Acta
Entomology and Zoology

E-ISSN: 2708-0021
P-ISSN: 2708-0013
www.actajournal.com
AEZ 2024; 5(2): 58-63
Received: 02-06-2024
Accepted: 08-07-2024

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Impact of insecticides applied in cotton fields on some piercing-sucking insects, pink bollworm, associated predators and *Bemisia tabaci* parasitoids

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DOI: https://doi.org/10.33545/27080013.2024.v5.i2a.157

Abstract
Cotton, *Gossypium barbadense* L. is the most important and widely cultivated fiber crop in Egypt and allover the world. Unfortunately, this crop is subject to infestations of too many insect pests which result in considerable yield losses, particularly piercing-sucking insect pests and pink bollworm, *Pectinophora gossypiella*. This work was carried out at the experimental farm of Cotton Research Institute, located at Sakha Agricultural Research Station, during 2022 and 2023 seasons to assess the effect of periodical insecticide applications on infestations of aphids, leafhoppers, whitefly, pink bollworm, associated insect predators, as well as *Bemisia tabaci* parasitoids. Aphid population decreased by 83.12 - 84.82% due to insecticide treatments, leafhoppers and whitefly decreased by 50.44- 63.99% and 78.91% - 93.79%, respectively. The insect predatory populations were also negatively affected by the periodical applications of insecticides, with 49.12- 83.04%, 65.29 -71.16% and 23.12- 40.21% for *Orius* spp, coccinellids and *Chrysoperla* carnea. The seasonal bollworm infestations averaged 42.29% and 24.00% in the first season and 52.57 and 24.57% in the second season in untreated and treated cotton plots, respectively. The seasonal averages of parasitsm of *Bemisia tabaci* nymphs by *Eretmocerus mondus* and *Encarsia lutea* were 22.28 and 7.50% in the first season and 24.00 and 6.34% in the second season in the untreated and treated cotton fields, respectively. Data of the current research reveal the high hazards of periodical applications of insecticides against natural enemies prevailing in cotton fields. So, these synthetic insecticides should carefully be applied within the integrated pest management.

Keywords: Pesticides, cotton, sucking insects, *Pectinophora gossypiella*, natural enemies

Introduction

Cotton, *Gossypium barbadense I*. is the most important and widely cultivated fiber crop in Egypt and all over the world. The top five cotton producing countries are China, India, Brazil, USA and Pakistan, contributing with about 85.00% of total world production (FAOSTATS 2024) [8]. Egypt has been ranked, for several decades, as one of the top countries in producing the finest long staple cotton. Unfortunately, the cultivated cotton area decreased from 1.53 million faddans (hectare = 2.38 faddans) in 1971 to only 255,000 faddans in 2023 (MOALR, 2024) [14].

Cotton plants are subject to infestations of too many insect pests which result in considerable yield losses, particularly piercing-sucking insect pests and bollworm complex which account for a considerable yield loss up to about 36% (Bhute *et al*. 2023) [4]. *Aphis gossypii, Bemisia tabaci, Empoasca* spp, and *Pectinophora gossypiella, Nezara viridula and Tetranychus* spp.have been surveyed as major important insect pests attacking cotton plants throughout different developmental stages (Hegab *et al*. 2022) [11]. Most of piercing-sucking insects have several hosts other than cotton, which act as alternatives to these pests to ensure high reproduction at variable crop ecosystems (Srinivasan and Rajan 2021) [21]. *Pectinophora gossypiella* is a key pest damaging the cotton bolls, resulting in quantitative and qualitative yield losses.

The common way for controlling the abovementioned insect pests is the application of synthetic insecticides which quickly reduce the damage of insect pests, but the isect pest resurgence occurs, in the absence of negatively affected natural enemies. Meanwhile, the insecticides creat many problems, in terms of direct toxicity to biocontrol agents, pollinators, fishes, humans, pesticides resistance and increased environmental and soil risks (Srinivasan and Rajan 2021) [21].

Since the ecosystem of cotton plantations is a good environment for building up and development of biological control agents, the role of predators and parasitoids has been crucial to avoid excessive pesticidal applications (Govinden *et al.* 2013) [10]. Santos *et al.* (2017) [18] evaluated the impact of some insecticoides on the coccinellid, *Hippodamia convergens*. The insecticides chlorpyrifos, etofenprox, phosmet and imidacloprid adversely affected the population and biological parameters of this generalist predator, in most cases the larvae of the predator were completely killed. Sattar (2022) [19] tested the impact of *Chrysoperla carnea* card releases on some insect pests, and found that populations of aphids, jassids, thrips and whiteflies were reduced by 76, 86, 39 and 52%, respectively.

The objectives of the current research were to 1) evaluate impact of treating cotton plants with insecticides on the reductions of the populations of sucking pests, *Pectinophora gossypiella* and associated predators, and 2) assessment the reductions in *Bemisia tabaci* parasitism due to periodical field spraying with insecticides.

Materials and Methods

Experimental Site

This work was carried out at the experimental farm of Cotton Research Institute, located at Sakha Agricultural Research Station, during 2022 and 2023 cotton seasons.

Land Preparation and Sowing

The experimental field was ploughed three times, with incorporation of calcium superphosphate just before the last tillaage. Giza 94 cotton cultivar was sown by the second week of May in both seasons. All agricultural practices were followed as recommended, but without pesticidal applications, with the exception of insecticides recommended by the Central Administration of Pesticides, Ministry of Agriculture (Table 1). In such concern, periodical applications of pesticides were adopted in one half feddan cultivated with Giza 94 cultivar, compared to an area of 200 m² cultivated with the same variety, but left to natural inset infestation.

Sampling and Target Insects

About two months after cotton sowing, biweekly samples were taken from both untreated and treated cotton fields starting from July 30th up to October 28th to assess the infestations of piercing- sucking insects, as well as *Pectinophora gossypidla*. Also, the reduction in predatory insects, associated with the target insects, were calculated. In addition, the reductions in *Bemisia tabaci* parasitism (*Eretmocerus mundus* (Mercet), and *Encarsia lutea* (Masi)] due to insecticide applications were considered by sampling *B. tabaci* nymphs from insecticide-treated and untreated to cotton fields. Twenty-five cotton plants were visually examined in the field to record the numbers of nymphs and adults of each of aphids and leafhoppers, adults of of *Orius* spp and larvae of *Chrysoperla carnea.*Numbers of nymphs of *Bemisia tabaci* were counted in 50 in² (25 leaves x 2 in² each). Infestation by pink bollworm, *P. gossypiella* was assessed in100 bolls/sample.

Table 1: Sequence of pesticide application (as recommended by the central administration of pesticides, ministry of agriculture, Egypt

Compounds (م)	Common name	Trade name	Concentrations	Rate	Applications date
2022					
1	Pestban	Chlorpyrifos	48% EC	1L/fed.	26/6/2022
2	Durasil Ferari	Chlorpyrifos Lufenuron	48% EC 5% EC	1L/fed. 160 cm^3/fed.	7/7/2022
3	Andraws Ferari	Emamectinbenzoute Lufenuron	5.7% WG 5% EC	80 g/fed. 160 cm^3/fed.	15/7/2022
4	Durasil Caprice	Chlorpyrifos Chlorfluazuron	48% EC 5% EC	1L/fed. 400 cm^3/fed.	23/7/2022
5	Andraws Ferari	Emamectinbenzoute Lufenuron	5.7% WG 5% EC	80 g/fed. 160 cm^3/fed.	1/8/2022
6	Teliton Tabron	Profenofos Chlorfluazuron	72% EC 5% EC	750 cm/fed. 400 cm^3/Fed.	8/8/2022
7	Katron Caprice	Lambadacyhaluthrin Chlorfluazuron	5% EC 5% EC	375 cm^3/Fed. 400 cm^3/Fed.	15/8/2022
8	Proklem Mospilan Tabron	Emamectin benzoate Acetamiprid Chlorfluazuron	5%WG 20% SP 5% EC	50 g/fed 30 g/100L 400 cm^3/fed	21/8/2022
9	Super alpha Mospilan Caprice	Alpha-cypermethrin Acetamiprid Chlorfluazuron	10% EC 20% SP 5% EC	250 cm^3/fed 30 g/100L 400 cm^3/fed	1/9/2022
10	Teliton Mospilan Caprice	Profenofos Acetamiprid Chlorfluazuron	72% EC 20% SP 5% EC	750 cm/fed. 30 g/100L 400 cm^3/fed	11/9/2022
11	Katron Tabron	Lambadacyhaluthrin Chlorfluazuron	5% EC 5% EC	375 cm^3/Fed. 400 cm^3/fed	19/9/2022
12	Teliton	Profenofos	72% EC	750 cm/fed.	2/10/2022
2023					
1	Durasil Ferari	Chlorpyrifos Lufenuron	48% EC 5% EC	1L/fed. 160 cm^3/fed.	25/6/2023
2	Pestban Ferari	Chlorpyrifos Lufenuron	48% EC 5% EC	1L/fed. 160 cm^3/fed.	6/7/2023
3	Proklem Ferari	Emamectin benzoate Lufenuron	5%WG 5% EC	50 g/fed. 160 cm^3/fed.	19/7/2023
4	Durasil Match	Chlorpyrifos Lufenuron	48% EC 5% EC	1L/fed. 100 cm^3/fed.	1/8/2023
5	Pasha Match	Emamectin benzoate Lufenuron	5%WG 5% EC	50 g/fed. 100 cm^3/fed.	10/8/2023

6	Andraws Ferari Mospilan	Emamectinbenzoute Lufenuron Acetamiprid	5.7% WG 5% EC 20% SP	80 g/fed. 160 cm^3/fed. 30 g/100L	20/8/2023
7	Super alpha	Alpha-cypermethrin	10% EC	250 cm^3/fed	3/9/2023
8	Proklem Mospilan	Emamectin benzoate Acetamiprid	5%WG 20% SP	50 g/fed 30 g/100L	17/9/2023
9	Katron	Lambadacyhaluthrin	5% EC	375 cm^3/Fed.	24/9/2023
10	Andraws	Emamectinbenzoute	5.7% WG	80 g/fed.	5/10/2023
11	Teliton	Profenofos	72% EC	750 cm/fed.	14/10/2023
12	Proklem	Emamectin benzoate	5%WG	50 g/fed	26/10/2023

Assessment of *Pectinophora gossypiella* Infestation
Biweekly samples of cotton bolls were taken, beginning from July 30th up to October 28th to determine the percentage of boll infestation in treated and untreated cotton fields, with a sample of 100 bolls from each field. The bolls were considered infested in case of the presence of the pink bollworm larvae, or the incidence of bollworm infestation symptoms.

5. Assessment of *Bemisia tabaci* Nymphal Parasitism
Biweekly samples, each of 25 cotton leaves, infested with whitefly were collected. From each leaf, two square inches were examined to record the numbers of *B. tabaci* nymphs. The nymphs were confined in Petri dishes (as 20 nymphs/ dish, 9.cm diameter) till the emergence of parasitoids, or the appearance of *B. tabaci* adults. Thus, the percentage of parasitism was calculated

6. Statistical Analysis.
Standard errors were calculated for each insect pest and insect predator population fluctuation throughout the experimental duration. Correlation coefficient values were computed between insect predators and sucking insect pests. Abbott formula (1925) [2] was used to calculate reductions in insect populations due to insecticide applications.

Results and Discussion
1. Sequence of Applied Insecticides
Data in Table (1) present the sequences of insecticides applied in cotton fields at the experimental site; Sakha Agricultural Research Station in 2022 and 2023 cotton seasons. The listed insecticides (12 insecticides per season) were recommended by the Central Administration of Pesticides, Ministry of Agriculture, Egypt.

2. Reductions in Populations of Insect Pests and Associated Predators due to Insecticidal Applications
Data presented in Table (2) show the effect of insecticidal treatments on three piercing-sucking insects, as well as on three associated predators in 2022 Cotton season. Nymphs and adults of aphids averaged 536.67 individuals/25 untreated cotton plants compared to 81.43 individuals in treated cotton, indicating into 84.82% population reduction, due to insecticide application. Populations of leafhopper nymphs and adults averaged 161.43 and 80.00 individuals /25 cotton plants. In case of untreated and treated plants, respectively exhibiting 50.44%. Population reduction. Nymphs of *Bemisia tabaci* were counted per 50 in^2 in 25 cotton leaves untreated and treated with the recommended insecticides, with averages of 286.00 and 42.57 of individuals, respectively. Thus, the application of the recommended insecticides reduced *B.tabaci* eggs and nymphs by 93.79%.
These results are similar to those of Prasad (2002) [17] who obtained 47.6% reduction in aphid populations in cotton fields due to application of sulfoxaflor and 42.8% reduction due to spray with flonicamid. They added that flonicamid and sulfoxflor resulted in 61.0 and 50.8% reductions in jassid pupulations, respectively.

Table 2: Population dynamics of piercing-sucking insect pests and associated predators, on cotton plants (Giza 94 cultivar), at the experimental farm of Sakha Agricultural Research Station, 2022 season

Examination date	Per 25 plants				Per 50 in^2		Per 25 plants					
	Aphids (N+A)		Leafhoppers (N+A)		*Bemisia tabaci* (N)		Coccinellids (A)		*Orius* spp (N+A)		*Chrysoperla carnea* (L)	
	U	T	U	T	U	T	U	T	U	T	U	T
Jul 30	767	198	210	142	388	188	18	3	1	0	0	1
Aug 14	760	120	320	100	312	42	15	3	2	0	1	1
Aug 28	580	68	230	112	328	32	7	2	1	0	3	1
Sept 14	986	70	189	96	312	17	5	2	2	0	2	2
Sept 28	420	58	112	62	318	11	1	1	3	0	3	2
Oct 14	210	38	44	30	228	8	2	2	1	1	2	2
Oct 28	33	18	25	18	116	0	4	2	2	1	2	1
Average	536.57	81.43	161.43	80.00	286.00	42.57	7.42	2.14	1.71	0.29	1.86	1.43
+SE	127.31	22.81	40.18	17.04	33.38	24.84	2.48	0.26	0.29	0.18	0.40	0.20
Reduction %	84.82		50.44		93.79		71.16		83.04		23.12	

N: nymph A: adult L: larva

The mixture of lambada-cyhalothrin plus thiamethoxam reduced populations of *Bemisia tabaci* by 77.05% (Ismail *et al.* 2019) [12]. Lambada- cyhalothrin was one of the scheduled insecticide applied in the current research.
Data in Table (2) revealed that the insect predatory populations were negatively affected by the periodical applications of insecticides, with *Orius* spp being the highest reduced (83.04%), followed by the coccinellids (71.16%), while *Chrysoperla carnea* was the least impaired (23.12% population reduction). Arshad *et al.* (2019) [3] concluded that the botanical insecticide, *Azadirachta indica* was less harmful to predators associated so with sucking pests in cotton fields compared to bifenthrin insecticide. In addition, the cotton yield increased by 63.40% in case of

botanical insecticide over the check (untreated), while the synthetic insecticide enhanced the cotton yield by 58.80% over the check plots.

Data in Table (3) summarize the effect of application of synthetic insecticides on the populations of piercing - sucking insects and their related predators in 2023 cotton season. Aphid population was the highest to be reduced (83.12% reduction) due to periodical insecticide application, followed by *Bermisia tabaci* (78.91%), and then, leafhoppers (63.99% population reduction).

Concerning the predators, the coccinellid populations were reduced by 65.29%, followed by *Orius* spp (49.12%), while the population of *Chrysoperla carnea* larvae was reduced by 40.21%. Findings of Abd El-Hady *et al.* (2020) [1] clarified that both methomyl and chlorpyrifos were more effective, as initial kill, against aphid, whitefly and predators, but KZ-oil and abamectin were more effective against jassids and spider mites. In contrast, abamectin, protecto and Kz-oil were safer against associated predators as initial Kill. Chlorpyrifos was one of applied insecticides in the current experiment. Similarly, El-Dewy *et al.* (2018) [7] obtained less harmful effects of flonicamid, imidacloprid and dinotefuran against the populations of predators compared to organophosphates or carbosulfan. They concluded that the three former insecticides are a good option to control cotton pests, within the Integrated Pest Management (IPM) system.

Table 3: Population dynamics of piercing-sucking insect pests and associated predators, on cotton plants (Giza 94 cultivar), at the experimental farm of Sakha Agricultural Research Station, 2023 season

Examination date	Per 25 plants				Per 50 in^2		Per 25 plants					
	Aphids (N+A)		Leafhoppers (N+A)		*Bemisia tabaci* (N)		Coccinellids (A)		*Orius* spp (N+A)		*Chrysoperla carnea* (L)	
	U	T	U	T	U	T	U	T	U	T	U	T
Jul 30	820	240	322	150	406	247	13	2	0	0	5	1
Aug 14	640	110	240	112	398	65	10	0	0	0	4	1
Aug 28	721	82	260	86	360	72	6	2	1	1	2	1
Sept 14	560	59	210	92	387	52	5	2	0	0	2	1
Sept 28	410	48	189	30	311	19	8	3	1	1	3	5
Oct 14	320	32	115	25	186	3	5	5	1	0	2	3
Oct 28	56	12	94	20	123	0	2	3	1	0	2	0
Average	503.86	83.29	204.29	73.57	310.14	65.43	7.00	2.43	0.57	0.29	2.86	1.71
± SE	99.04	28.79	30.33	18.86	42.46	32.19	1.38	0.57	0.20	0.18	0.46	0.64
Reduction%	83.12		63.99		78.91		65.29		49.12		40.21	

N: nymph A: adult L: larva

As for the insecticides sequence, Hegab *et al.* (2022) [11] used the sequence of chlorpyrifos + chlorfluzeron. (First spray), lambada-cypermethrin (second) and chlorpyrifos (third spray) against piercing-sucking pests in cotton fields. Populations of five pests; *Aphis gossypii*, *Nezera viridula*, *Tetranychus* spp, *Bemisia tabaci* and *Empoasca* spp. were reduced by 90.65, 79.82, 71.52, 58.56 and 36.49%, respectively. Unfortunately, these pesticides reduced the population of *Chrysoperla* spp by about 53.72%. All insecticides, applied by the latter author were used in the current experiment, but the reductions of the target insect pests, in our experiment, were higher than the evaluations of Hegab *et al.* (2022) [11].

Correlation coefficient values between some piercing-sucking insect pests and associated predators in cotton fields: The Correlation coefficient values between some piercing-sucking insect pests and associated predators in cotton fields were computed (Table 4). The coccinellids positively correlated with each of aphids, leafhoppers and whitefly with either significant or highly significant values in 2022 and 2023 seasons. *Orius* spp correlated with insignificant negative values with the piercing-sucking insects in 2022 season, but correlated significantly with negative or positive values with these insects in 2023 season. *Chrysoperla carnea* correlated with insignificant negative values with the piercing-sucking insects in 2022 season, but correlated with significant positive values with each of aphids and leafhoppers in 2023 season. However, the correlation between *Chrysoperla carnea* and *B. tabaci* was insignificant positive in 23023 season.

Table 4: Correlation coefficient values between some piercing-sucking insect pests and associated predators in cotton fields (Giza 94 cultivar) at the experimental farm of Sakha Agricultural Research tation

Item	2022	2023
Coccinellids X Aphids	0.5486*	0.7819**
Coccinellids X Leafhoppers	0.7274**	0.8310**
Coccinellids X *Bemisia tabaci*	0.5430*	0.7394**
Orius spp X Aphids	-0.0418	-0.6050*
Orius spp X Leafhoppers	-0.1019	-0.6184*
Orius spp X *Bemisia tabaci*	-0.1348	0.7232*
Chrysoperla carnea X Aphids	-0.3506	0.5899*
Chrysoperla carnea X Leafhoppers	-0.3469	0.6996*
Chrysoperla carnea X *Bemisia tabaci*	-0.2754	0.1847

Cotton Boll Infestation by the Pink Bollworm as Influenced by Insecticidal Treatments

2022 Cotton Season: Cotton boll sampling, beginning from July 30th up to October 28th, revealed that *Pectionophora gossypiella* infestations were relatively low in both untreated and treated cotton up to mid-August (Table 5). In untreated cotton, the infestation became relatively higher (24.00%) by late August and formed a peak of 52.00% infested bolls by the second week of September. The second and highest peak of infested bolls (86.00% infestation) was attained by late October. In the insecticidal treated cotton, the first high boll infestation (32.00%) occurred by the third week of September, and abruptly increased by mid-and late-October with values of 56.00 and 64.00%, respectively. The seasonal boll infestations averaged 42.19±11:53% and 24.00± 0.14%. In utreated and treated Giza 94 cotton cultivar, respectively.

2023 Colton Season

By late July, the infestations in untreated cotton by the cotton bollworm, *P. gossypiell*a (Table 5) were relatively low (12.00%), increased gradually to record a sharp increase (80.00%) in September 28th. The infestation steadily increased towards the end of sampling duration to record 100.00% on October 28th. In the treated cotton plots, the first sample (on July 30th) was free from pink bollworm infestation, relatively increased to reach to 12.00% infestation on September 14th. However, the highest Infestations were recorded during October, with values of 56.00 and 88.00% on October 14th and 28th, respectively.

The seasonal average infestations of cotton bolls by *P. Gossypiella*, throughout 2023 season, were 52.75±14.54 in untreated cotton plots compared to 24.57±12.18% in treated ones.

Table 5: Percentages of cotton bolls infested with *Pectinophora gossypiella* as influenced by insecticidal treatments

Sampling date	2022 Season		2023 Season	
	Treated	Untreated	Treated	Untreated
Jul 30	4.00	8.00	0.00	12.00
Aug 14	0.00	8	4.00	12.00
Aug 28	4.00	24	8.00	32.00
Sept 14	8.00	52	12.00	36.00
Sept 28	32.00	46	4.00	80.00
Oct 14	56.00	72	56.00	96.00
Oct 28	64.00	86	88.00	100.00
Average	24.00	24.29	24.57	52.75
S.E.	24.00±01.14	42.19±11.53	24.57±12.18	52.75±14.54

Bhute *et al.* (2023) [4] reported that the cotton bollworms are widely distributed across the cotton growing regions of variable countries. In Egypt, it was found that the pink bollworm, *P. gossypiella* (Saunders) is the most destructive insect pest on cotton bolls (Gosh 2011) [9]. Patil (2003) estimated the losses in cotton due to bollworm infestations as 2.8-61.9%, in seed cotton yield, 2.1-47.1% in oil content and 10.7-59.2% in normal opening of bolls.

In the current study, the highest boll infestation by *P. gossypiella* occurred by late September and throughout October which is about five months after cotton sowing (conducted by the second week of May). This agrees with the results of Patil (2003) [16] who found that the insect infestation becomes effective at 100-110 days post-sowing of cotton, and forms the maximum infestations to the cotton bolls at the plant age of 140 days.

It is well-known that excess of insecticides is used to control cotton bollworms, particularly *P. gossypiella*. In such concern, El-Sayed *et al.* (2023) [6] obtained good results of insecticidal treatments by spraying profenofos, chlorpyrifos and alpha-cypermethrin. However, they indicated that the dramatic effect is the high hazard of the chemicals against predators; coccinellids and true spiders. Most of applied insecticides in cotton fields are highly toxic to most of predators prevailing cotton fields (Abd El-Hady *et al.* 2020) [1]. The latter author recommended using abamectin, protecto and K-Z oil as safer chemicals, as initial kill, on associated predators. Bhute *et al.* (2023) [4] indicated that since the *Bt* cotton has been introduced in some countries, several problems of lepidopteran insects have been solved. But, recently, the pink bollworm, *Pectinophora gossypiella* has developed resistance against *Bt* toxins.

***Bemisia tabaci* nymphal parasitism as influenced by insecticidal treatments**

Data in Table (6) show the negative effect of treating cotton fields by the insecticides on levels of *Bemisia tabaci* nymphal parasitism by each of *Eretmocerus mundus* and *Encarsia lutea.*

2022 Cotton Season

In untreated cotton, *B. tabaci* nymphal parasitism started with 9.09% on July 30th, and progressively increased to exhibit its peak (35.60% parasitism) on September 28th, and then, gradually decreased to 11.76% on October 28th. In the plots treated with insecticides, the parasitism was usually lower in all examinations compared to untreated plots, with small peaks of 10.00, 15.00 and 12.50% on August 14th September 14th and October 14th, respectively. Accordingly, the seasonal averages were 22.28 ± 4.09 and 7.50 ± 2.19 in the untreated and treated fields, respectively (Table 6)

Table 6: Percentages of *Bemisia tabaci* nymphal parasitism (*Eretmocerus mundus* and *Encarsia lutea*) as influenced by insecticidal treatments

Sampling date	2022 Season		2023 Season	
	Treated	Untreated	Treated	Untreated
Jul 30	0.00	9.09	0.00	10.00
Aug 14	10.00	13.63	13.30	27.63
Aug 28	8.33	29.34	11.11	39.45
Sept 14	15.00	35.60	20.00	33.33
Sept 28	6.66	32.92	0.00	29.47
Oct 14	12.50	23.63	0.00	15.62
Oct 28	0.00	11.76	0.00	12.50
Average	7.50	22.28	6.34	24.00
S.E.	2.19	4.09	3.16	4.27

4.2. 2023 Cotton Season

Parasitism of *Bemisia tabaci* nymphs by *E.mondus* and *E. lutea* began relatively low (10.00%) on July 30th, reached a high peak of 39.45% parasitism on August 28th, but gradually decreased to 12.50% by the last examination carried out on October 28th (Table 6).

In comparison, *B.tabaci* nymphs in treated cotton plants were free from the parasitoids on July 30th, September 28th, October 14th and October 28th. A peak of nymphal parasitism (20.00%) was detected on September 14th. As for the seasonal averages of parasitism, they were 24.00 ± 4.27 and 6.34 ± 3.16% in the untreated and treated fields, respectively.

Some of insecticides could be considered safe to the parasitoids of *Bemisia tabaci*. In this trend, Jones *et al.* (1995) [13] concluded that luprofezin was not toxic to any of the aphelinid parasitoids; *Eretmocerus* sp, *Eretmocerus mundus* Mercet, *Encarsia pergandiella* Howard and *Encarsia fermoz*a Gahan. The most tolerant parasitoid to the abovementioned insecticide was *E. mondus* which exceeded the survival of the three other parasitoids exposed to the insecticide by about 40%. However, three other insecticides; amitraz, thiodicarb and cypermethrin were toxic to the four aphelinid hymenopterous parasitoids. This result confirms partially the results of the current study, as cypermethrin was one of insecticidal complex sprayed in our experimental cotton field.

Also, chlorpyrifos was used in the current research in treated cotton fields, which is similar to the findings of Sharma *et al.* (2008) [20] who found that the same insecticide, and other synthetic ones, negatively affected the population of *Encarsia lutea* (Masi). Conservations of parasitoids of *B. tabaci* could be achieved using the botanical insecticide, nimbecidine and/or intercropping of cotton with seasame (Sharma *et al.* 2008) [20].

Mortalities of *B. tabaci* parasitoids; *Eretmocerus mondus* (Mercet), *E. eremicus* Rose and *Zolnerowich*, and *Encarsia fermosa* Ghan were less than 30%, when exposed to insect growth regulators (flufenoxuron and lufenuron) or *Bacillus thuringiensis* (Sugiyama *et al.* 2011) [22]. In contrast, the parasitoids suffered higher mortalities with the applications of neucnicotinoids (acetamiprid, clothianidin, dinotefuran, imidacloprid and nitenpyram), synthetic pyrethroids, organophosphates, emamectin benzoate, spinosad and tolfenpy. In the current study, some of the abovementioned insecticides were applied in cotton fields, such as acetamiprid, and emamectin benzoate.

In the study of De Oliveira *et al.* (2019) [5], both thiamethoxam and Imidacloprid were safe to *Encarsia hispida* pupal stage, but harmful to the parasitoid adult stage. By contract, both deltamethrin and pirypoxyfen were harmful to both pupal and adult stages of *E. hispida***.** To avoid the highly toxic effects of synthetic pesticides against *B. tabaci* parasitoids, Naranjo *et al.* (2004) [15] recommended using insect growth regulators (IGRS) to control major insect pests in cotton fields, meanwhile conserve the *B. tabaci* parasitoids; *Eretmocerus eremicus* Rose and Zolnerowich and *Encarsia* spp. Thus, the use of IGRS could be incorporated into the integrated pest management (IPM) system in cotton production operation.

References

1. Abd El-Hady AAA, El-Din Shaheen FAH, Saleh AA, Hamid AM. Comparative efficiency of certain products against some piercing-sucking pests and their associated predators on cotton plants. Journal of Plant Protection and Pathology, Mansoura Univ. 2020;11(2):153-159.
2. Abbott WS. A method of computing the effectiveness of an insecticide. J Econ Entomol. 1925;18:265-267.
3. Arshad M, Ullah MI, Cagtay NS, Abdullah A, Dikmen F, Kaya C, Khan RR. Field evaluation of water plant extracts on sucking insect pests and their associated predators in transgenic Bt cotton. Egyptian Transgenic Journal of Biological Pest Control. 2019;29:39.
4. Bhute NK, Patil CS, Deshmukh KV, Wagh RS, Medhe NK. Pink bollworm, *Pectinophora gossypiella* (Saunders) a destructive pest of cotton: A review. The Pharma Innovation Journal. 2023;12(3):2036-2042.
5. De Oliveira R, De Souza MDS, Vunes GDS, Batista JDL, De Brito CH. Selectivity of insecticides to *Encarsia hispida* (Hymenoptera: Aphelinidae). Rev Caatinga, Mossoro. 2019;32(2):312-317.
6. El-Sayed AA, Amer AEA, Abd-El Azeem EM. Effect of some insecticides on pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) associated predators in cotton field and some of their biochemical effects. Journal of Plant Protection and Pathology. 2020;11(2):147-151.
7. El-Dewy M, Sadek A, El-Sarand ES. Impact of synthetic insecticides against *Aphis gossypii* Glover, *Bemisia tabaci* (Genn.) and their associated predators on cotton plants. Alexandria Science Exchange Journal. 2018;19(4):669-675.
8. FAOSTAT. Statistics of Food and Agriculture Organization, for 2023; c2024.
9. Gosh SK. GM Crops: Rationally irresistible. Curr Sci. 2001;6:655-660.
10. Govindan K, Gunesekaran K, Kuttalam S. Emamectin benzoate 5 SG. A safer insecticide to coccinellids predators in cotton ecosystem. African Journal of Agricultural Research. 2013;8(2):2455-2460.
11. Hegab MEMA, Zaki AAT, El-Sayed AA, Amer AA. Impact of certain insecticides against pink bollworm, *Pectinophora gossypiella*, sucking pests and their associated predators in cotton fields. Syrian Journal of Agricultural Research, 2022, 9(5).
12. Ismail SM, Hafez SS, El-Malla MA. Effectiveness of certain insecticides on some sucking-piercing insects inhabiting cotton plants. Egypt J Plant Prot Res. 2019;7(3):50-58.
13. Jones WA, Wolfenbarger DA, Kirk AA. Response of adult parasitoids of *Bemisia tabaci* (Hom: Aleyrodidae) to leaf residues of selected cotton insecticides. Entomophaga. 1995;40(2):153-162.
14. MOALR. Statistics of Ministry of Agriculture and Land Reclamation of Egypt, for 2023; c2024.
15. Naranjo SE, Ellsworth PC, Hagler JR. Conservation of natural enemies in cotton: role of insect growth regulators in management of *Bemisia tabaci*. Biological Control. 2004;30(1):52-72.
16. Patil SB. Studies on management of cotton pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae). Ph. D. Thesis (unpublished) submitted to University of Agricultural Sciences, Dhatu Dahrwad (India); c2003.
17. Prasad BR. Bio-efficacy of sulfoxaflor and other insecticides against sucking pests of cotton. International Journal of Bioresource and Stress Management. 2022;13(6):535-542.
18. Santos KFA, Zandari OZ, de Morais MR, Jacob CRO, de Oliveira MB, Yamamoto PT. The impact of six insecticides commonly used in control of agricultural pests on the generalist predator, *Hippodamia convergens* (Coleoptera: Coccinellidae). Chemosphere. 2017;186:218-226.
19. Sattar M. Field release performance of *Chrysoperla carnea* for population management of sucking insect pests of cotton. Journal of Nanoscope (IN). 2022;3(1):69-83.
20. Sharma SS, Saini RK, Ram RP. Effect of insecticides on parasitism of white fly, *Bemisia tabaci* (Gennadius) and aphid, *Aphis gossypii* Glover on cotton. Journal of Cotton Research and Development. 2008;22(1):97-100.
21. Srinivasan R, Rajan MR. Effect of selected neonicotinoids on predatory coccinellids in Bt cotton systems. Journal of Biological Control. 2021;35(4):247-254.
22. Sugiyama K, Katayama H, Saito T. Effect of insecticides on the mortalities of three whitefly parasitoid species, *Eretmocerus mundus*, *Eretmocerus eremicus* and *Encarsia formosa* (Hymenoptera: Aphelinidae). Applied Entomology and Zoology. 2011;46:3.