance the effectiveness of tactic for thrips controlling in Solanaceae and Cucurbitaceae cultivations.

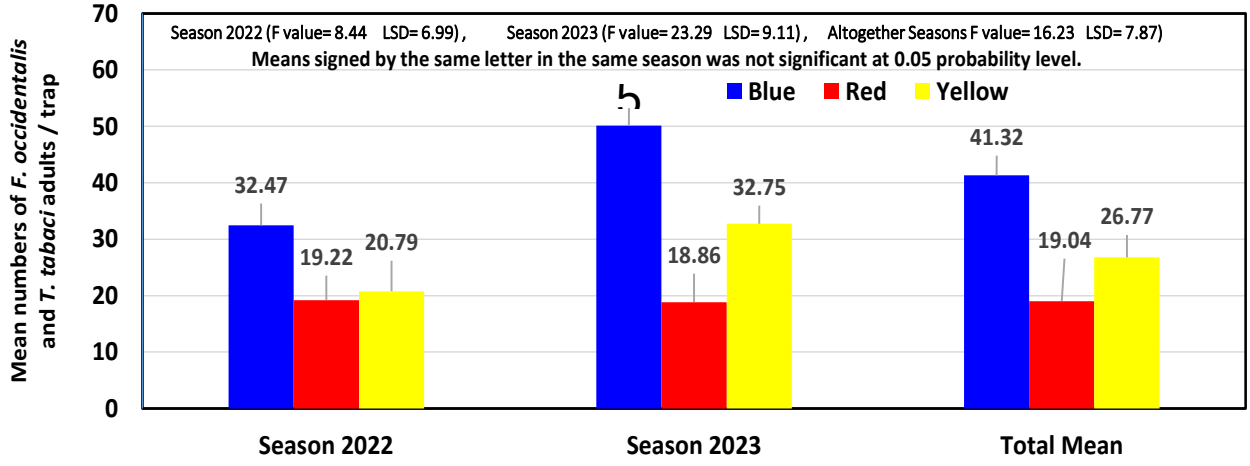

Figure (2): Attractiveness of *Frankliniella occidentalis* and *Thrips tabaci* adults in colour sticky traps on vegetable crops.

During the present study, it was observed that the mirid predator *N. tenuis* associated with *F. occidentalis* and *T. tabaci* individuals in all tested six crops. Data in Table (4) show the mean numbers of *N. tenuis* individuals per flower was higher in Solanaceae plants, eggplant (0.39 individual / flower) and pepper (0.21 individual / flower) than in Cucurbitaceae plants (from 0.08 to 0.16 individual / flower) through season 2022. There are significant differences were recorded between *N. tenuis* individuals per flower on eggplant with the other five tested crops during 2023 (Table 4). The overall mean number of the mired predator *N. tenuis* associated with *F. occidentalis* and *T. tabaci* was slightly higher on Solanaceae than Cucurbitaceae plants, despite, the presence of thrips being high in cantaloupe and snake-cucumber. This may be explained that the flower colour of Solanaceae and thrips numbers were favourable for *N. tenuis* development.

Table (4): Mean numbers of the associated mirid predatory bug, *Nesidiocoris tenuis* with *Frankliniella occidentalis* and *Thrips tabaci* individuals in vegetable crops.

Crops	Season 2022	Season 2023	Overall mean
	Mean ± SE / flower	Mean ± SE / flower	Mean ± SE / flower
Eggplant	0.39±0.08 a	1.04 ±0.11 a	0.72 ±0.325 a
Pepper	0.21 ±0.05 b	0.86 ±0.07 ab	0.54 ±0.325 b
Squash	0.08 ±0.02 c	0.74 ±0.09 b	0.41 ±0.33 b
Cantaloupe	0.13 ±0.04 bc	0.79 ±0.07 b	0.46 ±0.33 b
Cucumber	0.16 ±0.05 bc	0.82 ±0.08 b	0.49 ±0.33 b
Snake-cucumber	0.11 ±0.04 bc	0.77 ±0.08 b	0.44 ±0.33 b
F value	8.83	2.33	5.52
LSD	0.103	0.215	0.131

Means signed by the same letter in the same column was not significant at 0.05 probability level.

The levels of plant enzyme, phenoloxidase of six vegetable crops (At the fruiting stage) were estimated. The obtained results showed that non-significant differences were recorded in all tested crops with mean ranging from 1.68 to 3.02 ΔO.D. /min/g fwt after 45 min. during two tested summer seasons, 2022 and 2023. (Table 5). The highest level of phenoloxidase was recorded with snake-cucumber by 3.02 ΔO.D. /min/g Fwt. Data presented in Table (5) showed a significant difference between the phytochemical component levels of flavonoids and alkaloids in the tested vegetable crops (At the fruiting stage) during two tested summer seasons, 2022 and 2023. The flowers of snake-cucumber contained the highest level of flavonoids and alkaloids at 41.00 and 81.00 mg/ g fwt, respectively, followed by cantaloupe contained 33.00 and 58.00 mg/ g fwt. The lowest level of the flavonoids and alkaloids components was found in the flowers of pepper (18.00 and 42.00 mg /g fwt, respectively) and cucumber (22.00 and 52.00 mg / g fwt, respectively, Table 5). In comparison between data in Table (5) and Figure (1), the results illustrated that the level of these elements was increased cantaloupe and snake-cucumber with increasing of thrips *F. occidentalis* infestations. That means there is a positive relationship between them. Also, these levels were decreased in pepper and cucumber with decreasing in *F. occidentalis* infestations.

Table (5): Phytochemical on flower at fruiting stage for two summer seasons 2022 and 2023.

Crops	Enzyme activity	Phytochemical components	
	Phenoloxidase O.D./g Fwt after 45 min.	Flavonoids (mg/gfwt)	Alkaloids (mg/gfwt)
Eggplant	2.74 a	29.00 bc	56.00 b
Pepper	1.68 a	18.00 c	42.00 c
Squash	2.52 a	27.00 bc	53.00 b
Cantaloupe	2.93 a	33.00 ab	58.00 b
Cucumber	1.75 a	22.00 bc	52.00 b
Snake-cucumber	3.02 a	41.00 a	81.00 a
F value	1.66	4.81	17.07
LSD	1.41	11.44	9.69

Means signed by the same letter in the same column was not significant at 0.05 probability level.

The population density of *F. occidentalis* was recorded as a high infestation on the tested six host plants after mid-May through seasons, 2022 and 2023 in the present study. Moreover, in this work, snake-cucumber harboured a high infestation (7.91 mean numbers of individuals/ 10 flowers) followed by cantaloupe (6.49 mean numbers of individuals/ 10 flowers). In cucurbit crops, cucumber was exposed to the lowest infestation of *F. occidentalis* (4.69 individuals/ 10 flowers), also pepper plant had a low infestation in Solanaceae crops (4.92 individuals/ 10 flowers). These results are in harmony with those obtained by Hanafy (2015), revealed that *F. occidentalis* occurrence on cucumber, squash, eggplant, and kidney bean was observed during the whole period of flowering stage from May to July. Also, Abd El-Wahab (2016) proved that the most abundant thrips species on soybean was *T. tabaci* (226.2individual/plant) and *F. occidentalis* (107.02 individual/plant) from June to mid-August, and there were associated weeds.

These weeds were alternative hosts for plant viruses and thrips vectors, therefore should be considered when endeavoring to manage plant viruses on vegetables like pepper, eggplant, squash cantaloupe, cucumber, and snake-cucumber. In addition, the high activity of *F. occidentalis* found in the mid-May on chili *Capsicum annuum* L. in Kunming, southern China (Hu *et al*., 2021). Yang *et al*. (2023) noticed that the pepper flowering stage was more favorable to the population development of western flower thrips populations.

However, Rosenheim *et al*. (1990) found a high infestation of *F. occidentalis* in female cucumber flowers compared to male flowers, and it indicated that suggested that this pest may have been feeding on the developing fruit. In the present study, *F. occidentalis* recorded between two/or three peaks on all tested vegetable crops at flowering and fruiting stages through May-June during 2022 and 2023. These results are in harmony with those obtained by Abd El-Wahab (2016).

He observed that *F. occidentalis* was recorded at two peaks in late June and mid-September in soybeans. On weeds, *F. occidentalis* was represented on 49 weed species and was detected between May and June (Atakan and Uygur, 2005). In China, the highest populations of *F.* occidentalis was found from April to November 2021 (Fan *et al*., 2023). In addition, *F. occidentalis* occurred in February and April on wild plant species (Chellemi *et al*., 1994). They also reported that *Frankliniella* species infested a wide host range during April-May.

In the present data, the injuries

caused by *F. occidentalis* in the first season of 2022 were very slight when compared to those that occurred in the second season of 2023. It may be due to the recent climate changes and increasing of Co_2 emissions (Skendži´c *et al*., 2021). The Solanaceae crops (Eggplant and pepper) harboured lower damages caused by *F. occidentalis* individuals on flowers during both tested two seasons, 2022 and 2023 than cucurbit crops (Squash, cantaloupe cucumber, and snake-cucumber). In the obtained data, the injurious caused by *F. occidentalis* was reported a significant value between the tested six vegetable crops.

The injuries caused by *F. occidentalise* were extended from 4-10%, 21.3- 27.6% and 12.7- 18.8% during season 2022, 2023 and altogether two seasons, respectively. Are going in a similar line of those findings by Hanafy (2015), he found that *F. occidentalise* caused significant damage in the flowers of four vegetable crops cucumber, squash, and eggplant. The highest significant damage percentage was recorded on cucumber flowers ranging from 20-30 %. Saad (2019) mentioned that the infestation by thrips affected the Tulip flowers. He stated that the annual tulip production decreased from 115-120 flower/m^2/year to 90-95 flower/m2/year after infestation by thrips. Moreover, Kindt *et al*. (2003) infer that the behavior feeding of *F. occidentalis* causes damage to plants and this thrips species transmits tomato spotted wilt virus (TSWV) during styles penetration. Not only, this pest cause leaf and flower damage in vegetable crops but also it transmitted different tospoviruses as like tomato spotted wilt virus (TSWV), tomato chlorotic spot virus (TCSV), impatiens necrotic spot virus (INSV), groundnut ringspot virus (GRSV) and chrysanthemum stem necrosis virus (CSNV) (Whitfield *et al*., 2005).

In all parts of the eastern Mediterranean region, *F. occidentalis* was concentrated on numerous weed species especially in vegetable crops and quickly spread in these countries (Atakan, 2003 and Atakan and Uygur, 2005). Therefore, management of this pest should be aimed to coincide just before this critical period of increased abundance for WFT, to reduce the infestation and their damage to Solanaceae and Cucurbitaceae crops.

In the obtained data, among three colour sticky traps (Red, yellow, and blue), the blue sticky trap in our study appeared to be the most attractive colour to *F. occidentalis* and *T. tabaci* adults and can be used to enhance the effectiveness of the tactic for thrips controlling in Solanaceae and Cucurbitaceae cultivations. In Solanaceae crops, the three tested sticky traps recorded significant differences between them, but no significant difference was observed between red and yellow sticky traps in four cucurbit crops during both tested two seasons. Our results agree with the findings of Sanad and Hassan (2019) that the using of blue sticky traps was more suitable for reducing and attracting WFT individuals.

Also, Broughton and Harrison (2012) represented that *F. occidentalis* was more attracted to blue, white, and yellow sticky traps than to black, red, and green sticky traps. They also found that blue sticky traps had more catches thrips individuals than yellow sticky traps. Carrizo and Klasman (2001) infer that the blue sticky traps of 10 cm x 10cm (100 cm^2) were appropriate to survey the thrips, *F. occidentalis* in the carnation crop. However, Hardy *et al*. (2005) reported that yellow sticky traps were more attractive than thrips.

In addition, Cloyd (2009) proved that the main method for scouting and

controlling thrips was the use of both blue and yellow sticky traps. In the obtained data, Solanaceae crops, eggplant and pepper were less attractive to *F. occidentalis* individuals on flowers than the tested cucurbit crops. Similarly, Papadaki *et al*. (2008) stated that the least attractive of *F. occidentalis* was observed on pepper leaves and eggplant flowers.

They also found there were differences in the host plant preference for leaves or flowers of cucumber, melon, eggplant, pepper, tomato, and bean. In our study, it may be suggested that flower colour may seem to be an important factor affecting thrips orientation to flowers, other signs such as odour may be an effect on the colonization of plants as that finding by Mulligan and Kevan (1973).

The presented results indicated that the susceptibility degree of this tested crop to the *F. occidentalis* infestation was limited to susceptible (S) and low resistance (LR) according to Chiang and Talekar (1980). The two investigated Solanaceae crops had a low resistant during tested summer seasons, 2022 and 2023. In addition, squash and cucumber in cucurbit crops were classified as low resistant to *F. occidentalis* infestation.

While cantaloupe and cucumber 1 in cucurbit crops were susceptible to *F. occidentalis* infestation in both two tested seasons. Our results were in harmony with Hanafy (2015) that cucurbit crops especially cucumber flowers were occupied by significantly higher numbers of *F. occidentalis* than the other three tested crops (Kidney bean, squash, and eggplant), and it is considered a susceptible crop. On the contrary, the lowest significant infestation of this pest was noticed on kidney bean flowers.

Also, Papadaki *et al*. (2008) observed that the least attractive *F. occidentalis* was observed on pepper leaves and eggplant flowers. They also found there were differences in the host plant preference for leaves or flowers of cucumber, melon, eggplant, pepper, tomato and bean. Although, the colour of vegetable flowers seems to be affected the thrips orientation, another factor such as odour may be an effective factor on plant colonization (Mulligan and Kevan, 1973).

However, *F. occidentalis* and *T. tabaci* might have a high potential to acquire TSWV from weeds, and TSWV has a wide weed host range (Groves *et al*., 2002). Additionally, the population density of *F. occidentalis* was variable on chili and maize crops and surrounding weed species, which included white clover, alfalfa and beggarticks in China. It may be to the color and odour of the flowers of these crops and weeds (Hu *et al*., 2021).

Numerous factors may be affecting the *F. occidentalis* occurrence in vegetable crops, which caused the preference and non-preference of this pest to different vegetable crops in Egypt as it may be suggested as weeds, flower colour, odour emission, phytochemical contents, climate changes, Co_2 emission and … etc.

Our results illustrated that the level of flavonoids, alkaloids and phenoloxidase was increased in cantaloupe and snake-cucumber with increasing thrips *F. occidentalis* infestations. That means there is a positive relationship between them. Also, these levels were decreased in pepper with is decrease in thrips *F. occidentalis* infestations. Similarly, Maharijaya *et al*. (2019) reported a variation in phytochemical components in pepper plants with significantly related to thrips resistance. They infer that flavonoid components may play an important role in inducing plant resistance against in thrips infestation.

Also, our results support previous findings that flavonoids, alkaloids and phenoloxidase increased when plants were under stress caused by pest infestation and affected the *F. occidentalis* density (Leiss *et al*., 2013; Liu *et al*., 2017 and Liu *et al*., 2019).

The obtained results were found that *N. tenuis* associated with *F. occidentalis* and *T. tabaci* was slightly higher on Solanaceae than Cucurbitaceae plants, despite, the presence of thrips being high in cantaloupe and snake-cucumber. This may be explained that the flower colour of Solanaceae and thrips numbers were favourable for *N. tenuis* development. Field monitoring showed that the occurrence of *N. tenuis* may be dependent on the presence of Solanaceae and Cucurbitaceae as major host plants, however, its abundance was affected by pest management.

The obtained results are in line with Hassan *et al.* (2017) found that the mirid bug *N. tenuis* is associated and related to whitefly density in squash plants. Indeed, numerous studies infer that tomato pests preyed on by *N. tenuis* could be entered into greenhouses, and it would be needed to control by increasing of *N. tenuis* (Chailleux *et al*., 2022).

Also, *Chinchilla-Ramírez et al.* (2021) reported that the mirid *N. tenuis* plays an important role in IPM in different crops. They found this predator at high population levels in tomato crops when prey was scarce. This predator is Zoophytophagous and causes plant damage. Additionally, an understanding of the interactions between *N. tenuis* and the plant might focus light on new approaches to reduce its damage potential to crops while retaining its benefits as a biocontrol element (Chailleux *et al*., 2022).

Therefore, both behavioral, mechanical and consumption levels of *N. tenuis* must be taken into consideration when used in IPM control program of *F. occidentalis* on Solanaceae and Cucurbitaceae crops. And then, the management of this pest should be aimed to coincide just before to this critical period of increased abundance for WFT, to reduce the infestation and damages on Solanaceae and Cucurbitaceae crops.

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