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MONITORING AND MANAGEMENT OF THE COTTON MEALYBUG, *Phenacoccus solenopsis* TINSLEY INSECT AND ITS ASSOCIATED NATURAL ENEMIES ON GREEN BEAN PLANTS

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ABSTRACT: Field studies were conducted on cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Sternorrhyncha: Coccoidea: Pseudococcidae) which infested green bean plants at Atfih distract, Giza Governorate, Egypt during two successive summer and nili seasons of 2016 and 2017. The population density, activity periods and the effects of some weather factors on *P. solenopsis* and its associated natural enemies were considered. The obtained results revealed that in summer season the total numbers of alive stages had one peak of activity in the 3rd of July during the first and second seasons (2016 and 2017), successively. While, in nili season the total number of alive stages had one peak of activity in the 3rd and the 17th December, during the first and second seasons (2016 and 2017), respectively. The total effects of some weather factors such as maximum and minimum air temperature (°C) and relative humidity percentage (RH%) showed significantly positive relationship with the cotton mealybug population. During this study, three hymenopterous solitary endparasitoids and four predacious species were recorded. The parasitoids were *Aenasius arizonensis* (Girault), *Anagyrus pseudococci* (Girault) and *Acerophagus gutierreziae* Timberlake (Encyrtidae). The predacious ones were *Scymnus syriacus* Mars., *Coccinella undecimpunctata* (L.) (Coleoptera: Coccinellidae), *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) and *Orius laevigatus* (Fiber.) (Hemiptera: Anthocoridae). In an attempt to control this insect pest specie, eight insecticides namely, mineral oil, lufenuron, chlorpyrifos, malathion, deltamethrin, buprofezin, thiamethoxam and imidacloprid were tested on *P. solenopsis* and its natural enemies on green bean under field conditions. The obtained results indicated that imidacloprid was the highest efficacy against *P. solenopsis* recording 90.71–89.17% reduction of the insect population after 21 days of application. Also imidacloprid was the highest efficacy against parasitoids and predators of the cotton mealybug. IGRs toxicants (buprofezin and lufenuron) found to be safer to the predacious insects than other tested insecticides.

Key words: Insecticides, green bean, weather factors, control, *Phenacoccus solenopsis*, natural enemies.

INTRODUCTION

Green bean, *Phaseolus vulgaris* L., is one of the most important leguminasae crops which used as human food in Egypt and playing a vital role in the global food system, which infested by meany pests throughout the growing season such as the cotton mealybug. The cotton mealybug, *Phenacoccus solenopsis* Tinsley attacking 159 host plant species (agricultural and horticultural crops) belonging to 21 different families. It causes large damages of the quantity of yield either directly by sucking plant juice, weakening and death of some parts of plants or indirectly by excreted honeydew, which causes growth of sooty mould and inhibit photosynthesis process in plant. Also, it may transmit the pathogens to plants (**Hodgson *et***

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***al.*, 2008; Arif *et al.*, 2009; Saini *et al.*, 2009; Abbas *et al.*, 2010; Vennila *et al.*, 2011**). The *P. solenopsis* had found on a wide range of vegetable crops including species of economically important families such as Malvaceae, Solanaceae and Cucurbitaceae which reported by many authors such as **Abd-Rabou *et al.* (2010), Wang *et al.* (2010), Zhu *et al.* (2011), Ibrahim *et al.* (2015), Nabil *et al.* (2015) and Nabil (2017)**. It is also recorded associated with 28 species of natural enemies including 12 predators and 16 parasitoids (**Shah *et al.*, 2015**). The effect of abiotic factors (temperature and relative humidity) on the biology, ecology and population dynamics of any organism was studied. Temperature is a major factor that affect on the abundance of mealybugs. Also, Fecundity of an insect pest is affected by RH% and temperature as well as life span and development of the mealybug (**Kumar *et al.*, 2013; Nabil and Hegab, 2019**). Parasitoids and predators are considered the most important biotic factors that affected on the population of *P. solenopsis*. For example the parasitoid, *Aneasius bambawalei* Hayat (Hymenoptera : Encyrtidae) caused 20-70% parasitism of *P. solenopsis* **(Tanwar *et al.*, 2008; Ram *et al.* 2009; Hanchinal *et al.*, 2010)**, respectively. The effect of the coccinellid predators on *P. solenopsis* population were recorded by **Kedar *et al.* (2011)**. Assessment of the potential effects that pesticides have on the natural enemies is therefore an important part of IPM programs. As such, more nonselective pesticides are not favoured and a reduced application rate of broad-spectrum pesticides may decrease the impact on natural enemies, but still remain efficacious against pests. Therefore, the current study aimed to determine some ecological parameters of the different stages of this insect and its associated natural enemies on green bean in summer and nili seasons to evaluate the effects of some weather factors on the different stages of the pest. And also aimed to screen some insecticides used to control the pest and its side effects on associated natural enemies (parasitoids and predators). Such study may help for designing a comprehensive pest management program and prediction models for the cotton mealybug.

MATERIALS AND METHODS

Study Location

The seasonal population of the cotton mealybug, *Phenacoccus solenopsis* Tinsley and its associated natural enemies were monitored during summer and nili seasons of 2016 and 2017 on green bean, *Phaseolus vulgaris* L., plantations at Atfih distract, Giza Governorate, Egypt. The experiments were conducted in an area of about half faddan (2100 m^2) of green bean (Giza 3 cv.) which cultivated on the first week of March in the summer seasons and on the first week of August at nili season. Each area was divided into four equal replicates. The green bean plantations received normal agricultural practices and were not subjected to any chemical control application.

Samples Collection

One hundred leaves, twenty five ones of each replicate were taken weekly at random throughout the seasons of the study. The collected samples were packed up in paper bags, transferred to the laboratory and examined by the aid of a needle using a stereoscopic microscope at the laboratory of the Scale Insects and Mealybugs Department, Plant Protection Research Institute, Agriculture Research Center. Alive stages (nymphs and adults) of the insect pest and natural enemies were categorized and their counts were recorded. Specimens were enclosed in glass jars (15 cm diameter and 20 cm height). The jars were covered with muslin held in position by a rubber band and checked daily. The predators and parasitoids were separated from the collecting leaves parts during the initial examinations. The predacious and parasitic species were identified with helping of Prof. Dr. S. Abd-Rabou, Chief Researcher emeritus, Scale Insects and Mealybugs Department, Plant Protection Research Institute, Agricultural Research Center, Egypt. Population fluctuations of the mealybug and its natural enemies (predators and parasitoids) were estimated during the period of investigation.

Effect of some Weather Factors on the Insect Population and Natural Enemies

The main weather factors, maximum temperature (Max. Temp.), minimum temperature (Min. Temp.) and relative humidity (RH%)

corresponding to the sampling periods were obtained from the Meteorological Central Laboratory, Agricultural Research Center, Ministry of Agriculture, to indicate the effect of each factor of the tested climatic factors on the population of tested insect and its associated natural enemies.

Insecticides

The current study was carried out to evaluate the field performance of eight insecticides in their respective commercial formulations available on the market. The insecticide generic and chemical information is given in Table 1. The concentrations used were based on the recommendations of the Egyptian Ministry of Agriculture for each insecticide to control the pest insects under field conditions.

A field trial was conducted on plants grown on a farm located in Atfih distract, Giza Governorate, Egypt during two consecutive summer green bean seasons of 2016 and 2017. The infested green bean plants with cotton mealybug were identified, selected and labeled before the application of insecticides according to **Monga *et al.* (2009)**. This area did not receive any insecticidal treatments before the start of the experiment. The trial of nine treatments (eight insecticides + control) was laid out in a randomized complete block design with three replicates. A spray was applied with a CP3 knapsack sprayer (Cooper Pegler Co. Ltd., Northumberland, England). The insecticides were used in commercial formulation and the concentrations were prepared using water as a diluent. Insecticides were sprayed in the early morning when the insects were active and the environmental conditions minimize the potential risk of spray drift and evaporation. Control plots were sprayed with water only. Thrity plants of 50-80 cm height with heavy infestation of mealybug and associated the natural enemies (parasitoids and predators) were randomly selected in the field. Plant to plant distance was 30 cm. Each plant was acted as a replicate. The spray application was done on 20th and 30th June during 2016 and 2017, respectively. Data were recorded on the selected plants before spraying as well as 7, 14 and 21 days after application. The mean numbers of cotton mealybugs per green bean plants and associated natural enemies were recorded.

The percent reduction of the mealybug population and associated natural enemies in all treatments compared to the control were calculated according to **Henderson and Tilton (1955)**.

Population reduction (%) = N in control before treatment × N in Treatment after treatment ÷ N in control after treatment × N in Treatment before treatment × 100

N= number of individuals

Statistical Analysis

Simple correlation values (r), partial regression (b), coefficient of determination percentage (CD%), The analysis of variance (ANOVA) and the least significant difference (LSD) values were calculated using CoStat, Computer Program version 6.311, 2005 (**Costat Statistical Sotware, 2005**).

Table 1. Common and trade names of the tested insecticides, their chemical classes, formulations and application rates

Common name	Trade name	Formulation	Application rate
Mineral oil	Tiger	97% EC	1L/100L
Lufenuron	Match	5% EC	160 ml/fad.
Malathion	Ictathion	57% EC	150 ml/100L
Deltamethrin	Decis	2.5% EC	500 ml/100L
Chlorpyrifos	Dursban H	48%EC	1L /fad.
Imidacloprid	Ecomida	30.5% SC	60 ml/100L
Thiamethoxam	Actara	25% WG	25 g/100L
Buprofezin	Applaud	25% SC	600 ml/fad.

RESULTS AND DISCUSSION

Population Density of *Phenacoccus solenopsis* Tensily in Summer Seasons

Results given in Figs. 1 and 2 show that during the first and second summer seasons (2016 and 2017) nymphs showed one peak of activity on the 3rd of July. Also, adult females during the first and second seasons (2016 and 2017) had one peak of activity on the 5th and the 12th of June, respectively. The total number of alive stages had one peak of activity on the 3rd of July during the first and second seasons (2016 and 2017), successively.

Effects of some Weather Factors on *P. solenopsis*

Results presented in Table 2 indicate that in the first season, maximum temperature had positive highly significant on the total alive stages of the cotton mealybug where r = 0.664**. While, in the second season each of maximum and minimum temperature had positive highly significant and positive significant on the total alive stages of the cotton mealybug where r =0.712** and 0.537*, consecutively. Coefficient of determination (CD%) obviously cleared that the three considered weather factors affected the total number of alive stages population by 72.30 and 64.57%, in the first and second seasons, successively.

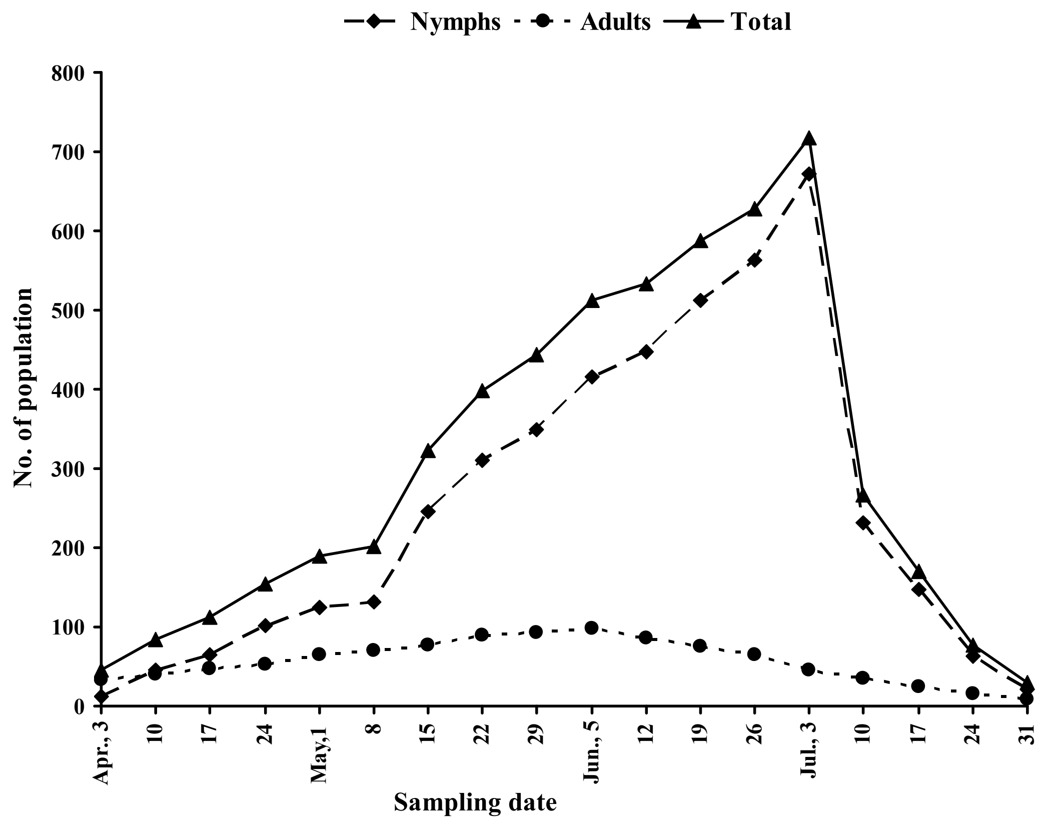
These results are in agreement with those obtained by **Hameed *et al.* (2014), Tehniyat *et al.* (2015), Nabil (2017) and Nabil and Hegab (2019)** who mentioned that cotton mealybug population showed positive significant relationship with maximum temperature, minimum temperature and RH%.

Natural Enemies

During this study three parasitoids and four predators species were recorded. The parasitoids were *Aenasius arizonensis* (Girault), *Anagyrus pseudococci* (Girault) and *Acerophagus gutierreziae* Timberlake (Hymenoptera: Encyrtidae). All previously mentioned species are solitary endoparasitoids. The predacious species were *Scymnus syriacus* Mars., *Coccinella undecimpunctata* L. (Coleoptera: Coccinellidae), *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) and *Oruis laevigatus* (Fiber.) (Hemiptera: Anthocoridae).

As shown in Tables 3 and 4 during the first and second seasons 2016 and 2017, *A. arizonensis* recorded the highest number on the 3rd of July (32 individuals/sample) and the 19th of June (14 individuals/sample), successively. While, *A. Pesudococci* reached the highest number on the 12th of June (7 individuals / sample) and the 5th of June (4 individuals / sample), respectively. *A. gutierreziae* appeared in rare individuals in all samples during the study course.

Chrysoperla carnea was the most abundant predator during the study period followed by *C. undecimpunctata.* But *S. syriacus* and *O. laevigatus* appeared in a few numbers all over the study period. During the first and second seasons 2016 and 2017 *C. carnea* recorded the highest number on the 3rd of July (21 individuals / sample) and on the 19th of June (14 individuals / sample), successively. While, *C. undecimpunctata* reached the highest number on the 26th of June (14 individuals/ sample) and on the 19th of June (9 individuals/sample), respectively. These results were in agreement with those obtained by **Khan *et al.* (2012)** who stated that *C. carnea* and *Cryptolaemus montrouzieri* predators showed strong predatory potential against *P. solenopsis*, and being the most ravenous feeder. Moreover, prey stages also had a considerable effect on consumption rate, development and fecundity. **Attia and Awadallah (2016)** surveyed the predators, parasitoids and hyperparasitoids associated with nymphal and adult stages of *P. solenopsis* infesting five ornamental host plants and six weeds. They recorded six predacious species, two endoparasitoids and four hyperparasitoids. The predacious species were *Hyperaspis vinciguerrae* Capra, *S. syriacus*, *Nephus (Sides) hiekei* Fursch (Coccinellidae), *Dicrodiplosis manihoti* Harris (Cecidomyiidae), *C. carnea*, *Sympherobius amicus* Navas (Hemerobiidae) and *Orius albidipennis* (Reuter). The primary parasitoids were *A. gutierreziae* and *Chartocerus dactylopii* (Ashmead). Also, **Bharathi and Muthukrishnan (2017)** stated that the solitary endoparasitoid, *A. bambawalei*, was found as one of the key regulating factor for the mealybug, despite harboring 11 different hyperparasitoids. **Nabil and Hegab (2019)** recorded *A. arizonensis* as a primary parasitoid of *P. solenopsis* infesting okra plants. Substantially, good deal of natural enemies, both the predators and parasitoids were



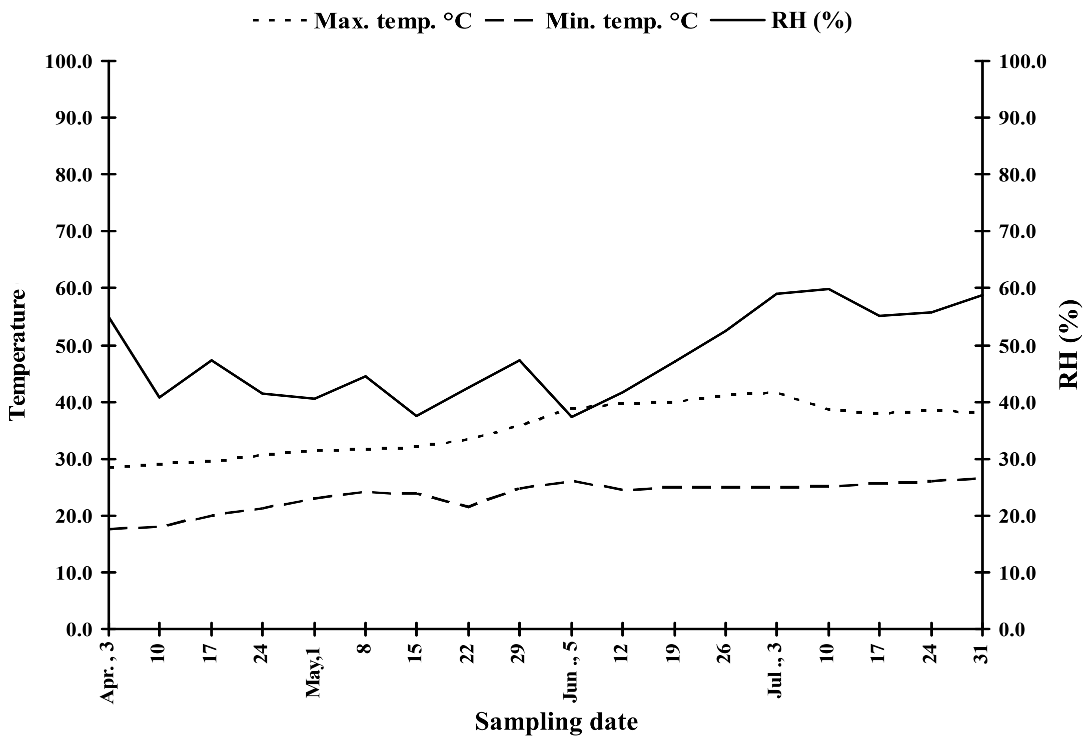
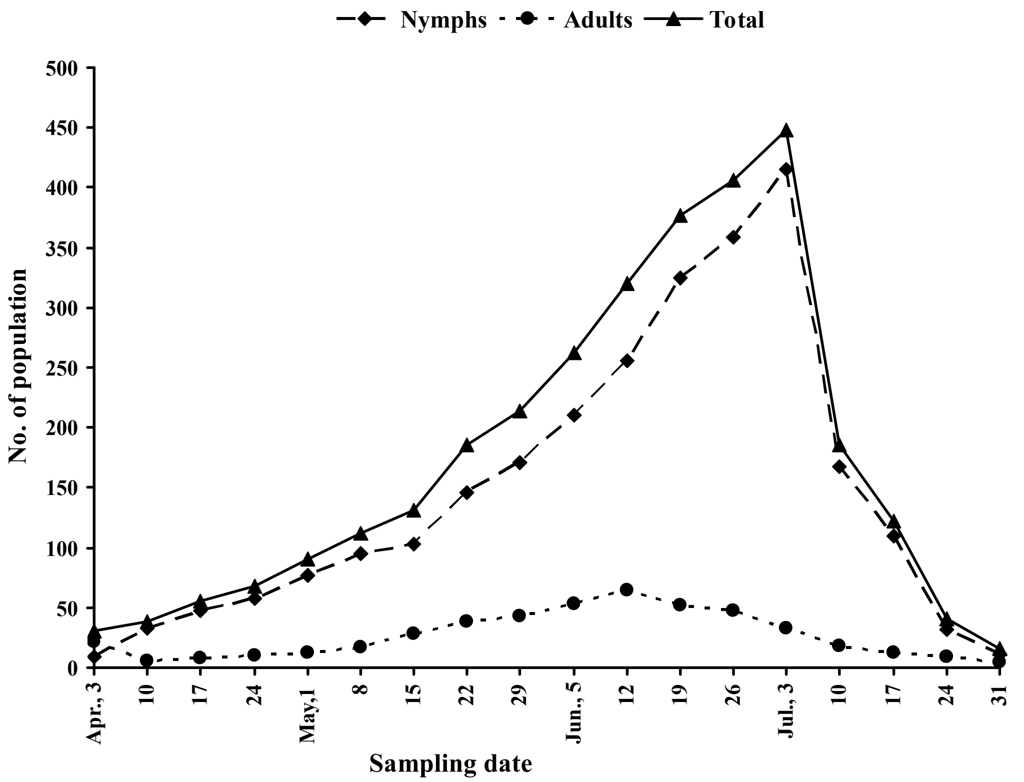


Fig. 1. Seasonal abundance of *Phenacoccus solenopsis* Tensily infesting green bean plants in Atfih (Giza) during summer season 2016



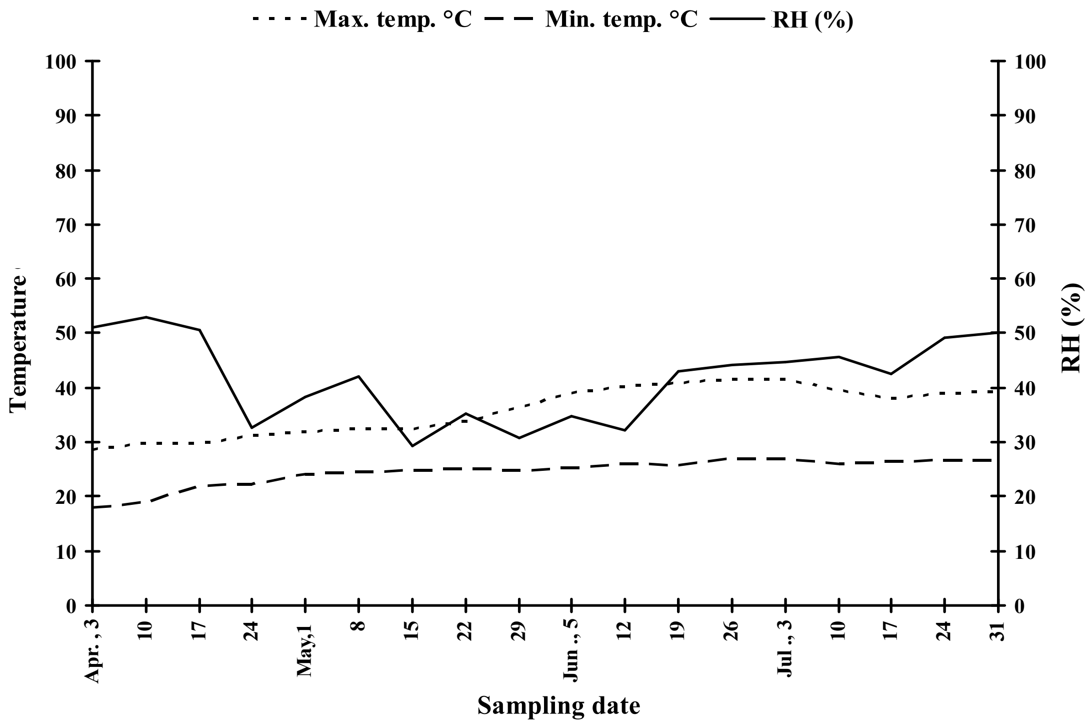


Fig. 2. Seasonal abundance of *Phenacoccus solenopsis* Tensily infesting green bean plants in Atfih (Giza) during summer season 2017

Table 2. Correlation coefficient and multiple regression indicating the effects of some weather factors on *Phenacoccus solenopsis* Tinsley on green bean plantations at Atfih (Giza) during summer and nili seasons 2016 and 2017

Location	Season	Considered weather factor	r	b	CD (%)
Atfih (Giza)	Summer 2016	Max. Temp. ˚C	0.664**	0.003	72.30
		Min. Temp. ˚C	0.412	0.089	
		RH (%)	-0.095	0.706	
	Summer 2017	Max. Temp. ˚C	0.712**	0.009	64.57
		Min. Temp. ˚C	0.537*	0.022	
		RH (%)	-0.296	0.022	
	Nili 2016	Max. Temp. ˚C	0.277	0.266	20.04
		Min. Temp. ˚C	0.398	0.102	
		RH (%)	0.413	0.088	
	Nili 2017	Max. Temp. ˚C	0.191	0.448	39.48
		Min. Temp. ˚C	0.456	0.057	
		RH (%)	-0.400	0.101	

Table 3. Seasonal abundance of natural enemies associated with *Phenacoccus solenopsis* Tinsley infesting green beans plants in Atfih (Giza) during summer season 2016

Sampling date	Total number of *P. solenopsis*	No. of parasitoids			No. of predators			
		A. arizonensis	*A. pseudococci*	*A. gutierreziae*	*S. syriacus*	*C. carnea*	*C. undecimpunctata*	*O. laevigatus*
Apr., 3	46	0	0	0	0	0	0	0
10	85	0	0	0	0	0	0	0
17	113	0	0	0	0	0	0	0
24	155	1	0	0	0	0	0	0
May,1	190	4	0	0	0	0	0	0
8	202	9	2	0	0	5	0	0
15	323	11	2	0	0	6	0	0
22	399	13	3	0	0	9	4	0
29	443	15	4	0	1	11	5	0
Jun., 5	513	16	5	0	1	13	9	0
12	533	22	7	0	0	15	11	0
19	588	24	3	0	0	17	12	2
26	628	25	1	0	0	18	14	4
Jul., 3	717	32	1	1	1	21	2	3
10	266	9	0	1	4	8	1	1
17	171	5	0	0	0	3	0	1
24	78	2	0	0	0	1	0	0
31	29	2	0	0	0	0	0	0
Total	**5479**	**190**	**28**	**2**	**7**	**127**	**58**	**11**
Mean	**304.39**	**10.56**	**1.56**	**0.11**	**0.39**	**7.06**	**3.22**	**0.61**

Table 4. Seasonal abundance of natural enemies associated with *Phenacoccus solenopsis* Tinsley infesting green beans plants in Atfih (Giza) during summer season 2017

Sampling date	Total number of *P. solenopsis*	No. of parasitoids			No. of predators			
		A. arizonensis	*A. pseudococci*	*A. gutierreziae*	*S. syriacus*	*C. carnea*	*C. undecimpunctata*	*O. laevigatus*
Apr., 3	31	0	0	0	0	0	0	0
10	39	0	0	0	0	0	0	0
17	55	0	0	0	0	0	0	0
24	68	0	0	0	0	0	0	0
May,1	90	0	0	0	0	0	0	0
8	112	0	0	0	0	0	0	0
15	131	0	0	0	0	0	0	0
22	185	1	0	0	0	0	2	0
29	214	6	3	0	0	1	3	0
Jun., 5	263	8	4	0	0	6	5	0
12	320	12	1	0	0	9	7	0
19	377	14	1	0	0	14	9	0
26	406	13	0	0	0	13	5	2
Jul., 3	448	10	0	0	2	9	0	2
10	185	2	0	0	6	5	0	1
17	122	1	0	0	0	0	0	0
24	41	0	0	0	0	0	0	0
31	16	0	0	0	0	0	0	0
Total	**3103**	**67**	**9**	**0**	**8**	**57**	**31**	**5**
Mean	**172.39**	**3.72**	**0.50**	**0.00**	**0.44**	**3.17**	**1.72**	**0.28**

found associated with the field population of *P. solenopsis*, indicating great potential for environmental friendly natural biological control.

Population Density of *Phenacoccus solenopsis* Tensily in Nili Seasons

Results illustrated in Figs. 3 and 4 show that during the first and second seasons (2016 and 2017) nymphs recorded one peak of activity on the 17th of December, consecutively. Also, adult females during the first and second seasons (2016 and 2017) had one peak of activity on the 19th of November, respectively. The total number of alive stages had one peak of activity on the 3rd and the 17th December, during the first and second seasons (2016 and 2017), successively.

Effects of some Weather Factors on *P. solenopsis*

Results presented in Table 2 indicate that in the first and second seasons (2016-2017) maximum temperature, minimum temperature and RH (%) affected the total number of alive stages population by 20.04 and 39.48%, successively. Climatic conditions have a great impact on the population dynamics of cotton mealybug and its distribution over a wide host range (**Prasad *et al.*, 2012**). Therefore, continuous monitoring of the population and dynamics of cotton mealybug is required to avoid severe crop losses with the ongoing changes in climatic conditions (**Rezk *et al.*, 2019**).

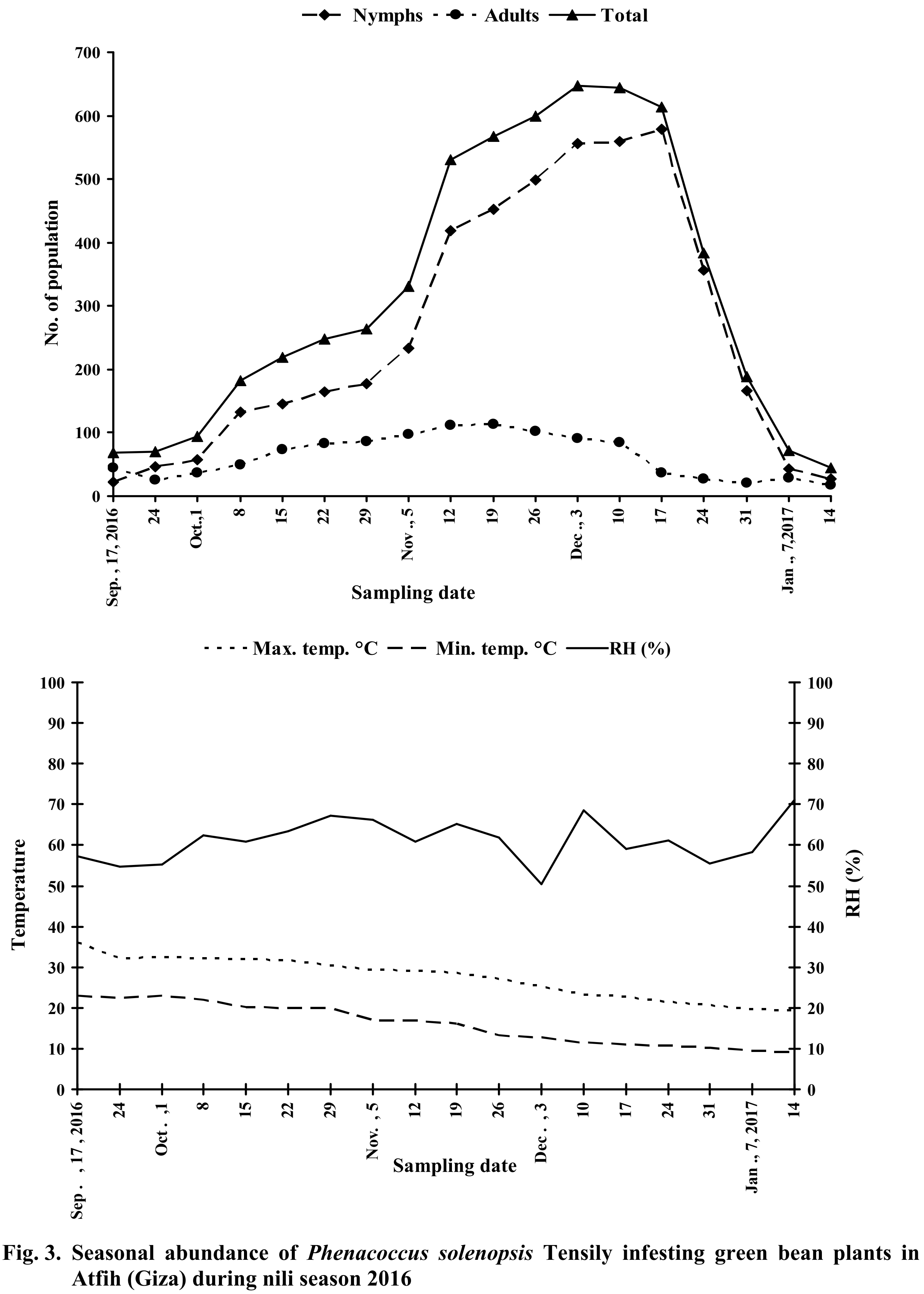


Fig. 3. Seasonal abundance of *Phenacoccus solenopsis* Tensily infesting green bean plants in Atfih (Giza) during nili season 2016

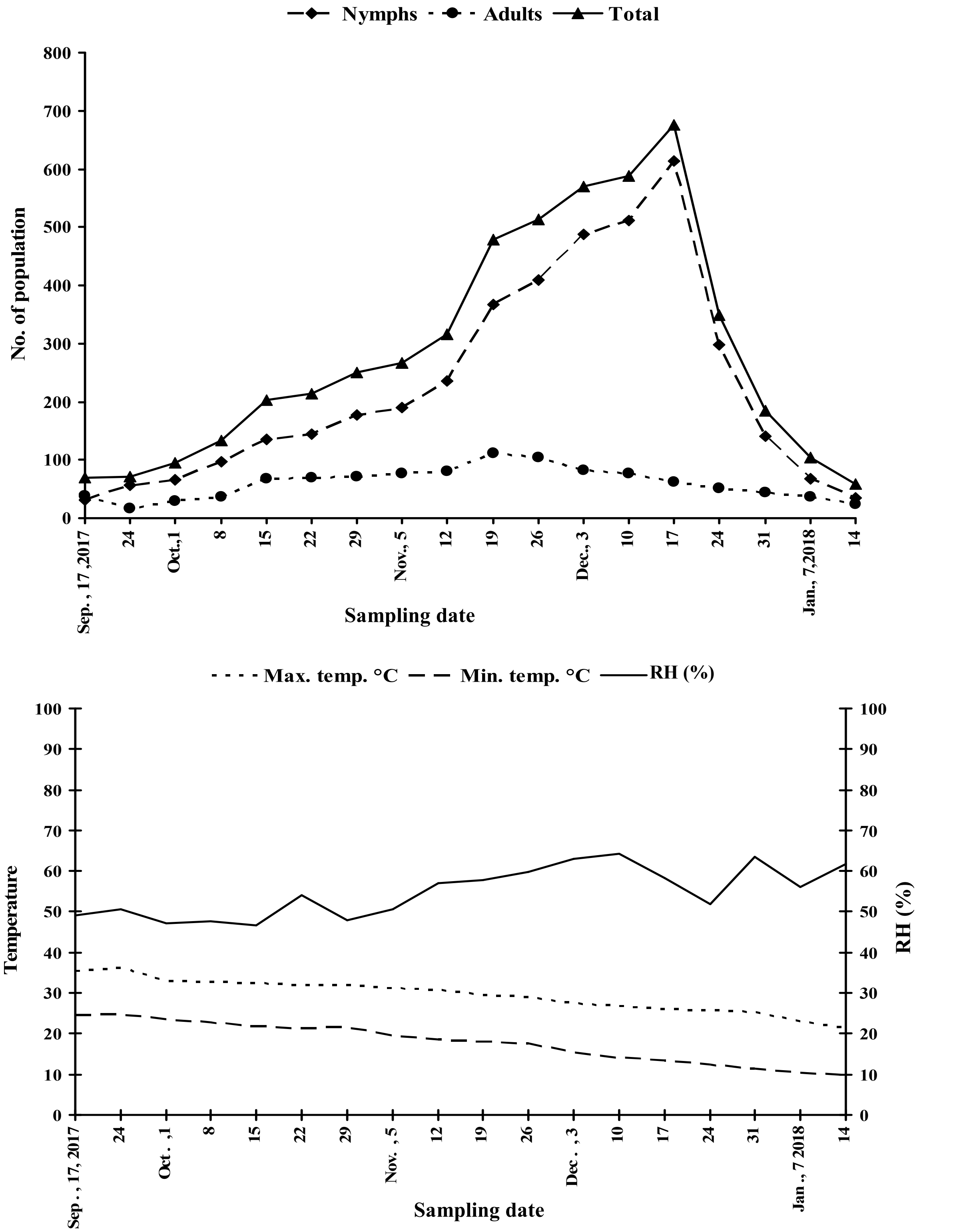


Fig. 4. Seasonal abundance of *Phenacoccus solenopsis* Tensily infesting green bean plants in Atfih (Giza) during nili season 2017

Natural Enemies

During this study three parasitoids and four predators species were recorded. The parasitoids were *A. arizonensis*, *A. pseudococci* and *A. gutierreziae*. All previously mentioned species are solitary endoparasitoids. The predacious species were *S. syriacus*, *C. undecimpunctata*, *C. carnea* and *O. laevigatus*.

As shown in Tables 5 and 6 during the first and second seasons 2016 and 2017 *A. arizonensis* recorded the highest number on the 12th of November (22 individuals/ sample) and the 5th of November (9 individuals/ sample), successively. While, *A. Pesudococci* reached the highest number in the 26th of November (5 and 9 individuals/sample) during the first and second seasons 2016 and 2017, respectively. *A. gutierreziae* appeared in rare individuals in all samples during the study course.

Chrysoperla carnea was the most abundant predator during the study period followed by *C. undecimpunctata* and *O. laevigatus*. But *S. syriacus* appeared in a few numbers all over the study period. During the first and second seasons 2016 and 2017 *C. carnea* recorded the highest number on the 10th of December (16 and 13 individuals / sample) during the first and second seasons 2016 and 2017, successively. While, *C. undecimpunctata* reached the highest number on the 26th of November (9 individuals / sample) and on the 3rd of December (6 individuals / sample), respectively. *O. laevigatus* occurred at the highest number on the 3rd of December (6 individuals / sample) during the first season 2016. While, during the second one *O. laevigatus* reached the highest number on the 19th of November (4 individuals / sample) and on the 3rd of December (4 individuals / sample).

These results were in agreement with those obtained by **Khan *et al.* (2012)** who stated that *C. carnea* and *Cryptolaemus montrouzieri* predators showed strong predatory potential against *P. solenopsis*, being the most ravenous feeder.

Efficacy of Some Insecticides Against the Cotton Mealybug and its Natural Enemies on the Cotton Mealybug, *Phenacoccus solenopsis*

Eight insecticides from different chemical groups as foliar treatment applications were evaluated against the cotton mealybug *P. solenopsis* and its natural enemies under field conditions of summer seasons during 2016 and 2017 on green bean plantation at Atfih district Giza Governorate. Results presented in Tables 7 and 8 summarize the effects of the evaluated insecticides. It is obvious that during the first and second seasons (2016 and 2017) malathion, imidacloprid and thiamethoxam induced a fast, initial effect after 7 days of application against the cotton mealybug population. The reduction in the population was 91.10 and 84.77, 85.51 and 83.99 and 82.23 and 81.25%, respectively. Followed by mineral oil, chlorpyrifos and buprofezin with values of 81.14, 80.05 and 71.62, consecutively during the first season, while during the second one chlorpyrifos, mineral oil and buprofezin showed varied percentage of initial reduction with values of 80.77, 75.91 and 66.89%, consecutively. Finally lufenuron and deltamethrin showed the lowest initial effect percentage of reduction after 7 days of application during the first and second seasons where the reduction were 65.70 and 65.57 as well as 62.08 and 61.71%, successively. The residual effect extended up to 21 days after initial application against the cotton mealybug population the reduction in the population during the first seasons (2016) was recorded with imidacloprid followed by thiamethoxam, chlorpyrifos, malathion, mineral oil, buprofezin, deltamethrin and lufenuron with values of 94.11, 93.89, 91.15, 90.36, 84.76, 84.45, 82.30 and 77.43%, respectively. While, during the second season (2017) the highest reduction in the population was recorded with imidacloprid followed by thiamethoxam, malathion, chlorpyrifos, mineral oil, buprofezin, lufenuron and deltamethrin with values of 92.22, 88.11, 87.99, 84.26, 81.10, 74.20, 73.69 and 69.27, consecutively. The mean population reductions of the cotton mealybugs after different insecticide treatments on green bean plants during two growing summer seasons (2016 and 2017) showed that imidacloprid was the most effective insecticide causing 90.71 and 88.14%, consecutively, followed by malathion, thiamethoxam, chlorpyrifos, mineral oil, buprofezin, lufenuron and deltamethrin with values of 88.90, 86.24; 88.69, 85.82 ; 85.49, 83.09 ; 82.35, 79.37; 78.45, 71.76 ; 72.24, 70.98 and 71.94, 60.75%, successively.

These results were in agreement with those obtained by **Mamoon-ur-Rashid *et al.* (2011),**

Table 5. Seasonal abundance of natural enemies associated with *Phenacoccus solenopsis* Tinsley infesting green beans plants in Atfih (Giza) during nili season 2016

Sampling date	Total number of *P. solenopsis*	No. of parasitoids			No. of predators			
		A. arizonensis	*A. pseudococci*	*A. gutierreziae*	*S. syriacus*	*C. carnea*	*C. undecimpunctata*	*O. laevigatus*
Sep., 17, 2016	68	0	0	0	0	0	0	0
24	71	0	0	0	0	0	0	0
Oct., 1	94	1	0	0	0	0	0	0
8	182	3	0	0	0	0	0	0
15	219	9	0	0	0	0	0	0
22	247	10	1	0	0	5	0	0
29	264	16	1	0	0	6	0	0
Nov., 5	331	19	2	0	0	7	3	0
12	531	22	2	0	1	10	4	0
19	567	18	4	0	1	12	7	1
26	600	15	5	0	0	13	9	1
Dec., 3	647	13	3	0	0	15	8	6
10	644	11	1	0	0	16	1	5
17	614	8	1	1	1	10	1	2
24	383	4	0	1	3	7	1	1
31	188	1	0	0	0	2	0	1
Jan., 7, 2017	72	1	0	0	0	1	0	0
14	45	1	0	0	0	0	0	0
Total	**5767**	**152**	**20**	**2**	**6**	**104**	**34**	**17**
Mean	**320.39**	**8.44**	**1.11**	**0.11**	**0.33**	**5.78**	**1.89**	**0.94**

Table 6. Seasonal abundance of natural enemies associated with *Phenacoccus solenopsis* Tinsley infesting green beans plants in Atfih (Giza) during Nili season 2017

Sampling date	Total number of *P. solenopsis*	No. of parasitoids			No. of predators			
		A. arizonensis	*A. pseudococci*	*A. gutierreziae*	*S. syriacus*	*C. carena*	*C. undecimpunctata*	*O. laevigatus*
Sep., 17, 2017	69	0	0	0	0	0	0	0
24	72	0	0	0	0	0	0	0
Oct., 1	95	0	0	0	0	0	0	0
8	133	2	0	0	0	0	0	0
15	203	2	0	0	0	0	0	0
22	213	3	0	0	0	3	0	0
29	250	7	0	0	0	5	0	0
Nov., 5	266	9	1	0	0	2	1	0
12	316	6	3	0	2	7	2	1
19	479	5	6	0	4	9	3	4
26	514	3	9	0	1	10	5	3
Dec., 3	570	3	4	1	1	11	6	4
10	588	1	2	1	0	13	1	2
17	676	0	1	2	0	8	1	1
24	349	0	1	1	0	6	0	1
31	184	0	0	1	0	1	0	1
Jan., 7, 2018	104	0	0	0	0	1	0	0
14	58	0	0	0	0	0	0	0
Total	**5139**	**41**	**27**	**6**	**8**	**76**	**19**	**17**
Mean	**285.50**	**2.28**	**1.50**	**0.33**	**0.44**	**4.22**	**1.06**	**0.94**

Table 7. Impact of different insecticides against the cotton mealybug, *P. solenopsis* and its associated natural enemies on green bean plants in Atfih (Giza) during summer season 2016

Treatment	Days after post treatment and reduction percentages											
	P. solenopsis				Parasitiods				Predators			
	7 days	14 days	21 days	Mean	7 days	14 days	21 days	Mean	7 days	14 days	21 days	Mean
Mineral oil	81.14	81.14	84.76	82.35c	76.69	78.45	76.79	77.31d	73.82	71.96	74.11	73.30e
Iufenuron	65.7	73.60	77.43	72.24e	75.71	78.95	73.12	75.92ed	74.64	74.64	70.74	73.34e
Chlorpyrifos	80.05	85.26	91.15	85.49b	82.91	83.54	81.09	82.51c	75.69	79.17	80.77	78.54d
Malathion	91.10	85.24	90.36	88.90a	88.17	89.74	90.18	89.36a	88.33	88.33	89.23	88.63b
Deltamethrin	62.08	71.43	82.30	71.94e	78.02	71.43	72.64	74.03fe	75.69	81.77	83.17	80.21d
Buprofezin	71.62	79.28	84.45	78.45d	69.70	75.76	72.92	72.79f	67.59	72.99	70.09	70.22f
Thiamethoxam	82.23	89.94	93.89	88.69a	85.11	85.66	89.02	86.59b	81.48	86.11	80.77	82.79c
Imidacloprid	85.51	92.50	94.11	90.71a	90.10	89.54	92.49	90.71a	88.78	94.39	89.64	90.94a
Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LSD	3.02				2.25				2.21			
f	50.61				62.08				72.77			

Table 8. Impact of different insecticides against the cotton mealybug, *P. solenopsis* and its associated natural enemies on green bean plants in Atfih (Giza) during summer season 2017

Treatment	Days after post treatment and reduction percentages											
	P. solenopsis				Parasitiods				Predators			
	7 days	14 days	21 days	Mean	7 days	14 days	21 days	Mean	7 days	14 days	21 days	Mean
Mineral oil	75.91	81.1	81.1	74.37^{c}	77.22	82.92	88.12	82.75^{c}	80.39	84.13	85.51	83.34^{c}
Iufenuron	65.57	73.69	73.69	70.98^{d}	68.94	70.88	79.74	73.19^{e}	67.65	76.19	72.83	72.22d^{e}
Chlorpyrifos	80.77	84.26	84.26	83.09^{b}	82.02	86.51	90.62	86.38^{b}	83.46	88.1	91.85	87.80^{b}
Malathion	84.01	87.99	87.99	86.24^{a}	89.95	92.46	94.76	92.39^{a}	90.71	92.48	89.7	90.96^{a}
Deltamethrin	61.71	69.27	69.27	60.75^{e}	69.85	71.53	80.19	73.85^{e}	64.71	64.29	80.43	69.81^{e}
Buprofezin	66.89	74.2	74.2	71.76^{d}	79.9	70.59	74.2	74.89^{d}	70.59	76.19	72.83	73.20^{d}
Thiamethoxam	81.25	88.11	88.11	85.82^{a}	91.01	93.26	90.62	91.63^{a}	88.97	92.86	91.85	91.23^{a}
Imidacloprid	83.99	90.22	90.22	88.14^{a}	85.14	94.43	96.12	91.89^{a}	90.2	94.44	92.75	92.46^{a}
Control	0.00	0.00	0.00	0.00^{g}	0.00	0.00	0.00	0.00^{g}	0.00	0.00	0.00	0.00 ^{g}
LSD	1.92				2.63				3.05			
f	144.31				63.93				63.93			

Ashiq *et al*. (2015) and Rezk *et al*. (2019) who stated that imidacloprid, thiamethoxam and malathion proved to be the best products after 5 and 7 days of application against mealybug.

Impact on the Natural Enemies

Results presented in Tables 7 and 8 indicate that there are significant differences among all treatments in parasitoids reduced percentages after insecticides application. During the first season (2016) imidacloprid was the most toxic insecticide against parasitoids where the percentage of reduction was 90.71% followed by malathion, thiamethoxam, chlorpyrifos, mineral oil, lufenuron, deltamethrin and buprofezin with values of 89.36, 86.59, 82.51, 77.31, 75.92, 74.03 and 72.79%, successively. While, during the second season (2017) Malathion was the most toxic insecticide against parasitoids where the percentage of reduction was 92.39% followed by imidacloprid, thiamethoxam, chlorpyrifos, mineral oil, buprofezin, deltamethrin and lufenuron where the percentages of reduction were 91.89, 91.63, 86.38, 82.75, 74.89, 73.85 and 73.19%, consecutively. Similar results were reported by **(Aheer *et al.*, 2009; Mamoon-ur-Rashid *et al.*, 2011)** who mentioned that all tested insecticides proved to be significantly effective against mealybug up to 7 days after treatment. The use of synthetic insecticides is extremely toxic to natural enemies of mealybugs. Results tabulated in Tables 7 and 8 clear that there were significant differences among all treatments in predators reduced percentages after insecticides application. During the first season (2016) imidacloprid was the most toxic insecticide against predators where the percentage of reduction was 90.94% followed by malathion, thiamethoxam, deltamethrin, chlorpyrifos, lufenuron, mineral oil and buprofezin with values of 88.63, 82.79, 80.21, 78.54, 73.34, 73.30 and 70.22%, successively. During the second season 2017 also imidacloprid was the most toxic insecticide against predators where the percentage of reduction was 92.46% followed by thiamethoxam, malathion, chlorpyrifos, mineral oil, buprofezin, lufenuron and deltamethrin with values of 91.23, 90.96, 87.80, 83.34, 73.20, 72.22 and 69.81%, respectively. In that year, there was insignificant difference among imidacloprid, thiamethoxam and malathion, Likewise, there were insignificant differences between treatments of buprofezin and lufenuron with LSD = 3.05 at ($P \leq 0.05$).

The cotton mealybug, *P. solenopsis* (Tinsley) (Hemiptera: Pseudococcidae), has become a widespread pest causing serious losses in several economically important crops, particularly cotton (**Rezk *et al.*, 2019**). The use of agrochemicals particularly pesticides, can hamper the effectiveness of natural enemies, causing disruption in the ecosystem service of biological control. Malathion, imidacloprid, thiamethoxam, chlorpyrifos, deltamethrin, buprofezin, lufenuron and mineral oil, these products that are registered for use in green bean and other vegetables against several pests. These results were in agreement with those obtained by **Mamoon-ur-Rashid *et al.* (2011) and Karmakar and Shera (2017)** who disclosed that, the use of synthetic insecticides is extremely toxic to predators such as *C. carnea, Hippodemia convergens, Coccinella septempunctata* L., *Brumus saturalus* and *C. montrouzieri* of mealybugs. Imidacloprid was found comparatively the most toxic to the activities of predator, *C. carnea* up to 10 days after application of insecticides. Also, mentioned that buprofezin insecticide may be preferred as first spray to other recommended insecticides for the control of mealybug to conserve the natural enemies in cotton ecosystem.

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رصد وإدارة حشرة بق القطن الدقيقى *Phenacoccus solenopsis* Tinsley وأعدائها الطبيعية المرتبطة بها على نباتات الفاصوليا الخضراء

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أجريت دراسات حقلية على حشرة بق القطن الدقيقي، *Phenacoccus solenopsis* Tinsley Hemiptera: Sternorrhyncha: Coccoidea: Pseudococcidae) التي تصيب نباتات الفاصوليا الخضراء في منطقة أطفيح بمحافظة الجيزة خلال موسمين متتاليين خلال العروتين الصيفى والنيلى موسمى ٢٠١٦ و ٢٠١٧، تم دراسة تأثيرات بعض عوامل المناخ على كثافة التعداد وفترات النشاط لحشرة *P. solenopsis* وأعدائها الطبيعية المرتبطة بها، أوضحت النتائج المتحصل عليها أن *P. solenopsis* فى المواسم الصيفية، سجل لها قمة موسمية واحدة في ٣ يوليو خلال الموسمين الأول والثاني (٢٠١٦ و ٢٠١٧)، على التوالي، بينما في المواسم النيليّة، سجلت الحشرة قمة موسمية واحدة في ٣ و ١٧ ديسمبر، خلال الموسمين الأول والثاني (٢٠١٦ و ٢٠١٧)، على التوالي، أظهرت عوامل المناخ المتمثلة في درجة حرارة الهواء القصوى والدنيا ونسبة الرطوبة النسبية علاقة معنوية موجبة مع حشرة بق القطن الدقيقي. خلال هذه الدراسة تم تسجيل ثلاثة طفيليات وأربعة أنواع مفترسة، الطفيليات التى سجلت *Aenasius arizonensis* (Girault)، *Anagyrus pseudococci* (Girault) و *Acerophagus gutierreziae* Timberlake (Encyrtidae). ، بينما المفترسات التى سجلت *Scymnus syriacus* Mars., *Coccinella undecimpunctata* (L.) (Coleoptera:Coccinellidae), *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) and *Orius laevigatus* (Fiber.) (Hemiptera: Anthocoridae). في محاولة للسيطرة على هذه الآفة الحشرية، تم تقييم ثمانية مبيدات حشرية mineral oil، lufenuron، chlorpyrifos، malathion، deltamethrin، buprofezin، thiamethoxam و imidacloprid على حشرة *P. solenopsis* وأعدائها الطبيعية تحت الظروف الحقلية على نباتات الفاصوليا الخضراء، أوضحت النتائج التي تم الحصول عليها أن إيميداكلوبريد كان أعلى فعالية ضد *P. solenopsis* مسجلاً انخفاضًا بنسبة ٩٠,٧١-٨٩,١٧% في عدد الحشرات بعد ٢١ يومًا من الاستخدام، إيميداكلوبريد سجل أعلى تأثير ضد الطفيليات والمفترسات المرتبطة بحشرة بق القطن الدقيقي، أوضحت النتائج أيضًا أن مبيدى منظمات النمو الحشرية (buprofezin و lufenuron) أكثر أمانًا للأعداء الطبيعية من المبيدات المختبرة الأخرى.

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