Evaluating Host Preference and the Population Dynamics of Insect Pests, Spider Mite and their Associated Predators on Solanaceous Crops

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Abstract

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Experiments were carried out at the experimental farm of the Faculty of Agriculture, Kafr El-Shiekh University, during 2020 and 2021 summer seasons. The objectives were to observe population fluctuations of some arthropod pests and their preference to three solanaceous crops: eggplant, tomato and pepper. The study also examined the correlation between predators and certain pests. In addition to the spider mite, *Tetranychus urticae* Koch and *Tuta absoluta*, five piercing-sucking insects infested each of the vegetable crops; Aphis spp., *Thrips tabaci* Lindeman, *Bemisia tabaci* (Genn.), *Empoasca* spp. and *Phenacoccus hirsutus* Green. Results obtained revealed that eggplant was the most preferred solanaceous host that harboured 81.17% out of total aphids, *B. tabaci* (87.07%), *Empoasca* spp. (53.51%), *P. hirsutus* (65.78%) and *T. urticae* (95.33%). The second preferred host was tomato that had 58.17 and 88.83% out of total populations of *T. tabaci* and *T. absoluta*, respectively. Pepper plants were mostly the least preferred host. Five predatory species were found associated with the above-mentioned pests. These arthropod predators were spiders, *Scymnus* spp., *Orius* spp., *Chrysoperla carnea* and *Coccinella* spp. Highly significant positive correlations were found between aphids and each of *Scymnus* spp. and *Coccinella* spp. In addition, the correlations between *T. tabaci* and *Orius* spp., and between *Empoasca* spp. and spiders were highly positively significant. Results highlighted that eggplant was the most infested by the piercing-sucking insects and the spider mite *T. urticae* compared to tomato and pepper.

Keywords: Arthropod pests, solanaceous plants, pest preference, piercing-sucking insects, predators.

Introduction

Solanaceous vegetables are very important crops for human nutrition all over the world, and consumed as fresh table foods and as essential raw materials for several food processing industries. The highest producing countries of eggplant, *Solananum melogena* L. are: China, India, Egypt, Turkey and Indonesia with 37, 13, 1.3, 0.84 and 0,17 million tons, respectively (FAOSTAT, 2020).

Tomato, *Solanum lycopersicum* L. is consumed worldwide as fresh vegetable because of its high contents of essential nutrients and antioxidant-rich phytochemicals, as well as tomato fruits are rich in minerals, vitamins, proteins, essential amino acids, fatty acids, carotenoids and phytosterols (Ali *et al.*, 2021). The top leading countries in tomato production are: China, India, USA, Turkey and Egypt with 62, 19, 13, 12 and 7 million tons, respectively (FAOSTAT, 2020)

Pepper, *Capsicum* spp. harbors several bioactive compounds with high nutritional and pharmaceutical values. Differentvarieties of peppers contain important micro- and macro elements, antioxidants, vitamins (C, E and provitamin A) in varying amounts (Olatunji & Afolayan, 2019). Major countries in pepper production are: Vietnam, Brazil, Indonesia, India and China with 264, 109, 89, 66, and 40 thousand tonnes, respectively (FAOSTAT, 2020)

Solanaceous vegetable plants face potential infestations by various insect pests including: *Aphis gossypii* Glov., *Thrips tabaci* Lind., *Bemisia tabaci* Genni., *Empoasca* spp., *Tuta absoluta* Meyrick, *Liriomyza trifolii* Brug., *Nezara viridula* L., *Phenacoccus hirsutus* Green. and *Tetranychus urticae* Koch. (Derbalah *et al.*, 2012; Desneux *et al.*, 2010; Lietti *et al.*, 2005; Sadek & El-Dewy, 2019;).

Kumar *et al*. (2021) and Rahayu (2022) reported that predators are effective biological control agents against several key pests of vegetable crops infesting eggplant, tomato and pepper. Among these predator species are: *Coccinella undecimpuctata* L., *Chrysoperla carnea, Orius* spp., *Scymnus* spp., and spiders (Agwu *et.al*., 2018; Hendawy & El-Fakharany, 2012; Sadek & El- Dewy, 2019).

Host-plant preference appears to be positively correlated with the attraction of insects to certain plants to fulfill their feeding requirements (Bethke *et al.*, 1991). Saleh & Al-Shareef (2010) concluded that plant infestation by *B. tabaci* leads to decline in the pH value in all leaves of eggplant, tomato and pepper.

Uzun *et al.* (2015) showed that the egg laying preference of *T. absoluta* directly affects the damage in tomato plants. In addition, the pest is more attractive to eggplant than to pepper. However, Idriss *et al.* (2020) indicated that tomato was the most preferred host of *T. absoluta* having the highest number of deposited eggs, followed by black nightshade (eggplant), French bean, and chilli pepper, and these findings confirm the oligophagous nature of the pest with highest preference to tomato.

This study aimed to monitor the population fluctuations of some piercing-sucking insect pests on eggplant, tomato and pepper. In addition, fluctuations of major predators

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associated with those pests were investigated, and the preference of key insect pests to eggplant, tomato and pepper were assessed.

Materials and Methods

Experimental site and design

The present study was carried out at the experimental farm of Faculty of Agriculture, Kafr El-Shiekh University, Egypt and at the laboratory of Economic Entomology Department, same Faculty during 2020 and 2021 summer seasons. The experimental field was divided into 12 plots, each of 42 $m^{2,}$ to evaluate three treatments (eggplant, tomato and pepper) with four replicates each.

Sowing and transplanting

Seeds of eggplant, tomato and pepper were sown at the nursery on April 1st. One month later, the seedlings were uprooted and transplanted in the permanent field. Regular agricultural practices were followed as recommended by the Ministry of Agriculture, Egypt, without any pesticidal treatments.

Sampling and examination

One week after transplanting, samples of 150 leaves were examined (10 plants × 5 leaves × 3 plant levels) per plot. All the considered insect pests were directly examined on the standing plants in the field in the early morning (7 am) with the aid of a lens as the insect stages are more stable. However, the samples assigned for *Bemisia tabaci* and *Tetranychus uriticae* were transferred to the laboratory for thorough examination under the binocular microscope. The cultivated vegetable varieties were Sawad el lel (eggplant), Elissa (tomato) and Mohannad (pepper) as they are common varieties in the region.

During the first season (2020), each vegetable species was examined through fifteen random samples, whereas in the subsequent season (2021), seven random samples per vegetable crop were analyzed. The sampling was predominantly conducted at 7-day intervals. In addition to pests monitoring, four insect predators and true spiders were monitored weekly, with evaluations based on 150 leaves per plot.

Statistical analysis

Correlation coefficient values were computed to determine the relationships among pests affecting eggplant, tomato, and pepper, as well as their associations with common predators according to Pearson and Spearman's Rank. .

Results

Population fluctuation of insect pests and spider mite on eggplant

Aphids (Homoptera: Aphididae)- Aphids population density are presented in Table 1. In the first season (2020), different aphid species were counted on eggplant leaf samples beginning from May 8th until August 11th. In the first sample, examined on May 8th, 42 nymphs and adults of aphids were recorded per 150 leaves, increased and fluctuated in their population densities and six peaks on May 22nd, June 12th, 26th, July 17thv, 31st, and August 11th were observed, with population densities of 68.2, 50.00, 79.7, 65.50, 70.25 and 90.50 nymphs and adults /150 leaves, respectively. The seasonal average was 47.83±5.82 nymphs and adults/150 leaves.

In the second season (2021), a relatively lower seasonal average was found with 42.18±13.39 nymphs and adults/150 leaves. However, only two peaks were observed on June 16th and June 30th, with 86.25 and 90.50 nymphs and adults/150 leaves, respectively.

Onion thrips, *Thrips tabaci* Lind (Thysanoptera: Thripidae)- In the first season 2020 (Table 1), *T. tabaci* Lindeman appeared in the first sample, on May 8th, with 100 larvae and adults/150 leaves, reaching to the first peak of 146.00 larvae and adults/150 leaves on May 15th, and the second peak (134.75) on May 29th. Then, the population densities declined and completely disappeared from June 19th until the end of the season. The seasonal average of thrips was 36.55±14.22 larvae and adults/150 leaves.

In the second season, *T. tabaci* reached much higher numbers compared to the first season, with a seasonal average of 123.32±25.49 larvae and adults/150 leaves. The highest population density of 206.50 larvae and adults/150 leaves was recorded in the first sample, followed by another peak of 179.50 larvae and adults /150 leaves on June 23rd.

The whitefly, Bemisia *tabaci* (Gennadlius) (Homoptera: Aleyrodidae)- During the first season (Table 1), the population densities of *B. tabaci* eggs and nymphs remained low until mid-May, with an increase by late May. However, the highest densities were recorded by the second week of July and persisted until the end of the season. Two peaks for *B. tabaci* eggs occurred on May 29th and July 31st, with an average count of 91.75 and 134.00 eggs per 150 leaves, respectively. Nymphs exhibited three peaks on June 12th, July 24th, and August 11th, with counts of 78.75, 120.75, and 100.25 nymphs per 150 eggplant leaves, respectively. The seasonal average was 56.90±11.45 for eggs and 50.12±10.78 for nymphs per 150 leaves.

In the 2021 season (Table 1), akin to the first season, *B. tabaci* egg and nymph population densities remained low until the beginning of June, and subsequently increased throughout June until the final examination conducted in the first week of July. Only one peak was observed for each stage on June 30, with counts of 196.50 eggs and 185.50 nymphs per 150 leaves, respectively. The seasonal averages for both stages were 77.54±25.23 for eggs and 77.89±24.72 for nymphs per 150 leaves.

Leafhoppers, *Empoasca* spp. (Homoptera: Cicadellidae)- In 2020 season (Table 1), nymphs and adults of *Empoasca* spp. were few in number throughout the season, with two small peaks of 20.00 and 11.00 individuals/150 eggplant leaves. The seasonal average of the leafhoppers was 9.52±1.33 nymphs and adults/150 leaves. In 2021 season, fewer numbers were recorded, compared to the first season, with a seasonal average of 6.32±1.49 nymphs and adults/150 leaves.

Tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae)- *Tuta absoluta* was counted in very few numbers in 2020 season (Table1), with seasonal average of 0.48±0.23 eggs and 0.20±0.14 mines/150 leaves. In the second season, the insect numbers were relatively higher with seasonal average of 5.04±1.55 eggs and 4.71±1.67 mines/150 leaves.

The pink mealybug, *Phenacoccus hirsutus* Green (Homoptera: Pseudococcidae)- Both nymphs and adults of *P. hirsutus* were not found on eggplants from the beginning of 2020 season (Table 1) up to July 3rd, then, the population density increased to reach only one peak of 70.50 nymphs and adults/150 eggplant leaves on July 17th. In the second season, neither nymphs nor adults were observed on the leaf samples.

Red spider mite, *Tetranychus urticae* C.L. Koch (Tombidiformes: Tetranychidae)- Nymph and adult stages of *T. urticae* were not detected (Table 1) on the eggplant samples up to May 22nd during the first season (2020). The population density then increased gradually to reach a peak of 101.25 nymphs and adults/150 leaves. Then, the numbers decreased gradually to disappear completely on July 31st until the last examination on August 11th. The seasonal average was 22.30±8.71individuals/150 leaves. In 2021 season, the spider mite nymph and adult stages exhibited only one peak of 190.25 individuals on June 30th, with a seasonal average of 58.07±26.19 nymphs and adults/150 leaves.

Population fluctuations of insect predators and spiders on Eggplant (Sawad el lel cultivar)

Results obtained (Table 2) summarize the population fluctuations of five predators on eggplants during 2020 and 2021 summer Seasons.

Spiders complex (Araneae: Different families and species)- In 2020 summer season, the spiders (different families and species) population averaged 6.33±1.32 spiderlings and adults/150 eggplant leaves (Table 2). The immature and adult stages exhibited three peaks of occurrence on June 5th, July 10th and August 4th with averages of 16.50, 10.50 and 9.25 individuals/150 leaves, respectively.

Table 1. Population fluctuation of insect pests and spider mites infesting eggplant (Sawad el lel cultivar) during 2020 and 2021 seasons at Kafr El-Shiekh region, Egypt.

	Mean no. of pests/150 leaves								
Sampling	Aphids	*Thrips tabaci*	*Bemisia tabaci*		*Empoasca* spp.	*Tuta absoluta*		*Phenacoccus hirsutus*	*Tetranychus urticae*
date	N+A	L+A	E	N	N+A	E	M	N+A	N+A
2020 season									
May 0 8	42.00	100.00	0.00	2.00	0.00	0.00	2.00	0.00	0.00
May 15	37.50	146.00	3.50	0.00	6.00	0.00	0.00	0.00	0.00
May 22	68.25	96.50	41.25	2.50	10.25	1.00	0.00	0.00	0.00
May 29	27.25	134.75	91.75	57.50	8.25	3.00	1.00	0.00	2.25
June 05	13.00	60.00	64.25	63.25	16.75	2.00	0.00	0.00	13.25
June 12	50.00	11.00	23.00	78.75	14.25	0.25	0.00	0.00	23.50
June 19	26.50	0.00	11.00	9.75	20.00	1.00	0.00	0.00	90.00
June 26	79.75	0.00	9.50	12.00	14.00	0.00	0.00	0.00	101.25
July 03	40.25	0.00	19.50	13.00	6.50	0.00	0.00	0.00	60.00
June 10	26.50	0.00	98.25	36.25	3.00	0.00	0.00	23.50	21.00
June 17	65.50	0.00	100.75	70.50	7.50	0.00	0.00	70.50	10.75
June 24	30.25	0.00	106.75	120.75	7.00	0.00	0.00	15.25	12.50
June 31	70.25	0.00	134.00	98.50	9.00	0.00	0.00	4.00	0.00
Aug. 04	50.00	0.00	62.50	86.75	11.00	0.00	0.00	10.50	0.00
Aug. 11	90.50	0.00	87.50	100.25	9.25	0.00	0.00	9.25	0.00
Total	717.50	548.25	853.50	751.75	142.75	7.25	3.00	133.00	334.50
Av.±SE	47.8±5.8	36.6±14.2	56.9±11.5	50.1±10.8	9.5±1.3	0.5±0.2	0.2±0.1	8.9±4.8	22.3±8.7
2021 season									
May 26	6.25	206.50	2.00	4.25	7.00	0.00	0.00	0.000	3.00
June 02	10.25	106.25	2.25	3.25	10.50	0.00	0.00	0.00	1.00
June 09	23.25	100.00	96.25	80.50	4.25	6.50	3.25	0.00	1.50
June 16	86.25	159.50	100.50	120.50	10.50	3.00	2.00	0.00	60.00
June 23	56.25	179.50	196.50	185.50	2.00	9.25	8.00	0.00	100.50
June 30	90.50	110.25	84.75	100.75	1.00	10.00	9.50	0.00	190.25
July 07	22.50	1.25	60.50	50.50	9.00	6.50	10.25	0.00	50.25
Total	295.25	863.25	542.75	545.25	44.25	35.25	33.00	0.00	406.50
Av.±SE	42.2±13.4	123.3± 25.5	77.5±25.2	77.9±24.7	6.3±1.5	5.0±1.6	4.7±1.7	0.0±0.0	58.1±26.2

E=egg, N=nymph, L=larva, M=mine and A=adult.

In 2021 season, the seasonal average was higher (9.40±3.58 spiderlings + adults/150 leaves) compared to that of 2020 season. Two considerable peaks were detected on June 9th (21.50 individuals/150 leaves) and on June 30th (20.50 individuals/150 leaves).

***Scymnus* spp. (Coleoptera: Coccinellidae)-** Seasonal averages of this coccinellid were 5.28±1.81 and 10.32±3.61 individuals/150 leaves, in 2020 and 2021 seasons, respectively.

***Orius* spp. (Hemiptera: Anthocoridae), *Chrysoperla carnea* (Neuroptera, Chrysopidae) and *Coccinella* spp. (Coleoptera: Coccinellidae)-** During the 2020 season (Table 2), the three above-mentioned predators were seldom observed on eggplants. Seasonal averages were 0.37±0.15, 0.65±0.21, 0.87±0.46, and 2.07±0.59 nymphs and adults per 150 leaves for Orius spp., *C. carnea* eggs and adults, and *Coccinella* spp. larvae and adults, respectively. In the second season (2021), the population densities of these predators were relatively higher compared to the first season. Orius spp. (nymphs and adults) maintained an average of 4.68±1.36 throughout the season. For *C. carnea*, the seasonal average were 3.39±1.28 eggs and 3.14±0.91 adults per 150 leaves. *Coccinella* spp. exhibited an average of 1.93±1.45 larvae and adults per 150 leaves.

Population fluctuation of insect pests and spider mite on tomato

Aphids- In the first season (Table 3), the seasonal average was found with 6.17±1.77 nymphs and adults/150 leaflets. However, only one peak was recorded on July 3rd with 16. 50 and 9.50 nymphs and adults/150 tomato leaflets. In the second season, the seasonal average was lower (10.58±3.81 nymphs and adults/150 leaflets) than the first season. One peak of 30.00 aphid nymphs and adults was recorded on July 23rd. The seasonal average of the second season was 10.68±3.81 nymphs and adults/150 tomato leaflets.

Table 2. Population fluctuations of insect predators and spiders inhabiting eggplant (Sawad el lel cultivar) at Kafr El-Shiekh region, Egypt.

	Mean no. of predators/150 leaves					
	Spiders	*Scymnus* spp.	*Orius* spp.	*Chrysoperla carnea*		*Coccinella* spp.
Sampling date	S+A	L+A	N+A	E	L	L+A
2020 season						
May 08	0.00	0.00	0.00	2.00	2.00	6.50
May 15	0.00	0.00	1.00	0.00	1.00	0.00
May 22	0.00	0.00	0.00	1.00	0.00	0.00
May 29	11.00	0.00	2.00	2.00	0.00	0.00
June 05	16.50	0.00	0.00	1.00	4.00	2.00
June 12	13.00	12.50	1.00	0.00	0.00	1.00
June 19	6.25	7.50	0.50	0.70	0.00	4.50
June 26	4.25	20.25	1.00	0.00	0.00	6.00
July 3	3.25	19.00	0.00	0.00	6.00	2.00
July 10	10.50	9.75	0.00	1.00	0.00	1.00
July 17	9.00	4.00	0.00	0.00	0.00	1.00
July 24	2.00	3.00	0.00	2.00	0.00	2.00
July 31	7.00	1.25	0.00	0.00	0.00	5.00
August 4	9.25	1.00	0.00	0.00	0.00	0.00
August 11	3.00	1.00	0.00	0.00	0.00	0.00
Total	95.00	79.25	5.50	9.70	13.00	31.00
Av.±SE	6.33±1.32	5.28±1.81	0.37±0.15	0.65±0.21	0.87±0.46	2.07±0.59
2021 season						
May 26	0.00	0.00	0.00	0.00	0.00	0.00
June 2	0.00	0.00	6.00	1.00	0.00	0.00
June 9	21.50	7.00	3.00	6.50	3.00	0.00
June 16	15.50	10.25	5.25	3.00	5.50	0.00
June 23	3.00	25.50	10.25	2.00	4.50	1.00
June 30	20.50	20.00	7.25	1.75	6.00	2.00
July 07	5.50	9.50	1.00	9.50	3.00	10.50
Total	66.00	72.25	32.75	23.75	22.00	13.50
Av.±SE	9.40±3.58	10.32±3.61	4.68±1.36	3.39±1.28	3.14±0.91	1.93±1.45

E=egg, N=nymph, L=larva, S=spiderling and A=adult.

Onion thrips, *Thrips tabaci* Lindeman- In 2020 season (Table 3), larvae and adults of *T. tabaci* appeared by the first examination with very few number (0.25/150 Leaves), and increased gradually to produce only one high peak on June 26th (150.0 larvae and adults). In the second season, the numbers of immatures and adults recorded much higher densities than those of the first season, with a big peak of 500.0 larvae and adults/150 tomato leaflets. The seasonal averages were 37.27±17.08 and 187.96±85.26 larvae and adults/150 leaflets in the first and second seasons, respectively.

The whitefly, *Bemisia tabaci* (Gennaolius)- The population densities of *B. tabaci* eggs and nymphs were counted in very few numbers in both seasons (Table 3), with 2020 seasonal averages of 2.19±0.74 eggs and 1.33±0.47 nymphs/150 leaflets. In the second season (2021), the insect numbers were relatively higher with seasonal averages of 3.75±1.07 eggs and 2.82±0.90 nymphs/150 leaflets, respectively.

Leafhoppers, *Empoasca* spp. (Homoptera: Cicadellidae)- *Empoasca* spp. nymphs and adults were found in very low densities in both seasons, with only one peak (14.50 nymphs and adults/150 leaves) in the first season, and one peak (16.50 nymphs and adults/150 leaves) in the second season on July 10th and June 23rd, respectively (Table 2). The seasonal averages were 3.33±1.77 and 4.61±2.45 nymphs and adults/150 leaves in the first and second season, respectively.

Tomato leafminer, *Tuta absoluta* (Meyrick)- In the 2020 season (Table 3), *T. absoluta* population density peaked on June 26th with 65.50 eggs, and on June 19th with 62.50 mines, with seasonal averages of 19.91± 6.70 and 12.97 ±6.61 eggs, and mines/150 leaves, respectively. In the second season, the insect density was higher with a peak of 75.75 eggs, and 45.75 mines/150 tomato leaves. The seasonal averages were 26.07±0.15 and 17.71 ±6.46 eggs and mines/150 leaves, respectively.

The pink mealybug, *Phenacoccus hirsutus* Green- Nymphs and adults of *P. hirsutus* were found in very few numbers in both seasons (Table 3). The seasonal averages were 0.88±0.45 and 2.66±0.81 nymphs and adults/150 leaves in 2020 and 2021 seasons, respectively.

Red spider mite, *Tetranychus urticae* C.L. Koch- Population densities of *T. urticae* were very low in both seasons (Table 3), with seasonal averages of 0.77±0.27 and 2.29±0.54 nymphs and adults/150 tomato leaves in the first and second seasons, respectively.

Table 3. Population fluctuation of insect pests and spider mite infesting tomato (Elissa cultivar) during 2020 and 2021 seasons at Kafr El-Shiekh region, Egypt.

	Mean no. of insect pests/150 leaves								
Sampling	Aphids	*Thrips tabaci*	*Bemisia tabaci*		*Empoasca* spp.	*Tuta absoluta*		*Phenacoccus hirsutus*	*Tetranychus urticae*
date	N+A	L+A	E	N	N+A	E	M	N+A	N+A
2020 season									
June 05	3.50	0.25	4.00	0.00	0.00	12.25	10.25	0.00	2.00
June 12	1.00	23.50	0.00	3.00	0.00	30.50	4.00	0.00	1.00
June 19	2.75	90.75	1.00	1.00	4.25	27.50	62.50	4.00	1.00
June 26	1.00	150.50	1.75	1.00	1.50	65.50	23.25	2.00	2.00
July 03	16.50	40.75	7.00	4.00	9.75	10.00	3.00	1.00	1.00
July 10	11.00	12.25	0.00	2.00	14.50	21.50	7.25	0.00	0.00
July 17	9.50	16.50	3.00	0.00	0.00	11.00	5.50	0.00	0.00
July 24	2.75	1.00	2.00	1.00	0.00	1.00	1.00	1.00	0.00
July 31	7.50	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	55.50	335.50	19.75	12.00	30.00	179.25	116.75	8.00	7.00
Av.±SE	6.2±1.8	37.3±17.1	2.2±0.7	1.3±0.5	3.4±1.8	19.9±6.7	13.0±6.6	0.9±0.5	0.8±0.3
2021 season									
May 26	6.25	460.00	0.00	0.00	0.00	17.50	6.25	1.25	0.00
June 02	7.50	500.00	3.00	0.00	4.25	20.50	19.75	1.00	1.50
June 09	3.25	300.00	6.50	5.75	1.00	75.75	36.50	3.50	2.00
June 16	10.75	18.75	2.00	3.00	10.50	36.50	45.75	3.25	2.25
June 23	30.00	18.50	1.50	1.75	16.50	19.75	7.75	1.00	4.50
June 30	17.00	18.50	7.50	5.75	0.00	3.50	6.00	7.00	2.25
July 07	0.00	0.00	5.75	3.50	0.00	9.00	2.00	3.00	3.50
Total	74.75	1315.75	26.25	19.75	32.25	182.50	124.00	19.00	13.50
Av.±SE	10.7±3.8	188.0± 85.3	3.8±1.1	2.8±0.9	4.6±2.5	26.1±9.2	17.7±6.5	2.9±0.8	2.3±0.5

E=egg, N=nymph, L=larva, M=mine and A=adult.

Population fluctuations of insect predators and spiders on tomato (Elissa cultivar) spiders- The spider complex (consisting of various species) showed seasonal averages of 5.25±2.12 and 7.18±1.94 spiderlings and adults/150 tomato leaves in the first and second seasons, respectively (Table 4). The spider complex exhibited a peak of 16.50 spiderlings and adults/150 leaves in each season.

***Scymnus* spp. -**Extremely low numbers of *Scymnus* spp. of 1.83±0.58 and 1.46±0.43 larvae and adults/150 tomato leaves were detected in 2020 and 2021 seasons, respectively.

***Orius* spp.-** Nymphs and adults of *Orius* spp. were higher in July of the first season (Table 4) than other dates, with a peak of 10.00 nymphs and adults on July 17th, and seasonal average of 5.08±1.26 nymphs and adults/150 tomato leaves. However, this predator was completely absent in all tested samples of the second season.

***Chrysoperla carnea*-** This chrysopid predator was rarely found on tomato leaves with a seasonal average of 1.28±0.32 eggs and 1.44 ± 0.29 adults/150 tomato leaves in the 2020 season (Table 4). *Chrysoperla carnea* individuals were completely absent in the tested samples of 2021 season.

***Coccinella* spp.-** Larvae and adults of this coccinellid were not detected in 2020 and 2021 seasons, with the exception of very few scattered individuals during 2020 season.

Population fluctuation of insect pests and spider mite on pepper (Mohannad cultivar)

Aphids- During the first season (2020), aphid population showed only one peak on July 10th with 7.25 nymphs and adults/150 pepper leaves (Table 5), with a seasonal average of 1.80±0.76. The corresponding seasonal average in 2021 was 2.21±0.83 nymphs and adults/150 leaves.

Onion thrips, *Thrips tabaci* Lindeman- One peak of *T. tabaci* larvae and adults (9.25/150 leaves) was recorded on May 22nd in the first season (2020), with a seasonal average of 0.83±0.58 larvae and adults/150 leaves (Table 5). However, no distinct peaks were observed in 2021, with a seasonal average of 3.07±1.83 larvae and adults/150 pepper leaves.

The whitefly, *Bemisia tabaci* (Genn.)- Population of *B. tabaci* eggs showed one peak in 2020 (23.00 eggs) on June 5th, and one peak in 2021 (30.25 eggs) on June 18th. The egg seasonal averages were 4.19±1.76 and 10.86±4.68 in the first and second seasons, respectively (Table 5). *B. tabaci* nymphs showed one peak (18.00 nymphs /150 leaflets) on June 19th in the first season, and one peak (24.50) on June 30th in the second season (Table 5). The nymph's population density showed seasonal average of 3.28±1.33 and 10.54±4.12 individuals/150 leaves, in the first and second seasons, respectively (Table 5).

Table 4. Population fluctuations of insect predators and spiders inhabiting tomato (Elissa cultivar) at Kafr El-Shiekh region.

	Mean no. of predators/150 leaves					
	Spiders	*Scymnus* spp.	*Orius* spp.	*Chrysoperla carnea*		*Coccinella* spp.
Sampling date	S+A	L+A	N+A	E	L	L+A
2020 season						
June 05	13.00	2.00	2.00	1.00	2.00	0.00
June 12	2.00	1.00	7.00	0.00	3.00	0.00
June 19	3.00	3.00	2.00	1.00	2.00	1.25
June 26	1.00	5.00	9.00	1.50	1.00	1.00
July 03	10.75	3.50	6.75	2.00	1.00	0.00
July 10	16.50	2.00	8.00	3.00	1.00	0.00
July 17	1.00	0.00	10.00	1.00	2.00	0.00
July 24	0.00	0.00	0.00	0.00	1.00	1.25
July 31	0.00	0.00	1.00	2.00	0.00	0.00
Total	47.25	16.50	45.75	11.50	13.00	3.50
Av.±SE	5.25±2.12	1.83±0.58	5.08±1.26	1.28±0.32	1.44±0.29	0.39±0.19
2021 season						
May 26	10.00	0.00	0.00	0.00	0.00	0.00
June 02	9.00	1.25	0.00	0.00	0.00	0.00
June 9	4.00	1.00	0.00	0.00	0.00	0.00
June 16	16.50	2.50	0.00	0.00	0.00	0.00
June 23	6.25	1.00	0.00	0.00	0.00	0.00
June 30	1.50	1.00	0.00	0.00	0.00	0.00
July 07	3.00	3.50	0.00	0.00	0.00	0.00
Total	50.25	10.25	0.00	0.00	0.00	0.00
Av.± SE	7.18±1.94	1.46±0.43	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00

E=egg, N=nymph, L=larva, S=spiderling and A=adult.

Table 5. Population fluctuation of insect pests and spider mite infesting pepper (Mohannad cultivar) during 2020 and 2021 seasons at Kafr El-Shiekh region, Egypt.

Sampling date	Mean no. of insect pests/150 leaves								
	Aphids	*Thrips tabaci*	*Bemisia tabaci*		*Empoasca* spp.	*Tuta absoluta*		*Phenacoccus hirsutus*	*Tetranychus urticae*
	N+A	L+A	E	N	N+A	E	M	N+A	N+A
2020 season									
May 08	0.00	0.00	0.00	2.00	2.75	0.00	1.00	0.00	0.00
May 15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May 22	3.00	9.25	0.00	0.00	1.50	0.00	1.25	2.00	4.00
May 29	0.00	2.50	14.50	5.00	3.50	2.50	0.00	4.00	0.00
June 05	3.00	1.50	23.00	0.00	0.00	1.50	0.00	1.00	5.00
June 12	6.50	0.00	0.00	10.50	2.75	0.00	1.00	5.00	3.00
June 19	0.00	0.00	10.00	18.50	0.00	0.00	0.00	2.00	0.00
June 26	0.00	0.00	12.50	10.00	0.00	0.00	0.00	0.00	1.00
July 3	9.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00
July 10	7.25	0.00	6.00	0.00	9.00	0.00	0.00	0.00	1.00
July 17	0.00	0.00	0.75	3.75	6.00	0.00	0.00	0.00	0.00
July 24	0.00	0.00	0.25	2.00	4.50	0.00	0.00	0.00	0.00
July 31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug. 04	0.00	0.00	0.00	0.75	1.00	0.00	0.00	0.00	0.00
Aug. 11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug. 18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	28.75	13.25	67.00	52.50	38.00	4.00	3.25	14.00	14.00
Av.±SE	1.8±0.8	0.8±0.6	4.2±1.8	3.3±1.4	2.4±0.7	0.3±0.2	0.2±0.1	0.9±0.4	0.9±0.4
2021 season									
May 26	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00
June 02	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
June 09	0.00	9.50	23.75	0.00	0.75	0.00	0.00	0.00	0.00
June 16	3.00	10.75	30.25	19.75	6.50	0.00	0.00	0.00	0.00
June 23	5.25	1.25	14.50	20.50	4.25	0.00	0.00	0.00	0.00
June 30	4.25	0.00	7.50	24.50	0.00	0.00	0.00	0.00	0.00
July 07	3.00	0.00	0.00	9.00	6.50	0.00	0.00	0.00	0.00
Total	15.50	21.50	76.00	73.75	24.00	0.00	0.00	0.00	0.00
AV.± SE	2.2±0.8	3.1±1.8	10.9±4.7	10.5±4.1	3.4±1.1	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0

E=egg, N=nymph, L=larva, M=mine and A=adult.

Leafhoppers, *Empoasca* spp.- In 2020 season (Table 5), *Empoasca* spp. nymphs and adults population had only one peak with 9.00 individuals/150 leaves on July 10th, with a seasonal average of 2.38±0.72 individuals/150 leaves. In 2021 season, also one peak of 6.50 nymphs and adults was detected on June 16th, with a seasonal average of 3.43±1.05 individuals/150 leaves (Table 5).

Tomato leafminer, *Tuta absoluta* (Meyrick)- In 2020 season, there were very few numbers of *T. absoluta* eggs and mines, but they were completely absent in 2021 season (Table 5).

The pink mealybug, *Phenacoccus hirsutus* green and red spider mite, *Tetranychus urticae* C.L. Koch- Both pests were found in very few numbers in the first season and both were completely absent during the second season (Table 5).

Population fluctuation of insect predators and spiders on pepper (Mohannad cultivar)

Data in Table 6 summarizes the population fluctuations of five predators on pepper plants during 2020 and 2021 summer seasons.

Spiders- In 2020, population densities of spiders exhibited two considerable peaks on June 5th and August 4th, with 13.50 and 10.00 spiderlings and adults/150 leaves, respectively. The spider densities were very low in the second season, with a seasonal average of 1.14±0.63 spiderlings and adults, compared to a seasonal average of 5.83±1.03/150 leaves as a seasonal average in the first season.

***Scymnus* spp. and *Orius* spp.-** Both predators were collected in very few numbers throughout the two seasons.

***Chrysoperla Carnea* Steph.-** The lacewing, *Ch. carnea* was found in few numbers as eggs or adults in both seasons. The seasonal averages of eggs were 1.55±0.40 and 1.46±0.61, whereas averages of adults were 1.52±0.45 and 0.71±0.42/150 leaves in the first and second seasons, respectively.

***Coccinella* spp.-** Population density of *Coccinella* spp. were found in one peak every season; 5.50 and 16.25 larvae and adults per 150 pepper leaves on May 22nd and June 16th in the first and second seasons, respectively. Seasonal average was lower in the first season (1.25±0.48 larvae and adults/150 leaves) than that of the second season (7.18±2.47).

Table 6. Population fluctuations of insect predators and spiders inhabiting pepper (Mohannad cultivar) at Kafr El-Shiekh region, Egypt.

	Mean no. of Predator/150 leaves					
	Spiders	*Scymnus* spp.	*Orius* spp.	*Chrysoperla carnea*		*Coccinella* spp.
Sampling date	S+A	L+A	N+A	E	L	L+A
2020 season						
May 08	4.00	2.00	0.00	2.00	3.00	0.00
May 15	2.00	1.00	0.00	0.00	1.00	1.00
May 22	6.00	1.00	1.00	0.00	1.00	5.50
May 29	9.00	2.00	2.00	1.00	0.50	4.00
June 05	13.50	0.00	1.00	2.00	1.00	1.25
June 12	11.00	2.00	1.00	1.00	1.00	3.00
June 19	7.00	1.00	1.00	4.00	6.00	4.00
June 26	6.00	0.00	0.00	2.00	4.25	0.00
July 03	3.00	0.00	1.00	1.00	1.00	0.00
July 10	2.00	2.00	0.00	3.25	1.00	0.00
July 17	1.00	1.00	0.00	5.00	3.00	0.00
July 24	4.00	0.00	0.00	0.00	0.00	0.00
July 31	9.00	0.00	0.00	2.00	0.00	0.00
Aug. 04	10.00	1.00	0.00	0.00	0.00	0.00
Aug. 11	0.00	0.00	0.00	0.00	0.00	0.00
Total	87.50	13.00	7.00	23.25	22.75	18.75
Av.± SE	5.83±1.03	0.87±0.21	0.47±0.16	1.55±0.40	1.52±0.45	1.25±0.48
2021 season						
May 26	0.00	0.00	0.00	4.00	0.00	0.00
June 02	0.00	0.00	0.00	2.25	1.00	10.25
June 09	0.00	0.00	0.00	0.00	3.00	14.25
June 16	0.00	0.00	0.00	0.00	0.00	16.25
June 23	3.00	0.00	0.00	3.00	1.00	5.25
June 30	4.00	0.00	0.00	1.00	0.00	4.25
July 07	1.00	0.00	0.00	0.00	0.00	0.00
Total	8.00	0.00	0.00	10.25	5.00	50.25
Av.±SE	1.14±0.63	0.0±0.0	0.0±0.0	1.46±0.61	0.71±0.42	7.18±2.47

E=egg, N=nymph, L=larva, S=spiderling and A=adult.

Correlation coefficient values among pests of eggplant, tomato and pepper and their common predators- Correlations among certain pests and common predators were determined (Table 7). Aphid populations had a highly significant positive correlation with *Scymnus* spp. (r = 0.887) and with *Coccinella* spp. (r= 0.927). However, the correlation between aphid population and *C. carnea* was insignificant negative (r= - 0.073). The correlation between *T. tabaci* and *Orius* spp. was highly significant and positive (r= 0.958). However, *B. tabaci* insignificantly correlated with a negative value with *Orius* spp., and with a positive value with *C. carnea*.

Empoasca spp. showed a highly significant positive correlation value with spiders. Whereas *T. absoluta* exhibited in significant positive correlation with *C. carnea* (0.390). *P. hirsutus* had insignificant negative correlation (- 0.292) with *C. carnea*.

Pests' preference to some solanaceous hosts

Data presented in Table 8 illustrates the relative preference

of seven eggplant, tomato and pepper arthropod pests during the summer seasons of 2020 and 2021. The most preferred species was eggplant (Sawad el lel variety), as it attracted the highest number of aphids (81.17%), *B. tabaci* (87.07%), *Empoasca* spp. (53.51%), *P. hirstitus* (65.78%) and *T. urticae* (95. 33%). The second preferred host species was tomato that harbored more populations of *Thrips tabaci* (58.17%) and *T. absoluta* (88.83%). Pepper was the least preferred host for all considered arthropods, but came second after eggplant in case of *B. tabaci* (9.58%).

Table 7. Correlation coefficient values among certain arthropod pests infesting eggplant, tomato and pepper and associated predators, during 2020 and 2021 seasons at Kafr El-Shiekh region, Egypt.

Item	*r* value
Aphids and *Scymnus* spp.	0.887**
Aphids and *Coccinella* spp.	0.927**
Aphids and *Chrysoperla carnea*	- 0.073 ns
Thrips tabaci and *Orius* spp.	0.958**
Bemisia tabaci and *Orius* spp.	- 0.321 ns
Bemisia tabaci and *Chrysoperla carnea*	0.052 ns
Empoasca spp. and spiders	0.723**
Tuta absoluta and *Chrysoperla carnea*	0.390 ns
Phenacoccus hirsutus and *Chrysoperla carnea*	- 0.292 ns

**= Significant at P= 0.01, ns= not significant at P=0.05.

Discussion

In the present study, six insect pest species as well as spider mite were reported to infesting each of the eggplant, tomato and pepper at Kafr El-Shiekh region, Egypt in 2020 and 2021 summer seasons. These insects were aphids, *Thrips tabaci*, *Bemisia tabaci*, *Empoasca* spp., *Tuta absoluta*, *Phenacoccus hirsutus* as well as the spider mite, *Tetranychus urticae*. Sadek & El- Dewy (2019) surveyed the same above mentioned insects, attacking eggplant at Kafr El-Shiekh region, in addition to *Liriomyza trifolii* and *Nezara viridula*. Hegab *et al*. (2014) and Kumar *et al*. (2021) reported earlier some or all of the following arthropods infesting eggplant: aphids, whiteflies, leafhoppers, spider mite.

Concerning tomato, the main insect pest was *T. absoluta* as indicated by Ata & Megahed (2014) and Hassan *et al*. (2017), as well as *Phenacoccus hirsutus* (or *P. solenopsis*) as indicated by Samah *et al.* (2015) and Hagar *et al.* (2018). In this study, both *T. absoluta* and *P. hirsutus* were minor pests on solanaceous plants, contrary to *T. absoluta* which was a major pest on tomato.

Ibrahim *et al.* (2015) reported that the main insect arthropods attacking pepper varieties were: *T. tabaci, T. urticae*, aphids, and leafhoppers. In the present study, the seven above-mentioned arthropods were found on all the host plants, but three of which; *T. absoluta, P. hirsutus* and *T. urticae* were found minor pests on peppers.

As a correlation between vegetable chemical components and degree of insect infestation, Hegab *et al*. (2014) reported a positive correlation between eggplant content of proteins and carbohydrates and infestation with each of aphids, leafhoppers and whiteflies, but the correlation was negative in relation to pH values.

Eggplant was found the most preferred vegetable species, among the three evaluated crops to aphids, *B. tabaci*, *Empoasca* spp., *P. hirsutus* and *T. urticae*, as they harbored 81.17, 87.07, 53.51, 65.78 and 95.33% of total population of the considered pests, respectively. Ibrahim *et al*., (2015) concluded that the dominant pests on peppers were homopterous insects (85% out of total pest population), *T. urticae* (13%) and *T. tabaci* (2%). The most dangerous insect pest which negatively affects tomato plantation is the tomato leafminer, *T. absoluta* (Ata & Megahed, 2014; Hassan *et al*., 2017; Salama *et al*., 2019).

This study revealed that tomato plants attracted 88.83% of the total population of *T. absoluta* which is in agreement with previous findings (Ata & Megahed, 2014). Results obtained in this study confirmed that *T. absoluta* mostly preferred tomato as compared to eggplant or pepper, which is in agreement with previous findings (Salama *et al*., 2019 and Idriss et al., 2020). In the present investigation, *T. absoluta* infestation peaked in June, which agrees with what has been reported by Amira (2012), and partially agrees with the results obtained by Ata & Megahed (2014).

Table 8. Preference of insect pests and spider mite to certain solanaceous crops, at Kafr El-Shiekh region, Egypt (average data of 2020 and 2021 seasons).

	Mean no. of pests/150 leaves				Preference %		
Insect species and stage	**Eggplant**	**Tomato**	**Pepper**	**Total**	**Eggplant**	**Tomato**	**Pepper**
Aphids N+A	45.01	8.43	2.01	55.45	81.17	15.20	3.62
Thrips tabaci L+A	79.04	112.62	1.95	193.61	40.82	58.17	1.01
Bemisia tabaci E+N	131.23	5.05	14.44	150.72	87.07	3.35	9.58
Empoasca spp. N+A	7.92	3.97	2.91	14.80	53.51	26.82	19.66
Tuta absoluta E	2.76	22.99	0.13	25.88	10.66	88.83	0.50
Phenacoccus hirsutus N+A	4.44	1.87	0.44	6.75	65.78	27.70	6.52
Tetranychus urticae L+N+A	40.19	1.53	0.44	42.16	95.33	3.63	1.04

E=egg, N=nymph, L=larva, M=mine and A=adult.

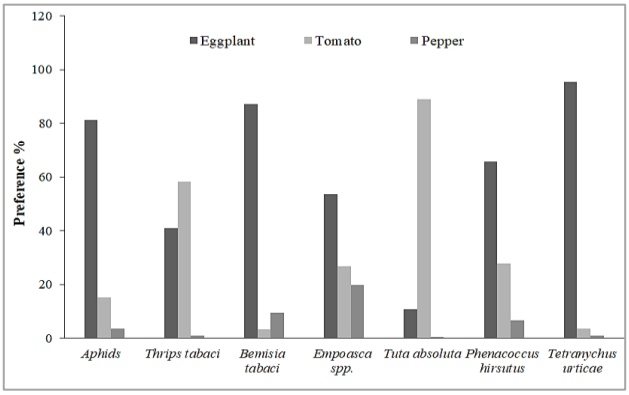

Figure 1. Preference of insect pests and spider mite to certain solanaceous crops, at Kafr El-Shiekh region, Egypt (average of two seasons).

Results obtained revealed the occurrence of several predators such as spider complex, *Scymnus* spp., *Orius* spp., *C. carnea* and *Coccinella* spp., with low population densities. Previous workers (Agwu *et al*., 2018; Hendawy & El-Fakharany, 2012) reported *C. undecimpunctata*, *C. carnea*, *Orius* sp, Scymnus spp. and true spiders as predators on eggplant, tomato or pepper pests, which is in agreement with the results obtained in the present study. Developing pest management systems to enhance the predator's population will reduce the number of chemical pesticides used which has positive impact on human health and the environment.

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الملخص

أبو عطية، فايز علي، هدير شاكر حمودة، سمير السيد قاسم وأسامة محمد رخا. 2025. تقييم التفضيل العوائلي وديناميكية تعداد الآفات الحشرية والعنكبوت الأحمر العادي ومفترساتها على نباتات خضار العائلة الباذنجانية. مجلة وقاية النبات العربية، 43(1):102−112.

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أجريت التجارب في المزرعة البحثية لكلية الزراعة، جامعة كفر الشيخ، مصر، خلال المواسم الصيفية 2020 و 2021. هدفت الدراسة إلى مراقبة التذبذبات العددية لبعض الآفات مفصلية الأرجل وتفضيلها لثلاث عوائل باذنجانية (الباذنجان، البندورة/الطماطم والفلفل/الفليفلة)، إضافةً لتقييم الارتباط ما بين بعض المفترسات الحشرية والآفات، حيث وجدت أربعة أنواع من الحشرات الثاقبة الماصة التي تصيب محاصيل الخضر السابقة، وهي: المنّ، الذبابة البيضاء، النطاطات، البقّ الدقيقي بالإضافة للعنكبوت الأحمر العادي وحافرة أنفاق أوراق البندورة/الطماطم. أظهرت النتائج أن الباذنجان كان أكثر العوائل الباذنجانية تفضيلاً حيث استقبل 81.17% من مجموع حشرات المنّ، 87.7% من الذبابة البيضاء، 53.51% من النطاطات، 65.78% من البق الدقيقي و 95.33% من العنكبوت الأحمر العادي. وكان العائل المفضل الثاني هو الطماطم/البندورة حيث استقبل 58.17 و 88.83% من مجموع حشرات التربس وحافرة أنفاق أوراق البندورة/الطماطم، على التوالي، في حين كان نبات الفلفل/الفليفلة أقلّ العوائل تفضيلاً. كما وجدت خمسة أنواع من المفترسات المرافقة للآفات الحشرية السابقة، وهي: العناكب، *Scymnus*، *Orius*، أسد المنّ وأبو العيد. تبيّن وجود ارتباط موجب عالي المعنوية بين حشرات المنّ وكلٍّ من *Scymnus* وأبو العيد، وكذلك بين التربس و *Orius*. كما وجدت علاقة ارتباط عالي المعنوية بين الجاسيد والعناكب. أوضحت الدراسة الحالية أن الباذنجان كان الأكثر إصابة بالحشرات الثاقبة الماصة والعنكبوت الأحمر العادي مقارنة بنباتات البندورة/الطماطم والفلفل، وعلى الجانب الآخر وجدت المفترسات المختلفة على المحاصيل الباذنجانية الثلاثة، مما يوجب الحفاظ عليها لاستعادة التوازن البيئي وبخاصةٍ على محاصيل الخضر والتي غالباً ما يتّم استهلاكها كأطعمة طازجة.

كلمات مفتاحية: آفات مفصلية الأرجل، نباتات العائلة الباذنجانية، تفضيل الآفة، الحشرات الثاقبة الماصة، المفترسات.

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