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EFFICACY OF CERTAIN INSECTICIDES AGAINST WHITEFLY *BEMISIA TABACI* (GENN.) INFESTING TOMATO PLANTS AND THEIR ASSOCIATED PREDATORS

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Abstract

Field experiments were carried out at El-Beheira Governorate, Egypt, on tomato plants during 2019 and 2020 seasons. The effectiveness of seven different insecticides; three compounds of natural insecticides (Orange oil, Azadirachtin and Abamectin), two formulations of Acetambride, (Ace ELnasr and Volley) and two chemical compounds (Thiocyclam hydrogen oxalate and Imidacloprid) were tested against *whitefly* and associated predators. The results showed that all tested pesticides were highly effective against the whitefly. There were significant differences among Orange oil, Azadirachtin Acetambrid, Thiocyclam hydrogen oxalate and Imidacloprid. The recorded residual effect mean percentages of *whitefly* were 69.92, 84.19, 66.49, 69.09, 86.98, 77.84 and 61.05 in the first season 2019, while they were 87.52 , 86.18, 62.26, 85.71, 83.54, 82.21 and 66.71 in the second season 2020 for the same tested pesticides, Acetamiprid Ace, Acetamiprid Voll, Orange oil, Imidacloprid, Abamectin, Thiocyclam-hydrogen-oxalate and Azadirachtin, respectively. The results, however, indicated that Abamectin and Acetambride Volley were the most effective treatments on whitefly in the 2019 and 2020 seasons, respectively. On the other hand, during the two testing seasons, the Orange oil was the least effective on whitefly. The results revealed also that Acetamiprid, Imidacloprid and Abamectin were the most effective compound causing in general, the highest percentage of *C. carnea* population reduction ether after three days post- treatment or after any of the two testing post-treatment periods. Hence, the Orange oil and Azadirachtin can suitably be included in Integrated Pest Management of sucking insect pests like whitefly in tomato because of their less toxicity to predators.
Keywords: *Bemisia tabaci*, insecticid, *Chrysoperla carnea*

Introduction

Tomato (*Lycopersicone sculentum* Mill) is one of the most important solanaceous vegetable crops in Egypt. The tomato plants are currently infested with many serious pests. The most destructive pest is whitefly, *Bemisia tabaci*. (Homoptera: Aleyrodidae). Whitefly is a polyphagous insect pest which effects on more than 600 different plant species (Oliveira *et al.*, 2001; Bayhan *et al.*, 2006; Stansly and Natwick, 2010). Tomato crops are normally attacked by a great variety of insects including, whitefly which is considered as the most harmful tomato pest (Medeiros *et al.*, 2005). *Bemisia tabaci* (Gennadius) (Hemptera: Aleyrodidae) is one of the most damaging and invasive pests worldwide, causing losses to several crops (De Barro *et al.,* 2011; Lapidot *et al.,* 2014). Whitefly causes economic losses in vegetable, fiber and ornamental crops due to both direct damage through phloem feeding and injection of toxins and indirect damage to the host plant through its ability to transmit plant viruses (Pereira *et al*., 2004; Brown, 2010). *Bemisia tabaci* can transmit hundreds of viruses to numerous agricultural crops in the worldwide (D.K. Hasegawa *et al.,* 2018). In Egypt, many chemical pesticides and integrated protection programs it was used to control this pest and to decrease the widespread damage which it causes. (Khattak *et al.,* 2006; Amjad *et al.,* 2009; Nadeen *et al.,* 2011 and Fida Magis *et al.*, 2017). Kumar, *et al., (*2019) reported that the infestation of whitefly on tomato started in the second week of December. The population increased gradually and reached its peak in second week of March.

Use of plant products as insecticides is one of the important approaches of insect pest management since they have many advantages over synthetic insecticides (Weinzierl and Henn, 1992). Among available non-chemical weapons, neem (*Azadirachta indica*) has the potential to be used as a substitute of synthetic insecticides (Schmutterer, 1995; Farooq *et al.,* 2011; Basedow *et al.*, 2002; Rashid *et al.*, 2012). Products derived from seeds, leaves, kernels and other parts of the neem tree are inexpensive and biodegradable naturally available sources (Shafeek *et al.,* 2004) and have been found to be effective against different pests (Gahukar, 2000; Liang *et al.,* 2003; Senthil Nathan *et al.*, 2005). Imidacloprid is the first boat compound from the neonicotinoid class and has systemic activity. Both foliar and soil formulations have been developed for use in many agricultural crops. Thiamethoxam is a second generation neonicotinoid with systemic activity; it provides good control for many agricultural pests, (MaienÞsch *et al*., 2001). Therefore, the objective of this study was to evaluate the effect of seven pesticides on *Bemisia tabaci* and their associated predators under field conditions.

Materials and Methods

The present study was carried out in the tomato fields at El-Beheira Governorate, Egypt, during two seasons 2019 and 2020.

Insecticides used

Seven insecticides with their field recommended doses were tested against of *whitefly* under the field conditions as illustrated in Table 1. Three natural insecticides as Orange oil, Azadirachtin and Abamectin, two formulations of Acetambride as Ace ELnasr and Volley as well as, two chemical compounds as Thiocyclam hydrogen oxalate and Imidacloprid, were also tested.

Table 1: Tested insecticides against Whitefly

Common name	Trade Name	Field rate
Acetamiprid	Ace ELnasr 20% SP	25 g/100 L.
Acetamiprid	Volley 20%SP	25 g/100 L.
Orange oil	Prev- AM® 6%SL	400ml/100L.
Imidacloprid	Pestidor 25% wp	100 g/100 L.
Abamectin	Gate Fast 12%Sc	200 Cm/Fadden
Thiocyclam hydrogen oxalate	Evisect® 50%SP	500 g/ Fadden
Azadirachtin	Oikos 23% EC	100 Cm /100 L.

The experimental site

This study was carried out in an experimental tomato (kind) farm at El-Beheira Governorate, Egypt, during two seasons, 2019 and 2020. The treated area was 1,456 m^2; it was divided into eight plots, one plot (182 m^2) per treatment; seven plots for insecticide treatments and one for control treatment. Each plot (treatment area) was split into four replicates. Every plot was separated from the other plot by one meter to reduce interference from another treatment drift. Motor sprayer with used to spray the tested pesticides with the recommended dose.

Procedures of evaluation

Twenty-five plants were randomly inspected in three levels of plant (the upper, middle and lower canopy) per replicate of treatment. The adults of whitefly and associated predators were recorded one day before treatment and one, three, seven and ten days after treatment in the field, and then the nymph was examined in the laboratory under the Anatomical microscope. Reduction ratios of whitefly were calculated by the following equation according to Henderson and Tilton (1955).

$$\text{Corrected }(\%) = 1 - \frac{\text{n in Co before treatment } x \text{ n in T after treatment}}{\text{n in Co after treatment } x \text{ n in T before treatment}} x\ 100$$

Statistical analysis:

Data were subjected to the statistical Package for Social Sciences (SAS institute, 1988). Data were analyzed using one way analysis of variance (ANOVA) followed by LSD test for comparison between treatments and expressed as mean ±S.D. Statistical significance was set at $p \leq 0.05$.

Results and Discussions

1. Efficacy of the tested pesticides against whitefly on tomato plants under field conditions during season, 2019

Results presented in Table 2 show the reduction percentages of whitefly on tomato plants after one, three, seven and ten days of treatment by the pesticides during 2019 season. The highest general mean of reduction percentage is obtained with the natural insecticide, Abamectin with 86.98% reduction, followed by the five chemical insecticides, namely Acetampirid voll, Thiocyclam hydrogen oxalate, and Acetamprid Ace, Imidacloprid insecticides with reduction percentages of 84.19, 77.83, 69.92, and 69.09%, respectively. While the other natural insecticides, i.e. Orange oil and Azadrachtin are exhibited lower toxicity, they achieve 66.49 and 61.05 % reduction.

Table 2: Reduction percentages of whitefly on tomato plant treated with the different insecticides during season, 2019

Pesticides	Reduction percentage (%) after treatment (day)				General mean of reduction (%)
	1	3	7	10	
Acetamiprid Ace	88.84 ±0.87 c	76.19±0.42 d	75.49±0.68 c	39.16±0.28 e	69.92±4.84 d
Acetamiprid Voll	94.39 ±0.54 b	82.66 ±0.14 b	80.14±0.44 b	79.59±0.41 a	84.19± 1.56 b
Orange oil	52.34 ±2.77 d	80.08±0.46 c	76.81±0.54 c	56.75±0.7 d	66.49±3.19 e
Imidacloprid	93.89 ±0.39 b	68.73±0.69 f	59.71±0.11	54.06±0.22 d	69.09±3.94 d
Abamectin	98.39 ±0.24 a	94.43±1.04 a	82.34±0.83 a	72.76±0.57 b	86.98±2.63 a
Thiocyclam-hydrogen-oxalate	95.13 ±0.49ab	79.59±0.56 c	73.58±0.50 d	63.07±1.06 c	77.84±3.01 c
Azadirachtin	32.84 ±1.24 e	73.00±1.19 e	76.22±0.38 c	62.17±1.65 c	61.05±4.44 f
LSD 0.05	**3.64**	**2.13**	1.59	4.05	1.45

Mean followed by the same letters in a column for each period not significantly differences at 0.05 level of probability

As shown in Table 1 and Figure 1 (A, B, C, D, E, F and G), the effect of tested insecticides are varied significantly in their efficacy against the *whitefly* not only between themselves but also between inspection dates within the same insecticide. It is indicted from the results that after one day treatment, Acetamiprid Ace, Acetamiprid Voll, Thiocyclam hydrogen oxalate, Imidacopride, and Abamectin has the highest reduction of *whitefly*. Abamectin, as a natural insecticide, has the highest effect on reduction of whitefly (98.39%), followed by Thiocyclam hydrogen oxalate, Acetamiprid Voll, Imidacloprid, and Acetamiprid Ace with reduction percentages of 95.04, 94.39, 93.89, 88.84%, respectively. During the periods of study except the 10^{th} day of treatment, it is indicated that the abamectin is the most effective on whitefly. The second efficacy along the test study is the acetamiprid Voll; it has for some extent good effect on reduction of whitefly during all period of study. The reduction percentages by abamectin and acetamiprid Voll after the 10^{th} day are 79.59 and 72.52%, respectively. Acetamiprid Ace, Imidacloprid and Thiocyclam hydrogen oxalate insecticides are extremely effective on the whitefly, at 1st, 3rd, 7th day, while at the 10^{th} day they have lower percentages of reduction, i.e. 39.16, 56.75 and 63.07 %, respectively.In regard to the naturally tested insecticides, Orange oil and Azadrachtin, their peak potency are 80.08 and 72.85% on the 3rd day of treatment, and then decrease along the dates tested. Orange oil is more effective than Azadrachtin during the study duration except on the 10^{th} day of treatment at which Azadrachtin is more effect than Orange oil with reduction percentages 62.17 and 56.75%, respectively.

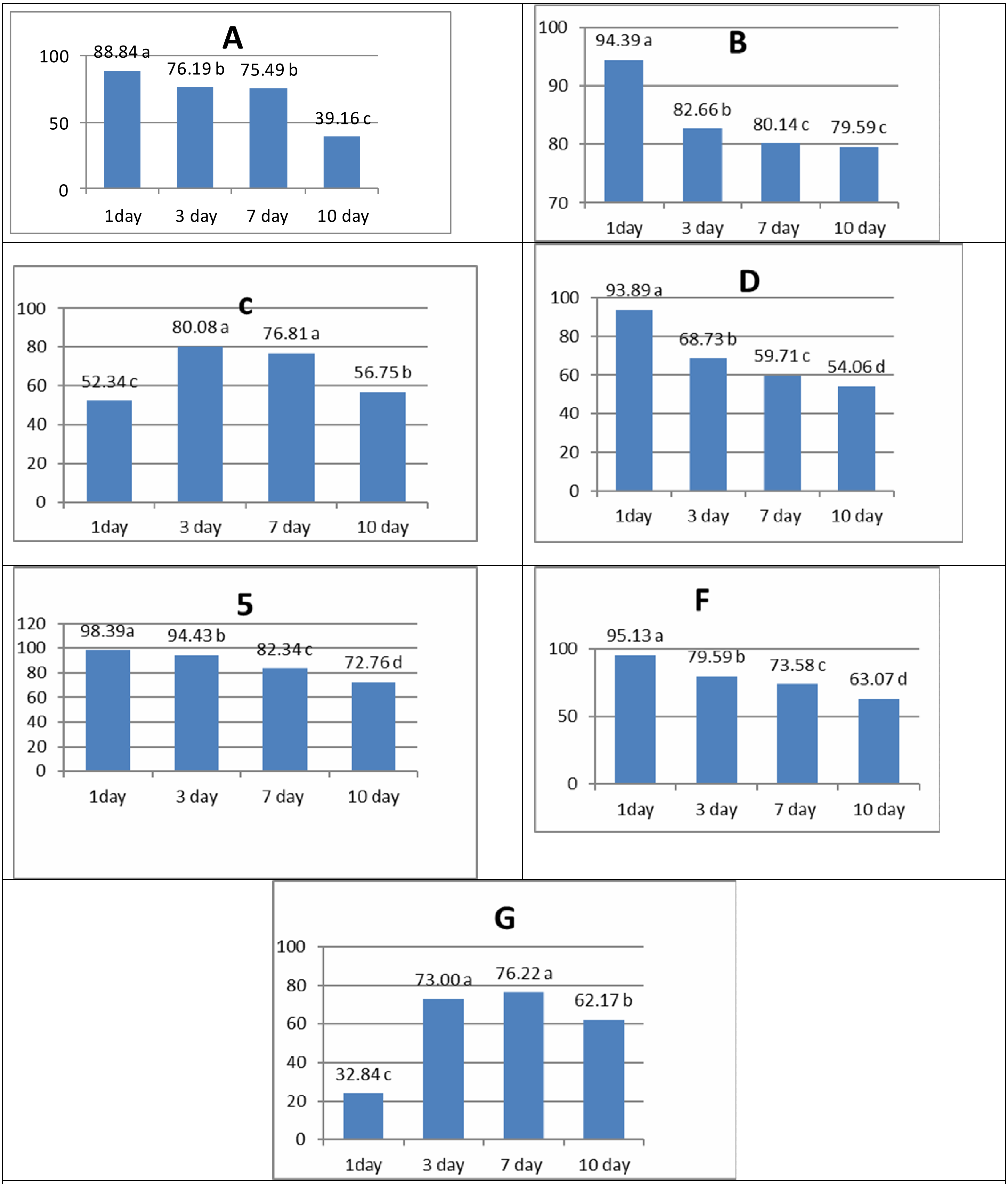

Fig. 1 : Effect of some insecticides (A (acetamiprid Ace), B (acetamiprid Voll), C (orange oil), D (imidacloprid), E (abamectin), F (thiocyclam hydrogen oxalate), G (azadirachtin)) on adults population of *Bemisia tabaci* on tomato under field conditions during seasons, 2019.

2. Efficacy of the tested pesticides against whitefly on tomato plants under field conditions during season, 2020.

Table 3 illustrates the reduction percentages of *whitefly* on tomato plant treated with different insecticides during season, 2020. Results presented in Table 3 show that the chemical insecticide (Acetamiprid Ace) is the highest efficiency on whitefly according to the general mean of reduction percentage (87.52%) after the 10^{th} day treatment, followed by Acetamiprid Voll which exhibits 86.18% reduction. In the same statistical category of reduction, Imidacloprid achieves 85.71%. The natural insecticide, Abamectin is statistically sorted in the second reduction category; it achieves 83.54% reduction, followed by Thiocyclam hydrogen oxalate in the same category with 82.21% reduction. While Azadirachtin and Orange oil, as naturally insecticides, record 66.71 and 62.26 % reduction, respectively. The present results are in a good agreement with those obtained by Ahmed *et al.* (2014), which showed that the mean of reduction percentages of whitefly caused by pyriproxyfen, novaluron, thiamethoxam, imidacloprid, acetamiprid and chlorantraniliprole were 68.98, 66.19, 79.71, 73.39,74.82 & 55.54%, respectively, at 2012. While in the second tested season in 2013, these insecticides recorded reduction percentages of 70.46, 68.71, 78.10, 75.43, 83.22 and 51.75%, respectively. Meanwhile, **Subba *et al.* (2017)** mentioned that Azadirachtin and Plant extracts biopesticides have less or no hazardous effects on human health and environment. Thus they can be incorporated in IPM programs and organic farming in vegetable cultivation. **Horowitz *et al.* (2020)** mentioned that the management of whiteflies relies mainly on the use of insecticides; however, its ability to develop resistance to major insecticide classes creates a serious challenge to farmers and pest control specialists. Among the cryptic species of *B. tabaci*, MED is considered more resistant than the MEAM1 to insecticides as pyriproxyfen and neonicotinoids.

Table 3: Reduction percentages of *whitefly* on tomato plant treated with the different insecticides during season, 2020.

Pesticides	Reduction percentage (%) after treatment (day)				General mean of reduction (%)
	1	3	7	10	
Acetamiprid Ace	98.19 ±0.45a	92.70±0.38a	b80.33±0.81a	78.86±3.44a	87.52±2.26 a
Acetamiprid Voll	97.56 ±0.24a	92.51±0.83 a	81.17±0.88 a	73.49±0.76 ab	86.18± 2.46 a
Orange oil	41.10 ±4.44 b	78.43±1.18 c	72.67±1.99 c	56.87±1.53c	62.26±3.93 e
Imidacloprid	97.63 ±0.44a	91.68±0.48 a	80.01±0.98 ab	73.51±0.83 ab	85.71±2.47 ab
Abamectin	97.64 ±0.55a	92.33±0.19 a	76.07±1.93 bc	68.15±1.23 b	83.54±3.12 bc
Thiocyclam- hydrogen-oxalate	97.03 ±0.59a	87.72±1.27b	76.17±1.85 abc	67.94±2.03 b	82.21±2.95 c
Azadirachtin	43.82 ±1.19 b	87.13±0.53b	76.38±2.72 abc	59.49±0.69c	66.71±4.31 d
LSD 0.05	5.23	2.67	5.08	5.199	2.236

Mean followed by the same letters in a column for each period not significantly differences at 0.05 level of probability.

As shown in Table 1 and Figure 2 (A, B, C, D, E, F and G), the effect of tested insecticides are varied significantly in their efficacy against the *whitefly* not only between themselves but also between inspection dates within the same insecticide. The results show that after one day treatment, Acetamiprid Ace and Acetamiprid Voll, Imidacoprid, Thiocyclam hydrogen oxalate, and Abamectin exhibit the highest reduction of whitefly. Acetamiprid Ace is the highest reduction of the whitefly with 98.19%, followed by Abamectin, Imidacloprid, Thiocyclam hydrogen oxalate, Acetamiprid Vol with 97.64, 97.63, 97.03, and 92.56 %, respectively. The reduction percentages decrease steadily over the intervals tested and reach 78.86, 73.59, 73.51, 68.15 and 67.94% reduction by Acetamiprid Ace, Acetamiprid Voll, Imidacloprid, Abamectin and Thiocyclam hydrogen oxalate insecticide, respectively.

In regards to the natural tested insecticides, Azadrachtin and Orange oil, their highest potency are 87.13 and 78.43% on the 3rd day of treatment, and then decrease along the dates tested. Azadrachtin is more effective than Orange oil during the study duration; they reach 59.49 and 56.87% reduction on the 10th day of treatment. The present results are in agreements with those obtained by Kuhar *et al.* (2002), who mentioned that neonicotinoid insecticides; thiamethoxam, imidacloprid and acetamiprid can cause mortality to whitefly. These results are also in agreement with those of Elbert *et al.* (1996), who mentioned that the imidacloprid had a higher systemic efficacy against whitefly adults under laboratory conditions. Also, acetamiprid was more effective against whitefly by the leaves applied (Nauen *et al.*, 1996). The present results are in agreements with those obtained by Kuhar *et al.* (2002), who mentioned that neonicotinoid insecticides; thiamethoxam, imidacloprid and acetamiprid can cause mortality to whitefly.

The results indicated that Orange oil (Prev-AM®)reduced the white fly along the tested periods during tested seasons, 2019 and 2020. These results are consistent with the results of Isaac and Horowitz (2006), and (Mona 2017), which indicated that Prev-AM® orange oil and peripoxine (Planta®) controlled the *whitefly*. The results indicate that treatment with Imidacloprid (Pestidor 25% wp) against whitefly increases the percentage of reduction during the season, 2019. This finding is parallel with the findings of Mohan and Katiyar (2000) who mentioned that imidacloprid was the most effective in reducing whitefly populations. Also, Khattak *et al.* (2004) reported that imidacloprid gave significant reduction in the whitefly populations after 24, 72 and 120 hours of application. Additionally, Kuhar *et al.* (2002), reported that imidacloprid gave fast initial effects in reducing whitefly with long residual action and moderate effect. The results indicate that Abamectin Gate Fast decreases the number of whitefly along tested period. These results are consistent with the results of (Dybas 1989), the effect of Abamectin on different stages of whitefly under laboratory conditions, where the eggs stage was more susceptible to the insecticide. Thiocyclam hydrogen oxalate Evisect® 50%SP was evaluated for reducing the population density of whitefly in field trials and comparing them with untreated plants during the season, 2019 on tomatoes at 1, 3, 7 and 10 days after the treatment. The present findings reveals that the effect of Oikos 23% EC against whitefly on tomato season, 2019 after 1, 3, 7 and 10 days the percentage reduction was 23.99%, 62.17%, 72.25% and 76.22%, respectively. In a similar study, whitefly eggs for cotton treated with neem seed extracts were 80% lower than that of untreated cotton control for up to 7 days after treatment (Coudriet *et al*., 1985). These results are similar to Dimetry *et al.* (1996), who observed mortality levels of whitefly adults ranged between 83 and 95% by exposing to three commercial formulations of neem. Barrania (2014) showed that, neonicotinoids (thiamethoxam, imidacloprid and acetamiprid) revealed a residual toxicity higher than chitin synthesis inhibitors (pyriproxyfen and novaluron) on B. tabaci which revealed a residual toxicity higher than chlorantraniliprole.

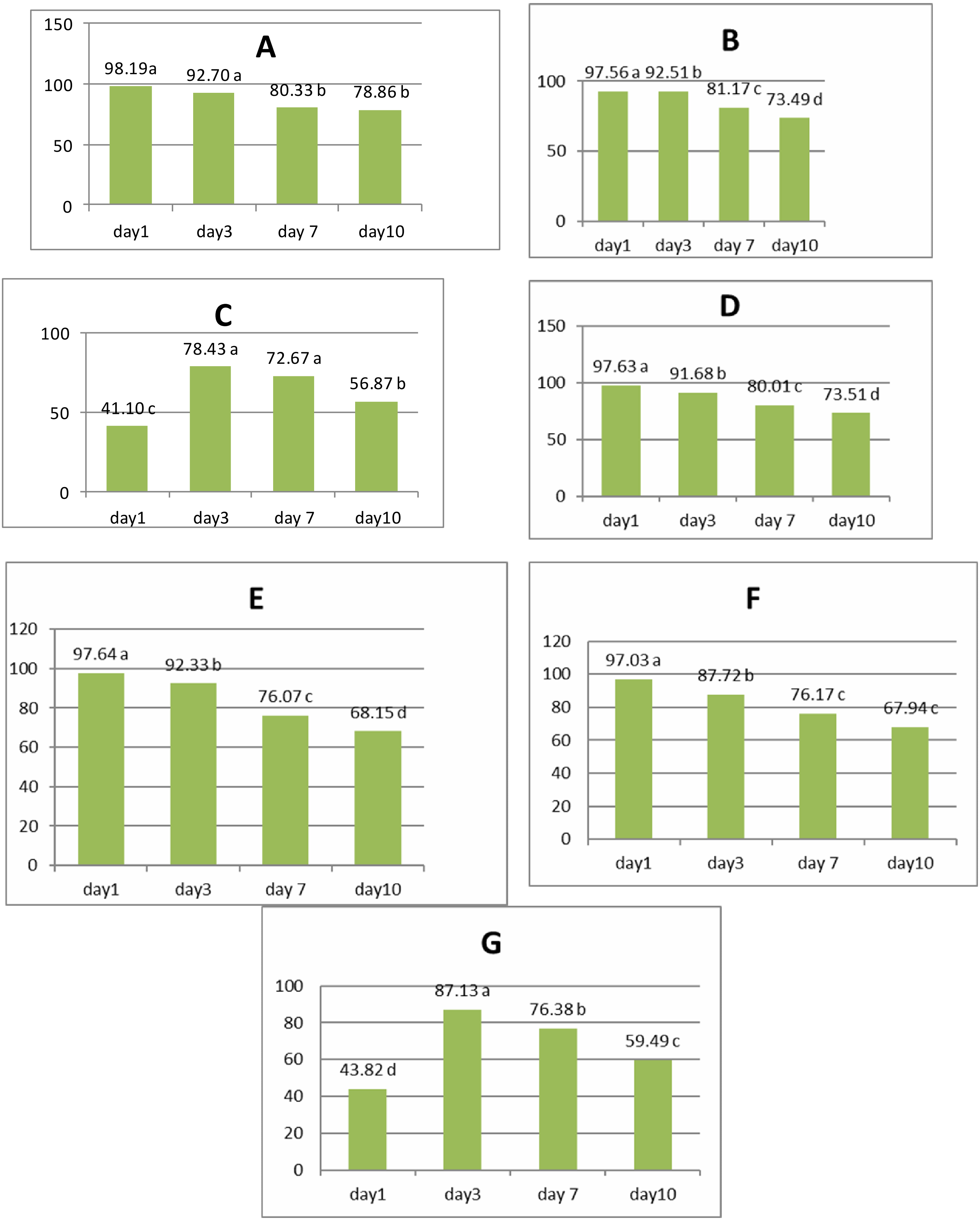

Fig. 2: Effect of some insecticides (A (acetamiprid Ace)), B (acetamiprid Voll), C (orange oil), D (imidacloprid), E (abamectin), F (thiocyclam hydrogen oxalate), G (azadirachtin))on whitefly on tomato under field conditions during seasons, 2020.

3. Efficacy of the Tested insecticides Against the Predator *whitefly* Lion, *Chrysoperla carnea* on tomato Plants.

The prevailing associated predators were *Orius* spp., *Metasyrphus corollae* F., *Chrysoperla carnea* (Steph.), *Coccinella undecimpunctata* L., and true spiders. Meanwhile, the dominant insect predator was *Chrysoperla carnea*. Results presented in Tables 4 and 5 show that the seven tested compounds did not cause complete mortality to *C. carnea* individuals found in tomato field neither immediately after spraying (3 days) nor after any of the other two tested post-treatment intervals. The results obviously reveal that Acetamiprid Voll and Acetamiprid Ace are the most effective compound causing in general, the highest percentage of *C. carnea* population reduction either after three days post-treatment or after any either two tested post-treatment periods. After three days from application, reduction percentages of 96.01 and 94.64 are indicated in 2019 while, 93.69 and 92.07% are obtained in 2020 for Acetamiprid Voll and Acetamiprid Ace, followed by 92.14, 91.03; 90.05, 88.47 and 88.94, 85.89% for Imidacloprid, Abamectin and Thiocyclam-hydrogen-oxalate in the two seasons, then they reduced after 7 and 14 day. Meanwhile, the Orange oil and Azadirachtin are the least effective percentage of *C. carnea* population after three days from application; their reduction percentages are 54.75, 57.97 and 59.43, 62.09 during two seasons, respectively. The general mean of reduction in population for Acetamiprid Ace and Acetamiprid Voll are 82.04 , 80.49% and 84.20, 79.14% during two seasons, while Imidacloprid, Abamectin and Thiocyclam-hydrogen-oxalate show 79.55, 77.00, 77.66, 74.89 and 75.89, 72.20% during two seasons respectively followed significantly by Orange oil (46.51 and 48.59 and%) then Azadirachtin (49.31 and 52.11 %) in the two seasons, respectively. It is well known that only *Chrysoperla carnea* (Stephens) and *Chrysoperla rufilabris* (Burmeister) have wide commercial availability and use as biological control agents for *B. tabaci*. (Arnó *et al.,* 2010). Pesticides constitute another common disruptive component in many agroecosystems. Here*, C. carnea* may have an advantage over other introduced or resident natural enemies because it has a relatively broad tolerance to many insecticides, particularly during the larval and cocoon stages (Mizell and Schiffhauer, 1990). These findings disagree with those of Bendict *et al.* (1986) who reported that number of predaceous insects were not significantly affected with chlordimee form treatment. Hegab (2002) evaluated the harmful side effects of three spray progammes (ES-Fevaporate, Es-Fenvalerate + Profenofos and ES-Fenvalerate + Profnofos+ thiodicarb) on the incidence of flying adults of some predaceous insects and reported that the three tested spray programmes had highly significant adverse effects on the population density of these arthropod species, recording 37.67 and 49.18% in 1998 and 1999 seasons, respectively. Al-Shannaf (2010) showed that seasonal reductions were 62.29 and 58.14% in 2008 and 2009. On the other hand, Abd-Elsamed *et al.* (2011) mentioned that *C. carnea* and *C. undecimpunctata* had high reduction percentage after two days post-treatment. The reduction percentages decreased gradually as the time exposed after spray increased for all tested insecticides (Couracron, Dursban, Atabron and Consult) during the two cotton seasons.

Table 4 : Effect of some insecticides *Chrysoperla carnea* (Steph.) population associated with tomato pests during 2019 season.

Pesticides	**Reduction percentage (%)**			**Mean of residual effect**	**General mean of reduction**
	Initial effect (3) 3()(3) days	**7 days**	**10 days**	**(%)**	**(%)**
Acetamiprid Ace	94.64 a	80.15 ab	71.34 ab	75.75	82.04
Acetamiprid Voll	96.01 a	82.94 a	73.65 a	78.30	84.20
Orange oil	54.75 e	45.87 d	38.91e	42.39	46.51
Imidacloprid	92.14 b	79.05 bc	67.45 bc	73.25	79.55
Abamectin	90.05 c	77.91 bc	65.01cd	71.46	77.66
Thiocyclam-hydrogen-oxalate	88.94 c	75.86 c	62.87 d	69.37	75.89
Azadirachtin	59.43 d	47.95 d	40.54 e	44.25	49.31
LSD 0.05	1.7512	3.3094	4.3403		

Mean followed by the same letters in a column for each period not significantly differences at 0.05 level of probability.

Table 5 : Effect of some insecticides *Chrysoperla carnea* (Steph.) population associated with tomato pests during 2020 season.

Pesticides	**Reduction percentage (%)**			**Mean of residual effect**	**General mean of reduction** (%)
	Initial effect (3)	**7 days**	**10days**	**(%)**	
Acetamiprid Ace	92.07 ab	79.48 a	69.94 a	74.71	80.49
Acetamiprid Voll	93.69 a	77.05 ab	66.72 ab	71.86	79.14
Orange oil	57.97 f	46.84 e	40.97 d	43.91	48.59
Imidacloprid	91.03 b	74.91 b	65.07 b	69.99	77.00
Abamectin	88.47 c	72.05 c	64.17 bc	68.11	74.89
Thiocyclam-hydrogen-oxalate	85.89 d	69.98 c	60.74 c	65.36	72.20
Azadirachtin	62.09 e	50.93 d	43.32 d	47.13	52.11
LSD 0.05	2.0099	2.7890	3.6114		

Mean followed by the same letters in a column for each period not significantly differences at 0.05 level of probability.

Conclusion

It is concluded from the present study that the application of Gate Fast 12% SC and Acetamiprid were the highest toxicity against *whitefly*, followed by Imidacloprid and Abamectin during two seasons. Meanwhile, the Orange oil and Azadirachtin were the least effective percentage of *whitefly* and *C. carnea* populations**.** Both the Orange oil and Azadirachtin showed minimum suppression of predator population at higher dose of spray. Hence the Orange oil and Azadirachtin can suitably be included in Integrated Pest Management of sucking insect pests like *whitefly* in tomato because of their less toxicity to predators.

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