



Potency of entomopathogenic fungi, as biocontrol agents on *Phenacoccus solenopsis* (Tinsley) and *Icerya seychellarum* (Westwood) at northern delta Egypt

M M Ismael¹, Abdel-Raheem M A^{2*}, Wafaa M M EL-Baradei³, Huda I Abdel-Aliem¹

¹ Department of Biological Control Research, Plant Protection Research Institute, Agricultural Research Center, Egypt

² Department of Pests & Plant Protection, Agricultural and Biological Research Institute, National Research Centre, Dokki, Giza, Egypt

³ Department of Scale Insect and Mealybugs, Plant protection Research Institute, Agric. Res. Center, Dokki, Giza, Egypt

Abstract

Background: *Phenacoccus solenopsis* (Tinsley) and *Icerya seychellarum* (Westwood) are the most important sucking insect attack several important economic crops around the world. Also, it secretes what is known as honeydew on the surfaces of the infested leaves of plants, which provides a fertile medium for the growth of black rot fungi that hinders the photosynthesis of these plants. Finally, the infestation by these species leads to losses in both quantity and quality of the crop.

Materials: These compounds were (Biosect (3.2×10^6 spores/mg) and Biover (3.2×10^4 spores/mg)), the two compounds contain *Beauveria bassiana* (Balasamo). Also used Silica gel where add Biosect with Silica gel ratio (2:1 & 1:1), Biosect: Silica gel. The concentrations used were 3.2×10^4 , 3.2×10^5 and 3.2×10^6 spores/mg of Biosect and add silica gel by ratio 2: 1 and 1:1 Biosect: Silica gel from concentration 3.2×10^6 . The concentrations used were 3.2×10^2 , 3.2×10^3 and 3.2×10^4 spores/mg of Biover.

Results: that efficiency of tested Entomopathogenic fungi against *Phenacoccus solenopsis* nymphs and adults under laboratory conditions: In nymphs % mortality ranging between 26.22 - 80 %. In adults and Percent mortality ranging between 6.66 % to 96.66 % at the concentration (3.2×10^4 spores/ ml.) of Biosect. In nymphs Percent mortality ranging between 10 – 97.0 %. In adults Percent mortality ranging between 35.22 - 100% at the concentration (3.2×10^4 spores/ ml.) of Biover. Also, at the concentration (3.2×10^4 spores/ ml.) of Biosect + Silica, % mortality of nymphs ranging between 55.22 - 100 % and in adults % mortality was 46.66 -100%. While on *Icerya Seychellarum* nymphs and adults under laboratory conditions. In nymphs % mortality ranging between 10.0 - 76.9%. In adults Percent mortality ranging between 3.22 - 66.88 % at the concentration (3.2×10^4 spores/ ml.) of Biosect, in nymphs Percent mortality ranging between 9.44 - 100 %. In adults Percent mortality ranging between 9.44- 95.0 % at the same concentration of Biover and in nymphs % mortality ranging between 29.0 - 100 %. In adults % mortality was 15.44 - 100% at the concentration (3.2×10^4 spores/ ml.) of F.+ Silica. During okra season 2022, Biosect+ Silica gel (1:1) was the most potent compound in reducing the population density of the *P. solenopsis* nymph and adult after three days (84.38 and 100% reductions of nymph and adult, respectively), after 7 days, the reductions were 93.07 and 100% with an average of 95.53% and provided an overall average of 91.74%. Biover (3.2×10^4 spores/mg) were the least effective compounds, where overall average reduction ratios were 75.90 %.

Keywords: potency, entomopathogenic fungi, *Icerya seychellarum*, *Phenacoccus solenopsis*

Introduction

Okra, *Abelmoschus esculentus* (Linn.) Moench, also known as lady's finger (family: Malvaceae), is one of the most important economical and high-income vegetables for farmers around the world. It is a rich source of fiber, ascorbic acid, and antioxidants. Okra is also an important source of potassium, phosphorus, and calcium [1]. *Phenacoccus solenopsis* Tinsley is one of the most important sucking insect pests that attack several important economic crops around the world. Also, the cotton mealybug secretes what is known as honeydew on the surfaces of the infested leaves of plants, which provides a fertile medium for the growth of black rot fungi that hinders the photosynthesis of these plants. It has been infested from 175 host plant species in 45 families, and from 26 countries in different ecological zones [2]. It causes damage by depleting the sap from all plant parts such as feeders on roots, root crowns, stems, twigs, leaves, flowers, and fruits. Also, *P. Solenopsis* sucks large quantity of the plant sap from stems and leaves it causes weakening and death the

susceptible plants and indirectly damage by transmission plant diseases, which leads to a loss in yield in terms of quantity and quality [3, 4]. This pest spread rapidly on different host plants to the extent that recorded it on 29 host plant species belonging to 16 plant families including field crops (3), vegetables (3), ornamentals (7), weeds (13) and fruits (3) [5]. Also, this insect pest was recorded for the first time in Egypt on weed plants by [6]. In Egypt, *P. solenopsis* was recorded for the first time on the okra plants at the inception during the summer season [7]. The Cotton mealybug, *P. solenopsis* has a new distribution and attack important host plants such as cotton, ornamental plants, eggplants, okra, and certain weeds [8]. The population density of *P. solenopsis* recorded the highest peaks of abundance on okra plants throughout its growth period [9]. The cotton mealybug, *P. solenopsis* affected the life cycle by different host plants and the fecundity was significantly affected by different host plants. Also, the insect pest recorded on the cotton plants, tomato, potato, and squash plants. Awadalla *et al.*, [10, 11]; Ata [12]. In Egypt, guava

Psidium gajava L. is attacking by several species of mealybugs (Hemiptera: Margarodidae) that finally the infestation by these species leads to losses in both quantity and quality of the crop [13, 14]. One of the most harmful species of mealybugs that attack guava trees in Egypt is the seychellarum mealybug, *Icerya seychellarum* (Westwood) [15]. Pests infest citrus trees in diverse ways. The cottony cushion scale is one of the most damaging citrus pests [16]. This pest is a very polyphagous insect pest that feeds on 123 different plant species from 49 different plant families [17]. Biological control involving entomopathogenic fungi played an important role in control mealybug pests of economically important crops. There is an immediate need to develop economically feasible and viable integrated pest management approach to combat the insect pests. Management of cotton mealybug chemically is difficult due to its wide host range, presence of waxy coating on the body and high reproductive potential. But the crawler stage is the most fragile and easily controllable stage in its life history. Recently Bio-pesticides have been recommended for the control of *P. solenopsis* and *I. seychellarum* [18, 19]. Biological control of insect pests using different entomopathogenic microorganisms is gaining importance due to their target specificity, self-perpetuity, and obvious safety to the environment. The pest control prospects chiefly of entomopathogenic fungi, *Metarhizium anisopliae* and *Beauveria bassiana* have been proved beyond doubt over the decades. [1, 20, 21].

This study was conducted with the aim to evaluate the efficiency of some different entomopathogenic fungi against cotton mealybug *P. solenopsis* on okra plants and *I. seychellarum* on guava trees under laboratory and field conditions.

Materials and methods

Experimental design

Entomopathogenic fungi test against *Phenacoccus solenopsis* Tinsley and *Icerya seychellarum* (Westwood) under laboratory conditions

Insects

Cotton mealybug, *P. solenopsis* collected from infected okra plants. and the seychellarum mealybug, *I. seychellarum* was collected on guava trees in Sakha, Kafr-El sheikh Governorate, Egypt during the 2022 season.

Bioassay

Evaluation of the effectiveness of two microbial compounds against cotton mealybug, *P. solenopsis* (nymphs and adults) on okra and *I. seychellarum* (nymphs and adults) on guava plants and under laboratory conditions of 25 ± 2 °C, 85 ± 5 RH and a 13:11 (L:D) photoperiod. Also, these compounds were evaluated for controlling cotton mealybugs on okra plants under field conditions during the 2022 season.

Rearing of test insect

In the present work cotton mealybug, *P. solenopsis* (nymphs and adults) were reared inside wooden box (100 x 50 x50 cm) on okra plants and *I. seychellarum* (nymphs and adults) were reared inside wooden box (100 x 50 x50 cm) on guava plants.

Laboratory application

Ten second-phase nymphs and adults from each of; *P. solenopsis* and *I. seychellarum* were transferred to okra leaves and guava leaves, placed in a Petri dish (9 cm diameter) and prepared for fungal treatments. Each treatment was repeated three times in addition to the control. Adults and nymphs were sprayed with all concentration. Every day were examining the insects and recorded it to count the percent mortality.

Treatments

Entomopathogenic Fungi

Commercial Compounds

These compounds were (Biosect (3.2×10^6 spores/mg) and Biover (3.2×10^4 spores/mg)), the two compounds contain *Beauveria bassiana* (Balasamo). Also used Silica gel where add Biosect with Silica gel ratio (2:1 & 1:1), Biosect: Silica gel.

Preparing Concentrations

The concentrations used were 3.2×10^4 , 3.2×10^5 and 3.2×10^6 spores/mg of Biosect and add silica gel by ratio 2: 1 and 1:1 Biosect: Silica gel from concentration 3.2×10^6 . The concentrations used were 3.2×10^2 , 3.2×10^3 and 3.2×10^4 spores/mg of Biover.

The effect of tow entomopathogenic fungi against *Phenacoccus solenopsis* on okra plants under field condition

Experiment was conducted during late summer 2022 to evaluate the efficacy of tow entomopathogenic fungi against *P. solenopsis* on the previously mentioned of okra plants variety at the field of sakha district, kafr-elsheikh governorate, Egypt. The experiment was laid out in a randomized block design with three treatments (Biosect (3.2×10^6 spores/mg) and Biover (3.2×10^4 spores/mg, Biosect: Silica gel) and control. Each treatment contained three replications (42 m2 each) per plot. A knapsack sprayer provided with one nozzle delivering 200 l water/feddan was used the numbers of different stages of *P. solenopsis* were recorded on whole plant and recorded a day before spray and three, five, seven, ten and 14 days after spray.

Statistical analysis

Mortality data was corrected with that in control by using [22].

Results

Entomopathogenic fungi test against *Phenacoccus solenopsis* Tinsley and *Icerya seychellarum* (Westwood) under laboratory conditions

Data presented in Table (1 and 2) indicated that efficiency of tested Entomopathogenic fungi against *Phenacoccus solenopsis* nymphs and adults under laboratory conditions. Mortality percentage of adults was 36.62 % after 5th days, at the concentration (3.2×10^4 spores/ ml.) of Biosect but after 7th days of infection of adults was 96.66 % with the same concentration. While percent mortality of nymphs was 46.58 % after 5th days, at the concentration (3.2×10^4 spores/ ml.) of Biosect but after 7th days of infection of nymphs was 80 % with the same concentration. In nymphs % mortality ranging between 26.22 - 80.0 %. In adults Percent mortality ranging between 6.66 % to 96.66 %. The % mortality of adults was 55.44 % after 5th days, at the concentration (3.2

X 10⁴ spores/ ml.) of Biover but after 7th days of infection of adults was 100 % with the same concentration. While percent mortality of nymphs was 76.66 % after 5th days at the concentration (3.2 X 10⁴ spores/ ml.) of Biover. In nymphs Percent mortality ranging between 10 – 97.0 %. In adults Percent mortality ranging between 35.22- 100%. Also, the % mortality of adults was 76.22 % after 5th days,

at the concentration (3.2 X 10⁴ spores/ ml.) of F.+ Silica (1:1) but after 7th days of infection of adults was 100 % with the same concentration. While % mortality of nymphs was 95.66 % after 5th days at the concentration (3.2 X 10⁴ spores/ ml.) of F.+ Silica. In nymphs % mortality ranging between 55.22 - 100 %. In adults % mortality was 46.66 - 100%.

Table 1: Mortality percentage of *Phenacoccus solenopsis* Adults after infected with Entomopathogenic fungi under laboratory conditions (25 ± 2 °C, 85 ± 5 RH and a 13:11 (L:D) photoperiod).

Days after treatment	Control	Biosect			Biover			F.+ Silica	
		*C ₁	C ₂	C ₃	**C ₁	C ₂	C ₃	*** C ₁	C ₂
2 nd	-	-	-	-	-	-	-	-	-
3 rd	-	6.66	16.66	26.66	22.0	33.33	35.22	40.22	46.66
4 th	-	26.66	43.33	53.34	25.0	33.66	38.33	50.8	56.66
5 th	-	36.62	53.36	63.33	32.0	43.32	55.44	65.3	76.22
6 th	-	56.33	73.35	83.88	38.0	54.22	72.22	85.0	96.33
7 th	-	96.66	100	100	85	92	100	100	100

*3.2 X 10⁴(C₁), 3.2 X 10⁵ (C₂) and 3.2 X 10⁶ (C₃) spores/mg of Biosect
 **3.2 X 10²(C₁), 3.2 X 10³ (C₂) and 3.2 X 10⁴ (C₃) spores/mg of Biover
 *** (2:1 (C₁), & 1:1(C₂)), Biosect: Silica gel

Table 2: Mortality percentage of *Phenacoccus solenopsis* Nymphs after infected with Entomopathogenic fungi under laboratory conditions (25 ± 2 °C, 85 ± 5 RH and a 13:11 (L:D) photoperiod).

Days after treatment	Control	Biosect			Biover			F.+ silica	
		*C ₁	C ₂	C ₃	**C ₁	C ₂	C ₃	*** C ₁	C ₂
2 nd	-	-	-	-	-	-	-	-	-
3 rd	-	26.22	36.66	53.33	10.0	13.33	10.0	13.33	55.22
4 th	-	36.67	46.47	73.22	33.22	25.22	43.33	76.33	78.66
5 th	-	46.58	66.22	86.45	43.35	43.33	76.66	90.8	95.66
6 th	-	66.33	86.55	95.0	53.43	63.88	86.88	98.0	100
7 th	-	80.0	95.0	100	70.0	85.0	97.0	100	100

*3.2 X 10⁴(C₁), 3.2 X 10⁵ (C₂) and 3.2 X 10⁶ (C₃) spores/mg of Biosect
 **3.2 X 10²(C₁), 3.2 X 10³ (C₂) and 3.2 X 10⁴ (C₃) spores/mg of Biover
 *** (2:1 (C₁), & 1:1(C₂)), Biosect: Silica gel

Data presented in Table (3 and 4) showed that efficiency of tested Entomopathogenic fungi against of *Icerya Seychellarum* nymphs and adults under laboratory conditions. Mortality percentage of adults was 23.25 % after 5th days, at the concentration (3.2 X 10⁴ spores/ ml.) of Biosect but after 10th days of infection of adults was 66.88 % with the same concentration. While percent mortality of nymphs was 33.33 % after 5th days, at the concentration (3.2 X 10⁴ spores/ ml.) of Biosect. In nymphs % mortality ranging between 10.0 - 76.9%. In adults Percent mortality ranging between 3.22 - 66.88 % . The % mortality of adults was 30.0 % after 5th days, at the concentration (3.2 X 10⁴ spores/ ml.) of Biover but after 10th

days of infection of adults was 95.0 % with the same concentration. While percent mortality of nymphs was 58.33 % after 5th days at the concentration (3.2 X 10⁴ spores/ ml.) of Biover. In nymphs Percent mortality ranging between 9.44 - 100 % . In adults Percent mortality ranging between 9.44- 95.0 % . Also, the % mortality of adults was 41.0 % after 5th days, at the concentration (3.2 X 10⁴ spores/ ml.) of F.+ Silica but after 10th days of infection of adults was 100 % with the same concentration. While % mortality of nymphs was 75.8 % after 5th days at the concentration (3.2 X 10⁴ spores/ ml.) of F.+ Silica. In nymphs % mortality ranging between 29.0 - 100 % . In adults % mortality was 15.44 - 100%

Table 3: Mortality percentage of *Icerya Seychellarum* Adults after infected with Entomopathogenic fungi under laboratory conditions (25 ± 2 °C, 85 ± 5 RH and a 13:11 (L:D) photoperiod).

Days after treatment	Control	Biosect			Biover			F.+ Silica	
		*C ₁	C ₂	C ₃	**C ₁	C ₂	C ₃	*** C ₁	C ₂
2 nd	-	-	-	-	-	-	-	-	-
3 rd	-	3.22	5.33	10.88	3.0	5.0	9.44	11.33	15.44
4 th	-	3.33	8.66	23.33	3.33	7.0	20.55	25.55	30.22
5 th	-	23.25	25.0	33.33	16.88	23.33	30.0	36.33	41.0
6 th	-	33.22	43.33	56.66	30.0	33.56	46.33	60.22	65.33
7 th	-	43.43	53.88	75.0	36.88	48.22	66.66	82.44	87.43
8 th	-	50.0	66.60	86.0	46.22	55.9	76.88	90.2	95.7
9 th	-	56.66	70.0	100	50.66	66.66	90.0	100	100
10 th	-	66.88	75.0	100	60.0	70.33	95.0	100	100

*3.2 X 10⁴(C₁), 3.2 X 10⁵ (C₂) and 3.2 X 10⁶ (C₃) spores/mg of Biosect
 **3.2 X 10²(C₁), 3.2 X 10³ (C₂) and 3.2 X 10⁴ (C₃) spores/mg of Biover
 *** (2:1 (C₁), & 1:1(C₂)), Biosect: Silica gel

Table 4: Mortality percentage of *Icerya Seychellarum* Nymphs after infected with Entomopathogenic fungi, under laboratory conditions (25 ± 2 °C, 85 ± 5 RH and a 13:11 (L:D) photoperiod).

Days after treatment	Control	Biosect			Biover			F.+ silica	
		*C ₁	C ₂	C ₃	**C ₁	C ₂	C ₃	*** C ₁	C ₂
2 nd	-	-	-	-	-	-	-	-	-
3 rd	-	10.0	12.0	26.66	9.33	10.0	10.0	27.0	29.0
4 th	-	10.0	33.33	33.33	9.66	18.33	33.0	35.0	40.0
5 th	-	33.33	43.33	70.0	22.22	33.33	58.33	73.33	75.8
6 th	-	40.33	50.0	73.33	35.66	48.0	65.0	75.9	77.66
7 th	-	45.66	63.33	75.22	48.7	55.22	68.0	83.33	87.0
8 th	-	55.8	66.66	86.66	50.66	58.66	78.0	90.0	95.8
9 th	-	67.33	86.22	94.0	62.33	76.9	86.0	98.0	100
10 th	-	76.9	90.0	100.0	72.0	86.88	100.0	100	100

* 3.2×10^4 (C₁), 3.2×10^5 (C₂) and 3.2×10^6 (C₃) spores/mg of Biosect

** 3.2×10^2 (C₁), 3.2×10^3 (C₂) and 3.2×10^4 (C₃) spores/mg of Biover

*** (2:1 (C₁), & 1:1(C₂)), Biosect: Silica gel

The effect of entomopathogenic fungi on *Phenacoccus solenopsis* under field condition

Table (5): potency of different entomopathogenic fungi against cotton mealy bug, *P. solenopsis* population under field conditions during okra season 2022.

Treatment	Rate Feddan	Population reduction %															Overall average
		3 Days			5 days			7 days			10 days			14 days			
		Adult	Nymph	Average	Adult	Nymph	Average	Adult	Nymph	Average	Adult	Nymph	Average	Adult	Nymph	Average	
Biosect (3.2×10^6 spores/mg)		62.75	77.94	70.34	34.40	88.44	61.42	28.03	87.53	57.79	95.76	96.47	96.12	87.27	97.79	92.53	75.64
Biovar (3.2×10^4 spores/mg)		21.37	100.0	60.69	43.08	97.42	70.25	47.65	88.43	68.04	96.99	89.36	93.17	87.96	86.70	87.33	75.90
Biosect+ Silica gel		84.38	100.0	92.19	94.78	91.93	93.36	93.07	100.00	96.53	96.81	94.46	95.64	93.62	65.36	80.99	91.74
Control		00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00

Data presented in Table (5) show the efficiency of tested entomopathogenic fungi against cotton mealy bug *P. solenopsis* nymphs and adults under field conditions during okra season 2022.

Data in Table (5) show that Biosect+ Silica gel was the most potent compound in reducing the population density of the *P. solenopsis* nymph and adult after three days (84.38 and 100% reductions of nymph and adult, respectively), after 7 days, the reductions were 93.07 and 100% with an average of 95.53% and provided an overall average of 91.74%. Biosect (3.2×10^6 spores/mg) resulted in *P. solenopsis* nymph and adult population reductions of 62.75 and 77.94 % after three days of treatment in nymph and adult population, respectively. After ten days of treatment, the reduction was 95.76 and 96.47% in the *P. solenopsis* nymph and the adult population, respectively with an average of 96.12% given the overall mean of 75.64%

Biover (3.2×10^4 spores/mg) were the least effective

compounds, where reduction ratios were recorded 21.37 and 100.00% after three days and 96.99 and 89.36 % after 10 days from treatment in *P. solenopsis* nymph and adult population reductions with an average of 93.17% and with overall average of 75.90 %.

Data illustrated in Fig. (1) show Mean population abundance of *P. solenopsis* nymphs and adults on okra plants after treatment with entomopathogenic fungi under field conditions during 2022 season. The highest peaks were recorded 8 and 17 individual's nymphs and adults after 5 days from treatment with Biosect (3.2×10^6 spores/mg), respectively. followed by the second one and presented by 10.4 adults after 5 days from treatment with Biover (3.2×10^4 spores/mg). While the lowest peak was recorded mean average population density of *P. solenopsis* 1.8 adults after 5 days from treatment with Biosect+ Silica gel. Also, not recorded any mean average for nymphs after 5 days from treatment with Biover (3.2×10^4 spores/mg) and Biosect+ Silica gel during this study.

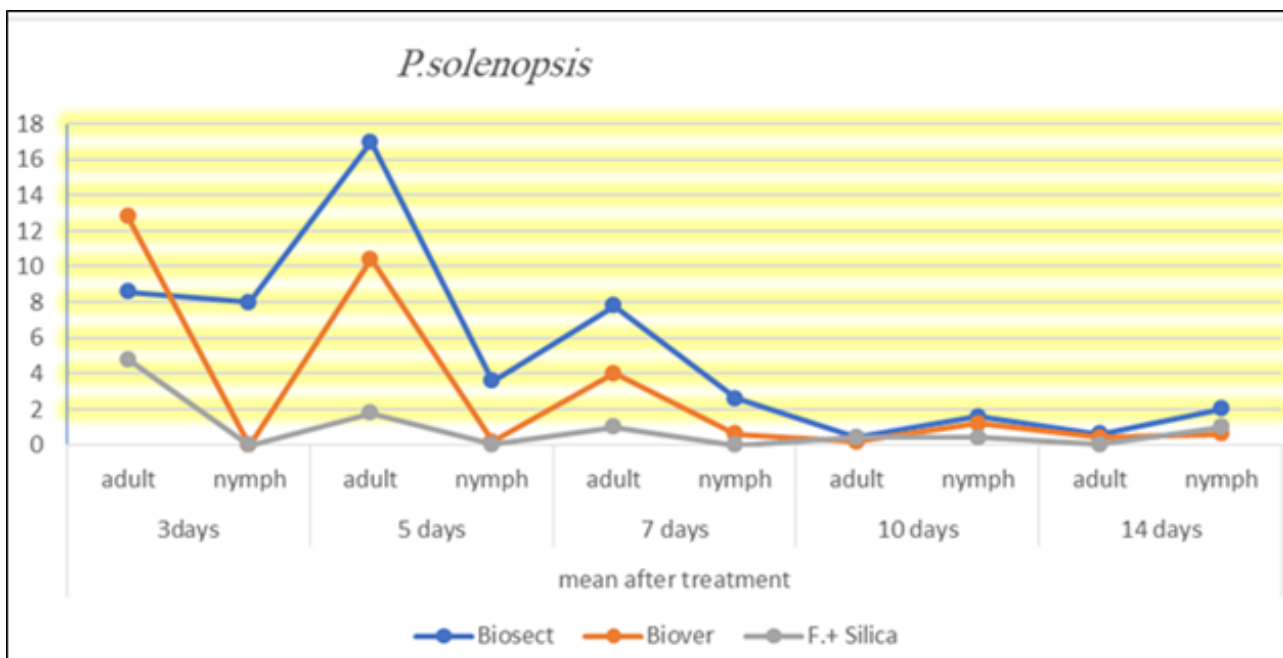


Fig 1: Mean numbers of *P. solenopsis* nymphs and adults on okra plants under field conditions during 2022 season.

Discission

The population density of the cotton mealybug, *P. solenopsis* recorded the highest peaks of abundance on okra plants during the two successive seasons 2018 and 2019 and presented by 341 and 397 individuals in the third week of October 2018 and in the second week of October 2019, respectively [9]. This results according with [23] where used the same compounds against *Spodoptera littoralis*; *Spodoptera exigua*; *Aphis craccivora*; and *Pegomyia mixta*. Also, [24-26] used of Entomopathogenic fungi against the Oliver black scale insect, *Saissetia oleae* (Oliver) and mentioned that these compounds may be used as components in (IPM) programmes for controlling this insect pest and to avoid pollution of environment and hazards to man or animals.

References

1. Halder J, Divekar PA, Rani AT. Compatibility of entomopathogenic fungi and botanicals against sucking pests of okra: an ecofriendly approach. Egyptian Journal of Biological Pest Control, 2021;31(30):2-7.
2. Abbas G, Arif MJ, Aslam M, Saeed S. Host plant distribution and overwintering of cotton mealybug (*Phenacoccus solenopsis*) Hemiptera: Pseudococcidae). Int. J. Agric. Biol., 2010;12:421-425.
3. Ibrahim SS, Morarumand FA, Abdel-Ghany NH. The cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) as a new insect pest on tomato plants in Egypt. J. Plant Protection Res, 2015;55(1):48-51.
4. Shah ZH, Sahito HA, Shar GA, Kousar T, Mangrio WM, Kanhar KA. Toxicity of different insecticides

- against mealybug, *Phenacoccus solenopsis* (Tinsley) under cotton field conditions', Pak. J. Entomol.,2016:31(1):39-50.
5. Abdel-Razzik MI, Attia AR, Abdel-Aziz M. Newly host plants of cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) in Egypt. Egypt. Acad. J. Biolog.,2015:8(3):31-33.
 6. Abd-Rabou S, Germain JF, Malausa T. *Phenacoccus parvus* Morrison and *P. solenopsis* Tinsley, two new scale insects in Egypt (Hemiptera: Pseudococcidae). Bull. Soc. Entomol., France,2010:115(4):509-510.
 7. Mohamed GS. Studies on Population Dynamic, Biology of The Cotton Mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) and Its Natural Enemies as A New Insect on Okra Plant, (*Abelmoschus esculentus* (L.) Moench) at Qena Governorate, Egypt. Egypt. Acad. J. Biolog. Sci.,2021:14(3):1-16.
 8. Ibrahim SS. Study on Cotton Host Plants of Mealybug *Phenacoccus solenopsis* (Tinsley) and Efficiency Release the Predator *Chrysoperla carnea* (Stephens) for its Controlling on Cotton Plants in Egypt. J. Plant Prot. and Path., Mansoura Univ.,2018:9 (3): 247-252.
 9. Fargalla FH. Effect of different Vegetable Crops on the Population Density of the Cotton Mealybug *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae) in Mansoura Region. J. of Plant Protection and Pathology, Mansoura Univ.,2020:11(1):41-45.
 10. Awadalla HSS, El-Kady HA, Eisa MMA. Effect of planting dates on the cotton mealybug *Phenacoccus solenopsis* (Tinsley) as a main insect pest attacking tomato plants in Damietta Governorate. J. Plant Prot. and Path. Mansoura Univ,2018:9(3):167-169.
 11. Awadalla SS, Abd Allah FD, El-Serafi HAK, Badawy WBF. Influence of different plantations on the main piercing-sucking insect pests attacking faba bean and soybean plants. J. Plant Prot. and Path. Mansoura Univ,2019:10(5):289-292.
 12. Ata TE. Biological studies on the cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) under the laboratory conditions. J. Plant Prot. and Path., Mansoura Univ,2019:10(3):195-198.
 13. Ata TE SS, Awadalla MH Bayoumy2, Aya A Osman. Population Estimates of The Seychellarum Mealybug, *Icerya sechellarum* (Hemiptera: Margarodidae) in Relation to some Biotic and Abiotic Factors. J. of Plant Protection and Pathology, Mansoura Univ.,2021:12(4):273-277.
 14. Awadalla HSS. Ecological and biological studies on certain mealybug species and their associated natural enemies at Mansoura district. Ph.D. Thesis, Fac. Agric. Mansoura Univ, 2013, 198.
 15. El-Sherbenie MKG. Role of established predatory insects in suppressing the population density injurious insects infesting guava orchards at Dakahlia Governorate. M. Sc. Thesis, Fac. Agric., Mansoura Univ, 2004, 121.
 16. Moursi KS, Mesbah HA, El-Sayed NA, Omar MAA. Scale insects and mealybugs associated with citrus trees in El-Beheira Governorate, Egypt, Alexandria Science Exchange J,2013:34(3):299-305.
 17. Ben-Dov YDR Miller, Gibson GAP. Scale Net: a database of the scale insects of the world, 2009. http://www.sel.barc.usda.gov/scalenet/scale_net.htm
 18. Mohanny KM, Mohamed GS, Bakry MMS, Ali 2 MK, Allam ROH. Toxicity of three insecticides and some alternatives against cottony cushion scale, *Icerya purchasi* (Maskell) under laboratory conditions .SVU-International Journal of Agricultural Sciences,2022:4(3):135-142.
 19. Suresh S, Jothimani R, Sivasubramanian P, Karuppuchamy, Samiyappan P, Jonatha REI. Invasive mealybugs of Tamil Nadu and their management Karnataka., J. Agric. Sci,2010:(23):6-9.
 20. Mohamed Abdel-Raheem, Amany Elbahrawy. Cotton mealybug, *Phenacoccus solenopsis*, Biology, Ecology and Control, Lambert Academic Publishing, ISBN: 978-620-2-67786-8, 2020, 132. https://shop.the-lazy-bookshop.com/products/978-620-2-67786-8?_pos=1&_sid=939ecfa5f&_ss=r
 21. Mohamed Abdel-Raheem, Wafaa EL- Baradeey. Scale Insects and Their Control, Lambert Academic Publishing, ISBN: 978-620-5-49652-7, 2022, 188, Scale insects and their control / 978-620-5-49652-7 / 9786205496527 / 6205496526 (lap-publishing.com)
 22. Henderson CF, Tilton EW. Tests with acaricides against the brown wheat mite. J. Econ. Entomology,1955:48:157-161.
 23. Zaki FN, Abdel-Raheem MA. Using of Entomopathogenic fungi and insecticide against some insect pests attacking peanuts and sugar beet. Archives of phytopathology and plant protection,2010:43(18):1819-1828. https://www.academia.edu/6684478/Use_of_entomopathogenic_fungi_and_insecticide_against_some_insect_pests_attacking_peanuts_and_sugarbeet_in_Egypt
 24. Abdel-Raheem M. Isolation, mass production and application entomopathogenic fungi for insect pests control, Cottage Industry of Biocontrol Agents and Their Applications: Practical Aspects to Deal Biologically with Pests and Stresses Facing Strategic Crops, 2019, 231-251. ISBN: 978-3-030-33160-3 <https://www.springer.com/gp/book/9783030331603> https://link.springer.com/chapter/10.1007%2F978-3-030-33161-0_7 https://doi.org/10.1007/978-3-030-33161-0_7
 25. Abdel-Raheem MA, Ismail IA, Abdel-Rahman RS, Wafaa MM EL-Baradeey. Virulence of some Entomopathogenic fungi against the Oliver black scale insect, *Saissetia oleae* (Oliver) on olive trees in Egypt. Journal of Pharmaceutical, Chemical and Biological Sciences,2017:5(2):97-102. http://www.jpccbs.info/2017_5_2_03_Abel-Raheem.pdf
 26. Abdel-Rahman RS, Abdel-Raheem MA, Ismail IA, Wafaa MM EL-Baradeey. The strategy of anti-soft scale insect *Pulvinaria tenuivalvata* (Newstead) Infesting Sugarcane. Journal of Pharmaceutical, Chemical and Biological Sciences,2017:5(2):125-132. http://www.jpccbs.info/2017_5_2_07_Abel.pdf