Efficacy of Some Predators and *Lecanicillium lecanii* Fungus in Controlling of *Aphis gossypii* (Glover) and *Myzus persicae* (Sulzer) in Potato Crop

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Abstract

Lokma, N., A.A.A. Saleh, S.A.M. Amer and M F.M. Zawrah. 2023. Efficacy of Some Predators and *Lecanicillium lecanii* Fungus in Controlling of *Aphis gossypii (*Glover) and *Myzus persicae* (Sulzer) in Potato Crop. Arab Journal of Plant Protection, 41(2): 152-160. https://doi.org/10.22268/AJPP-041.2.152160

This study was conducted to evaluate the efficiency of predators and *Lecanicillium lecanii* suspension as bicontrol agents against *Myzus persicae* and *Aphis gossypii* in potato crop, whereas *Aphis gossypii* had two peaks in the third week of March and April in 2020 and 2021 seasons. In addition, *M. persicae* had two peaks for both seasons in the fourth week of March and third week of April in 2020 and in the third week of March during 2021. The common predators observed in potato fields were: *Coccinella undecimpunctata* L., *Chrysoperla carnea* Steph., *Coccinella septumpunctata*, *Metasyrphus corollae* F. and *Cydonia vicina isis* (Muls.). Regarding potato predators, one peak was found in the second week of March (60 predators/25 leaves) during the 2020 season, and two peaks were found in the third week of March and second week of April (53 and 38 predators/25 leaves, respectively), in 2021 season. On the 8th day after treatment, the entomopathogenic fungus *L. Lecanii* produced maximum aphid mortality at highest concentration of 10^8 conidia/ml and 50% concentration of fungal metabolites for both *M. persicae* and *A. gossypii*. Meanwhile, *L. lecanii* 50% metabolites solution had more latent effect by decreasing the longevity and the number of nymphs than when using the spore suspension of 10^8 conidial/ml.

Keywords: *A. gossypii*, *M. persicae*, aphid predators, *Lecanicillium lecanii*, potato.

Introduction

Aphids are one of the most important piercing-sucking pests of green house and field crops throughout the world (Emden & Harrington, 2007). The role of predators against *Aphis gossypii* and *Myzus persicae* has drawn the attention of many investigators in Egypt (Ali, 2008; Jabbar *et al.*, 2020; Saleh, 2008; Saleh *et al.*, 2020). Nearly all pest control programs depend on the use of chemical insecticides formulated as direct contact sprays or dusts which have hazardous impact on the natural environment. Biological control which includes effective predators and microorganisms and microbial products can be employed as an alternative to chemical control (Mahfouz & Abou El-Ela, 2011; Saleh *et al.*, 2020; Zawrah *et al.*, 2020). The entomopathogenic fungus *Lecanicillium lecanii* is used as an effective bio-pesticide to manage harmful insects (Vinodhini *et al*., 2017). Entomopathgenic fungi have been used as alternative to chemical pesticides for control of different insects including aphids (Ali *et al.*, 2020; Butt *et al.*, 2001; Shi *et al.*, 2008) because they are cheap in cost, easily applied as suspension or powder, and safe to humans, animals and environment. The fungus *L. lecanii* is an entomopathogenic fungus with a broad variety of hosts including insects (Johnson *et al.*, 1988; Khachatourians, 1992). It is a very important pathogen of insects isolated from coccids, aphids and whiteflies (Liu *et al.*, 2011). Akram *et al.* (2018) stated that the isolation of *L. lecanii* was the most virulent to both. *A. gossypii* and *M. persicae* populations in the laboratory and under greenhouse conditions.

Miranpuri & Khachatourians (1995) applied the fungal mats treatment and conidia spore sprays of various strains of *B. bassiana* and *L. lecanii* either directly on aphid or on aphid infested barely in cages and recorded that the LT_{50} ranged from 2.2 to 2.7 days for *V. lecanii* and from 3 to 5.4 days for the different *B. bassiana* strains. The population of cotton aphid is significantly affected by *L. lecanii* by reducing life span, reproductive period and total fecundity. It was found that, the reproduction period was significantly shortened with increasing conidia concentration (Kim, 2007). In Pakistan, the virulence of the entomopathogenic fungi *L. lecanii*, *Metarhizium anisopliae* and *B. bassiana* against the third instar of *C. medinalis* larvae was investigated. The maximum mortality rate of *C. medinalis* was recorded *with M. anisopliae*, whereas the minimum was observed by applying *L. lecanii* (Ali *et al.*, 2020; Rizwan *et al.*, 2019).

The success of using fungal entomopathogens as biocontrol agents is attributed to high host specificity, long shelf life and non-toxic effects to the environment. The entomopathogenic fungus *L. lecanii* was used as an effective bio-pesticide to manage insects (Ali *et al.*, 2020; Vinodhini *et al.*, 2017). Both *Verticillium lecanii* and *Trichoderma album* (biozeid) were also found effective biocontrol agents against adults of cabbage aphid (El-Gendy, 2015).

Entomopathogenic fungi such as *Beauveria bassiana*, *L. lecanii*, *M. anisopliae* and *Isaria fumosorosea* were found effective against *A. gossypii* and *M. persicae* (Ali *et al.*, 2020; Ambethgar, 2018; Majeed *et al.*, 2017). In this study the efficacy of *L. lecanii* as biocontrol against *A. gossypii* and *M. persicae* was investigated by conducting a survey and monitor seasonal abundance of *A. gossypii*, *M. persicae* and their predators in potato fields during two successive seasons

https://doi.org/10.22268/AJPP-041.2.152160

2020 and 2021, and assess the effects of the entomopathogenic fungus *L. lecanii* on aphid pests *A. gossypii* and *M. persicae*.

Materials and Methods

Survey and seasonal abundance of *A. gossypii*, *M. persicae* and their predators on potato plants

The seasonal abundance of *A. gossypii* and *M. persicae* and their associated predators in El-Khattara district, Sharkia Governorate was monitored during the two successive seasons 2020 and 2021 in potato crops. Half an acre was cultivated with potato under drip irrigation system in both seasons. The sowing date was 1st of January in the first season, whereas it was 2nd of January during the second season. Inspections continued until the third week of May in the two seasons. Sampling started around three weeks after planting and continued until harvesting time. The weekly sample size was 25 leaves chosen randomly from plants. Normal agricultural practices were carried out according to recommendations of the Ministry of Agriculture without using chemical control.

The use of the entomopathogenic fungus *L. lecanii* in the control of *A. gossypii* and *M. persicae*

In this study, *L. lecanii* (NRRL/1003) was supplied by Microbiological Resources Centre, Faculty of Agriculture, Ain Shams University, Cairo, Egypt.

Culture media - Media used for isolation, purification and identification of entomopathogenic fungi were as follows: (i) Czapek-Dox's agar medium (oxide, 1982) composed of (g/l): 30 g sucrose, 3.0 g $NaNO_3$, 1.0 g KH_2PO_4, 0.5 g $MgSO_4.7H_2O$, 0.5 g KCl, 0.01 g $FeSO_4.7H_2O$, 0.5 g yeast extract and 20 g agar-agar and dissolved in distilled water (pH 5.0), (ii) Potato-dextrose-agar medium was prepared according to Bilgrami & Verma (1981), and composed of (g/l): 250 g pealed potato, 20.0 g dextrose, and 20.0 g agar-agar, dissolved in 1 L distilled water.

Preparation of inoculum - Inoculum was prepared by agitating a slant of fungal isolate (7-days old culture) with 10 ml sterile distilled water using an inoculation needle. One ml of the spore suspension was then used as standard inoculum. The fungal spores counted in each 1ml spore suspension of fungal isolate according to El-Sayed (2008).

Erlenmeyer conical flasks (250 ml) each containing 50 ml of liquid potato dextrose medium were used. The pH of the medium was adjusted to 5.0. The flasks were plugged with cotton plug and sterilized at 121°C for 20 min. Each flask, after cooling, was inoculated with one ml of spore suspension under aseptic conditions. The culture flasks were then incubated at 25°C in an incubator. Each treatment was carried out in triplicates and the results obtained throughout this study were the arithmetic average of at least two trials.

After the incubation period, conidia collected from 7 days old cultures and four concentrations (10^2, 10^4, 10^6 and 10^8 conidia/ml) were prepared. After filtration of liquid culture media, different metabolites dilutions (50%, 25%, 12.5% and 6.25%) of selected isolates were prepared.

Insect rearing - Mass rearing of the aphids *M. presica* and *A. gossypii* collected from potato plants were reared in a greenhouse and a laboratory colony was established on cotton. Aphid colonies were maintained at 25±1°C and 65±5% RH.

Insects bio-control by selected entomopathogenic fungi

Insect rearing

The proper conditions and diet for rearing laboratory colony of the green peach aphid *(M. persicae*) and cotton aphid *(A. gossypii)* were followed according to the method described by Ramadan (1982), and colonies were maintained according to Ramadan (1982) and El-Gendy (2009). Preparation of serial cultivation of cotton plants in plastic pots (30 cm diameter and 25 cm high) under laboratory conditions. Samples of plants infested with peach and cotton aphid were collected separately from the field, placed in paper bags and brought to the laboratory. Aphids were transferred from infested plants to non-infested ones by using a fine brush. Infested samples with aphid colonies were placed in cages covered with a muslin cloth, to prevent and avoid parasites and predators access to aphids (El-Gendy, 2009).

Bio-control treatments

Impact of selected two fungal species and its metabolites as bio-control agents on two different aphid pests was assessed to evaluate mortality rate and effect on some biological aspects of the insects, by using the leaf dip technique as described by El-Gendy (2009). Thirty aphid mothers were counted and placed in sterile petri dishes, four dishes (replicates) for each treatment, as well as control. Cotton leaf discs (2 square inch) were prepared, dipped in tested concentrations for 10 seconds, then left to dry at room temperature and provided to the aphids in petri dishes. The four concentrations 10^8, 10^6, 10^4 and 10^2 conidia/ml spore suspensions of 50%, 25%, 12.5% and 6.25% metabolites solution of *L. lecanii* per petri dish, were used. The dead and alive aphid individuals were counted 2, 4, 6 and 8 days after treatments under laboratory conditions (25-28°C and 70-80% RH) as described by Ghatwary (2000).

The mortality rate was calculated and corrected according to Abbott's formula (Abbott, 1925):

$$\text{Corrected mortality rate (\%)} = \frac{\text{Mortality in treatment- mortality in control}}{\text{100- mortality in control}}$$

The concentration-mortality regression analysis was computed for the tested fungus according to Finney (1971). The relative potency (RP) and tolerance ratio (TR) were calculated according to the following formula described by Zidan & Abdel-Megeed (1988).

$$\text{R.P.} = \frac{LD_{50} \text{ or } LD_{90} \text{ of most potent compound}}{LD_{50} \text{ or } LD_{90} \text{ of each compound}} \times 100$$

$$\text{T.P.} = \frac{LD_{50} \text{ or } LD_{90} \text{ of most tested compound}}{LD_{50} \text{ or } LD_{90} \text{ of most potent compound}} \times 100$$

Biological studies
To study the latent effect of tested fungal specie spore suspension and fungal filtrate on certain biological aspects of the two aphids. The entomopathogenic fungus caused higher mortality rate on *M. persicae* as compared to *A. gossypii*. The aphids survived from each treatment were transferred individually to cotton leaf discs, and kept under the same conditions as mentioned above. Adults were examined daily to record the longevity of adult, pre-oviposition, oviposition and post oviposition periods as well as number offspring per adult under laboratory conditions.

Statistical analysis
Data were analyzed using SAS package 8.2 v (SAS, 2003). Obtained data were analyzed using one-way ANOVA. When F values were significant, means were compared using Tukey's HSD at P= 0.05.

Results

Survey of aphids and their predators on potato plants
Potato plants are attacked by two aphid species, *A. gossypii* (Glover) and *M. persicae* (Sulzer). Insect predators found associated with these aphids on potato were as follows: Coccinellids: *Coccinella septumpunctata* L., *C. undecimpunctata* L. and *Cydonia vicinia isis* Muls. (Coleoptera: Coccinellidae); Chrysopids: *Chrysoperla carnea* Steph. (Neuroptera: Chrysopidae); Syrphids: *Metasyrphus corollae* F. (Diptera: Syrphidae).

Population density of aphids infesting potato plants: Results obtained (Table 1) showed clearly that the infestation of *A. gossypii* was the highest, which represented 65.45 and 69.10% of the total number of aphids, followed by *M. persicae* with 34.55 and 30.90% of the total number of aphids, during 2020 and 2021 growing seasons, respectively.

Table 1. Mean of aphid species (*A. gossypii* and *M. persicae*) and its associated predators on potato plants during 2020 and 2021 seasons.

Pests and predators	2020 Total	2020 %	2021 Total	2021 %
Insect pests				
A. gossypii	1432	65.40	1221	69.10
M. persicae	756	34.55	546	30.90
Total	2188	100	1767	100
Insect predators				
C. undecimpunctata	104	27.51	98	28.49
Chrysoperla carne	87	23.01	81	23.55
Coccinella septempunctata	68	17.99	57	16.57
Cydonia vicina isis	52	13.76	45	13.08
Metasyrphus corolla	67	17.73	63	18.31
Total	378	100	344	100

Insect predators associated with insect pests
Coccinella undecimpunctata incidence was the highest and represented 27.51 and 28.49%, followed by *C. Carnea* (23.01 and 23.55%) then *C. septempunctata* (17.99 and 16.57%) and *M. corolla* (17.73 and 18.31%), whereas *C. vicinia isis* represented 13.76 and 13.08% from the total number of insect predators during the 2020 and 2021 seasons, respectively.

Seasonal abundance of *A. gossypii* and *M. persicae* infesting potato plants

Population of *A. gossypii* - Results (Table 2) showed that aphids infestation started on the second week of February (10 individuals/25 leaves), it increased sharply to produce two population peaks *during* the third week of March and April (178 and 330 individuals/25 leaves), respectively during the 2020 season. In 2021 season, *A. gossypii* appeared on potato plants during the 2nd week of February (4.0 individuals/25 leaves) and produced two population peaks during 4th week of March and April (203 and 240 individuals/25 leaves), respectively (Table 3). The general mean numbers of *A. gossypii* during the two seasons were 1432.0 and 1221 individuals/25 leaves, respectively.

Population of *M. persicae* - For 2020 season, results obtained (Table 2) showed that aphids infestation started on the second week of February (4.0 individuals/25 leaves), and then increased sharply to produce two population peaks (133 and 115 individuals/25 leaves) during the fourth week of March and third week of April, respectively. In addition, during 2021 season**,** *M. persicae* had two population peaks during the third week of March and April (101 and 88 predators/25 leaves, respectively). The general mean numbers of *M. persicae* during the two seasons were 756.0 and 546.0 individuals/25 leaves, respectively.

Seasonal abundance of predators associated with *A. gossypii* and *M. persicae* infesting potato plants

Coccinella undecimpunctata - The results obtained (Table 2) showed that *C. undecimpunctata* began to appear on potato plants during 2nd week of February (3 individuals/25 leaves). Two population peaks were detected during the second week of March and first week of April (15 and 13 individuals/25 leaves, respectively), during the 2020 season.

In the 2021 season, the number of *C. undecimpunctata* during the 2nd week of February was 2 individuals/25 leaves, and then increased to produce two population peaks (19 and 17 individuals/25 leaves) during the second week of March and April, respectively (Table 3).

Chrysoperla carnea - Results obtained showed that *C. carnea* started to appear on potato plants during the 2nd week of February (2 and 4 individuals/25 leaves during 2020 and 2021 seasons, respectively), and then produced one population peak during the first season (17 individuals/25 leaves) during the second week of March and two population peaks during the second season (13 and 10 individuals/25 leaves), during the first week of March and fourth week of April, respectively (Tables 2 and 3).

Coccinella septumpunctata - Results obtained (Tables 2 and 3) showed that *C. septumpunctata* individuals appeared during the 3rd week of February (4 and 2 individuals/25 leaves during the two seasons, respectively) and then produced two population peaks (11 individuals/25 leaves) during the second week of March and first week of April, respectively, during the 2020 season. On the other, during the 2021 season, *C. septumpunctata* produced one peak during the third week of March (14 predators/25 leaves) (Table 3).

Metasyrphus corollae - Results obtained (Table 2) showed that *M. corollae* individuals appeared during the 4th week of February and then produced two population peaks of 13 and 11 individuals/25 leaves) during the second week of March and April, respectively, during the 2020 season. However, during the 2021 season the predator appeared during the 1st week of March (3 individuals/25 leaves), and produced two population peaks (11 and 10 individuals/25 leaves) during the third week of March and April, respectively (Table 3).

Cydonia vicinia isis **-** Results obtained (Table 2) showed that *C. vicinia isis* first appeared during the 1st week of March and then produced two population peaks (12 and 9 individuals/25 leaves) during the fourth week of March and 2nd week of April, respectively, during the 2020 season. However, during the 2021 season, it first appeared during the 2nd week of March (5 individuals/25 leaves), and then produced one population peak (10 individuals/25 leaves) during the second week of April (Table 3).

Regarding predators on potato, one peak was found in the second week of March (60 predators/25 leaves) during the first season (2020), and two peaks were produced during the third week of March and second week of April (53 and 38 predators/25 leaves, respectively), during the 2021 season.

Using *L. lecanii* entomopathogenic fungus for the control of *M. persicae* and *A. gossypii*

Results obtained (Table 4) showed that the *L. lecanii* metabolites solution had relatively higher effect against peach aphid as compared to the cotton aphid. The metabolites solution had an LC_{90} of 346.4 ml/L and 255.5 m/L against the two aphid species, respectively. Whereas the spore suspension had a LC_{90} of 5.34×10^{8} and 11.9×10^{12} spores/ml against the two aphid species, respectively.

L. lecanii metabolites solution (four concentrations) had relatively higher potency (LC_{50} and LC_{90}) spore suspension (four concentrations. On the other hand, the tolerance rate of *M. persicae*, and *A. gossypii* in response to the tested materials suggested that the tested aphids were more susceptible to spore suspension than to metabolites solution.

Table 2. Seasonal abundance of aphid species (*A. gossypii* and *M. persicae*)) and its associated predators on potato fields during 2020 season.

Date of inspection	*A.g.**	*M.p.*	Total	*C.u.*	*C.c.*	*C.s.*	*C.v.*	*M.c.*	Total	P:P ratio	Mean Temperature C°	Mean Humidity R.H.
February 1	0	0	0	0	0	0	0	0	0	0	13.11	61.03
February 2	10	4	14	3	2	0	0	0	5	1: 2.8	12.59	63.73
February 3	12	7	19	5	3	4	0	0	12	1: 1.58	13.75	67.58
February 4	28	19	47	8	7	5	0	4	24	1: 1.90	14.47	63.02
Mean	12.5± 5.79	7.5± 4.09	20± 9.86	4.0± 1.68	3.0± 1.47	2.25± 1.31	0	1.0± 1.0	10.25± 5.2			
March 1	33	23	56	12	8	7	2	6	35	1: 1.6	15.70	54.08
March 2	80	54	134	15	17	11	4	13	60	1: 2.23	16.90	65.05
March 3	178	124	302	12	9	5	6	5	38	1: 7.95	13.79	59.61
March 4	116	133	249	8	11	7	12	6	44	1: 5.66	18.58	48.30
Mean	101.75± 30.57	83.5± 26.80	185.25± 55.48	11.75± 1.44	11.25± 2.02	7.5± 1.26	6.0± 2.16	7.5± 1.85	44.25± 5.57			
April 1	108	111	219	13	7	11	5	4	40	1: 5.48	19.19	50.14
April 2	144	98	242	7	4	6	9	11	37	1: 6.54	17.46	54.34
April 3	330	115	445	9	7	8	5	6	35	1: 12.71	21.19	46.59
April 4	201	44	245	6	5	3	3	5	22	1: 11.14	19.43	59.51
Mean	195.75± 48.67	92.0± 16.41	287.75± 52.74	8.75± 1.55	5.75± 0.75	7.0± 1.68	5.50± 1.26	6.5± 1.55	33.5± 3.97			
May 1	112	14	126	4	3	1	2	3	13	1: 9.69	22.08	33.27
May 2	80	10	90	2	4	0	3	1	10	1: 9.0	25.46	33.46
May 3	0	0	0	0	0	0	1	2	3	0	31.14	30.09
Mean	64.0± 33.35	8.0± 4.17	72.0± 37.51	2.0± 1.16	2.3± 1.2	0.33± 033	2.0± 0.58	2.0± 0.6	8.33± 3.29			
Sum	1432	756	2188	104.0	87	68	52.0	67.0	378			
General Mean	95.47± 23.68	50.40± 13.14	145.87± 34.28	6.93± 1.21	5.8± 1.15	4.53± 0.99	3.47± 0.91	4.47± 0.99	25.2± 4.57			

* Abbreviations: *A.g.= Aphis gossypii; M.p.= Myzus persicae; C.u.= C. undecimpunctata; C.c.= C. carnea; C.s.= C. septempunctata; C.v.= C. viciniaisis; M.c.= M. corollae;* P:P ration= Predator:Prey ratio.

Table 3. Seasonal abundance of aphid species (*A. gossypii* and *M. persicae*) and its associated predators on potato fields during 2021 season.

Date of inspection	*A.g.*[*]	*M.p.*	Total	*C.u.*	*C.c.*	*C.s.*	*C.v.*	*M.c.*	Total	P:P ratio	Mean Temperature C°	Mean Humidity R.H.
February 1	0	0	0	0	0	0	0	0	0	0	16.53	51.13
February 2	4	7	11	2	4	0	0	0	6	1:1.83	16.13	51.12
February 3	9	5	14	3	5	2	0	0	10	1:1.4	11.04	67.16
February 4	23	21	44	5	8	4	0	0	17	1:2.6	14.11	67.53
Mean	9.0± 5.02	8.25± 4.5	17.25± 9.4	2.5± 1.04	4.25± 1.65	1.5± 0.96	0	0	8.25± 3.57			
March 1	41	31	72	8	13	6	0	3	30	1:2.4	13.77	62.94
March 2	75	51	126	19	9	7	5	7	47	1:2.7	13.80	55.07
March 3	153	101	254	9	11	14	8	11	53	1:4.8	13.91	53.46
March 4	203	90	298	10	3	5	3	6	27	1:11.0	13.63	61.52
Mean	119.25± 37.75	68.25± 16.41	162.5± 66.81	11.50± 2.53	9± 2.16	8.0± 2.04	4.0± 1.68	6.75± 1.65	39.25± 6.36			
April 1	107	61	168	5	4	7	5	4	25	1:6.7	18.38	48.42
April 2	90	55	145	17	2	3	10	6	38	1:3.8	16.82	49.17
April 3	151	88	239	9	6	2	4	10	31	1:7.7	22.89	39.12
April 4	240	30	270	5	10	4	3	8	30	1:9.0	23.57	37.83
Mean	147.0± 33.56	58.5± 11.91	205.5± 29.37	9.0± 2.8	5.5± 1.71	4.0± 1.08	5.5± 1.6	7.0± 1.3	31.0± 2.68			
May 1	90	6	96	3	4	2	2	5	16	1:6.0	29.88	34.39
May 2	30	0	30	2	0	1	3	3	9	1:3.3	26.39	33.96
May 3	0	0	0	1	2	0	2	0	5	0	25.58	38.50
Mean	40.0± 26.49	2.0± 2.0	42.0± 28.39	2.0± 0.58	2.0± 1.16	1.0± 0.57	2.33± 0.33	2.67± 1.45	10.0± 3.22			
Sum	1221	546	1767	98.0	81.0	57.0	45.0	63.0	344.0			
General Mean	81.40± 20.04	36.40± 9.36	117.80± 27.44	6.53± 1.02	5.4± 1.03	3.8± 0.96	3.0± 0.79	4.2± 0.98	22.87± 4.09			

* Abbreviations: *A.g.= Aphis gossypii; M.p.= Myzus persicae; C.u.= C. undecimpunctata; C.c.= C. carnea; C.s.= C. septempunctata; C.v.= C. viciniaisis; M.c.= M. corollae;* P:P ratio= Predator:Prey ratio.

The effect of *L. lecanii* 10^8 spores/ml and 50% metabolites solution on two aphid species (*M. persicae* and *A. gossypii*) 8 days after treatment had higher mortality rate of 54.69% and 79.81% for both spore suspension and metabolites, respectively, on *M. persicae* as compared to 44.65% and 68.53% mortality of *A. gossypii*, respectively.

Latent effect of *L. lecanii* on some stages and nymph number of peach aphid *M. presicae*

The results obtained (Table 5) showed that the impact of conidial spore suspension and metabolites solution treatments on adult duration and number of nymphs of *M. presicae*. Adult duration was 10.38, 11.88, 12.35 and 12.88 days for the four conidial suspension concentrations (10^8, 10^6, 10^4 and 10^2 spores/ml), respectively, and 8.86, 9.69, 10.56 and 11.73 days for the four concentrations (50%, 25%, 12.5% and 6.25%) of fungal metabolites solution, respectively. In case of the oviposition period, the duration on the Okra leaf disc mixed with fungal conidia treatments was 9.16, 8.48, 9.57 and 10.70 days for 10^8, 10^6, 10^4 and 10^2 spores/ml of *L. lecanii*, respectively, and shorter than that of the control (10.56 days). whereas the oviposition period was 6.69, 7.27, 8.13, and 8.65 days when treated with 50%, 25%, 12.5% and 6.25% of *L. lecanii* metabolites solution, respectively.

Concerning the post oviposiyion period, the duration in all treatments ranged between 0.56 to 1.93 days for 10^8, 10^6, 10^4 and 10^2 spores/ml of *L. lecanii* spore suspension and from 0.64 to 1.13 days for 50, 25, 12.5 and 6.25% of *L. lecanii* metabolites solution, respectively.

As for the mean number of nymphs, results obtained (Table 5) indicated that all experimental treatments by *L. lecanii* spore suspensions and metabolites had significant effect on the number of offspring compared to the experimental control, and the *L. lecanii* spore suspension had more effect than *L. lecanii* metabolites solution.

When the cotton leaf discs were mixed with 10^8, $10^{6,}$ 10^4, and 10^2 spores/ml of *L. lecanii* spore suspension, the number of nymphs obtained was 13.84, 16.82, 18.26 and 20.91 nymphs, respectively, whereas when leaf discs were mixed with 50, 25, 12.5 and 6.25% metabolites solution of *L. lecanii*, the number obtained was 9.53, 13.00, 14.06 and 16.94 nymphs, respectively.

Discussion

In this study, the infestation of potato plants with *A. gossypii* was higher than that of *M. persicae*. The cotton aphid, *A. gossypii* and the green peach aphid *M. persicae* are considered the important pests causing serious damage to vegetables crop especially potato plants (Barakat, 2018; Erdogan & Yldrm, 2017). In this research, the predator *C. undecimpunctata* was the most prevalent, followed by *C. Carnea, C. septempunctata* and *M. corollae*, and the least prevalent *was C. vicinia isis* during the 2020 and 2021 seasons. These results agreed with Nicoli *et al.*, (1994), who found that the most abundant coccinellid on watermelon, accounting for 61.2% of the total number of aphidophagous coccinellids in 1992 and 87.5% in 1993. Similarly, Al-Allan *et al.* (2004) stated that, the aphidophagous coccinellids were of particular importance and usually play an important natural role in regulating and/or suppressing the populations of their potential preys principally aphid species. Boraei *et al.* (2005) found that, chrysopid and coccinellid beetles were among the common predators in most Egyptian field crops. However, in Egypt, Barakat (2018) and Ali, *et al.* (2020) observed the predators *C. carnea, C. septumpunctata* and *Metasyrphus corollae* associated with pests infesting potato plants.

Entomopathogenic fungi used as alternative to pesticides in order to avoid the deleterious effects of pesticides. Butt *et al*. (2001) and Shi *et al*. (2008) used some of these fungi for the control of different insects including aphids. Similar to this study, many isolates of *Lecanicillium longisoprum,* previously identified as *L. lecanii* (V17), were found pathogenic to several aphid species such as *Brevicoryne brassicae*, *A. gossypii*, *Macrosiphum euphorbiae* and *M. persicae* (Kim, 2007). In this study, the effects of metabolites and spore suspension of *L. lecanii* were investigated at different concentrations on some biological aspects of some developmental stages of the peach aphid (*M. presicae*), and the results obtained were similar to those obtained by Kim *et al*. (2010) which revealed that degradation of insect body was observed in infiltrate treated aphids and the reduction of aphid population was more at high concentrations and high doses of filtrate treatments. Likewise, our results were in agreement with the results of Ibrahim *et al*. (2011). In addition, our results were in agreement with those of Saranya *et al*. (2010) who reported that *L. lecanii*, *M. anisopliae* and *B. bassiana* strains caused 100, 83.3 and 61.5% mortality, respectively, of cow pea aphid, *Aphis craccivora* after 7 days after treatment with a suspension of 10^7spores/ml.

Table 4. Biological control of the aphids, *Myzus persicae* and *Aphis gossypii* by *L. lecanii*.

Treatments name	Conc. ml	Mortality %	LC_{50} %	LC_{90} %	Slope	Relative potency LC_{50}	R.P. at LC_{90}	Tolerant rate at LC_{50}	T.R at LC_{90}
Myzus persicae									
V. lecanii	10^8	54.69 c							
spore suspension	10^6	43.03 d							
	10^4	33.71 ef	3.26×10^5	5.34×10^8	2.1	26.8×10^4	62.6×10^9	100	100
	10^2	29.02 g							
Control (water + Tween)	-	2.94	-	-	-	-	-	-	-
V. lecanii	50%	79.81 a							
metabolites	25%	68.95 b	14.4	346.4	9.3	100	100	0.0004	0.000006
	12.5%	35.27 e							
	6.25%	32.092 f							
Control (water)	-	2.85 h	-	-	-	-	-	-	-
$LSD_{0.05}$		1.99							
Aphis gossypii									
V. lecanii spore	108	44.65 c							
suspension	106	33.18 de	1.15×10^{12}	11.9×10^{12}	0.142	1.7×10^{-11}	2.14×10^{-11}	100	100
	104	21.60 f							
	102	16.94 g							
Control (water + Tween)	-	2.94	-	-	-	-	-	-	-
V. lecanii	50%	63.53 a							
metabolites	25%	56.31 b	20.02	255.5	1.16	100	100	5.7×10^{10}	4.7×10^{10}
	12.5%	34.77 d							
	6.25%	31.16 e							
Control (water)	-	2.85	-	-	-	-	-	-	-
$LSD_{0.05}$		2.4500							

Mean under each variety having different letters in the same raw denote a significant different ($p\leq 0.05$)

Table 5. Effect of *L. lecanii* spore suspension and metabolites on adult longevity, oviposition period and number of offspring/female of *M. persicae*.

Concentration (spores/ml)	Longevity (days)	Pre-oviposition period (days)	Oviposition period (days)	Post-oviposition period (days)	No. of nymphs/ female
***L. lecanii* spore suspension**					
10^2	12.880 a	0.85 b	9.57 ab	1.93 a	20.91 a
10^4	12.350 a	1.16 a	10.70 ab	1.02 a	18.26 a
10^6	11.879 ab	0.91 b	9.16 ab	1.81 a	16.82 b
10^8	10.380 b	1.40 a	8.48 b	0.56 c	13.84 c
Control	12.930 a	1.25 a	10.56 a	1.12 b	22.49 a
$LSD_{0.05}$	1.5295	0.2678	1.1348	0.2817	1.9706
***L. lecanii* metabolites**					
6.25%	11.73 a	1.92 a	8.65 b	1.16 a	16.94 a
12.5%	10.56 ab	1.79 b	8.13 bc	0.64 b	14.06 b
25%	9.688 ab	1.68 b	7.27 cd	0.738 b	13.0 b
50%	8.86 b	1.05 d	6.69 d	1.123 a	9.53 c
Control	11.83 a	1.19 c	10.36 a	0.28 b	18.36 a
$LSD_{0.05}$	1.7261	0.1242	1.0889	0.3764	1.8296

Means followed by the same letters in the same column are not significantly different at P=0.05.

It can be concluded from this study that the peach and cotton aphids were more tolerant to *L. lecanii* spore suspensions than to *L. lecanii* metabolites, which could be due to the metabolites composition especially the various degrading enzymes. These results were in agreement with these obtained by Bateman & Alves (2000) and Altre & Vandenberg (2001) who demonstrated that the use of fungal filtrate for the control of insects was the most effective method and was especially effective for those insects which had a short life cycle. Our findings were also similar to what has been obtained by Hanan *et al.* (2019) who demonstrated that *L. lecanii* filtrate contained toxic enzymes that contributed to the degredation of insect body.

Based on the results obtained in this study, it is suggested that *L. lecanii* can be applied as a biocontrol agent for aphids. This is in agreement with the results recently obtained by (Tuyelee *et al*., 2021), who showed that *L. lecanii* can be useful against aphid control and the mode of action of this fungus is the same as *M. anisopliae* and *B. bassiana* due to the production of specific metabolites toxic to insects. The present work successfully demonstrated the high efficiency of predators and the fungus *L. lecanii* as alternative to chemical insecticides against *A. gossypii* and *M. persicae* on potato crop in Egypt.

الملخص

لقمة، نهى حسن عصام، أحمد أمين أحمد صالح، سعيد عبد الفتاح محمود عامر ومحمد فرج زوره. 2023. فاعلية بعض المفترسات والفطر *Lecancillium lecanii* في مكافحة منّ القطن (*Aphis gossypii*) ومنّ الخوخ (*Myzus persicae*) على محصول البطاطس/البطاطا. مجلة وقاية النبات العربية، 41(2): 152–160. https://doi.org/10.22268/AJPP-041.2.152160

أجريت هذه الدراسة لتقييم فاعلية بعض المفترسات والفطر *Lecanicillium lecanii* في مكافحة منّ القطن (*Aphis gossypii*) ومنّ الخوخ (*Myzus persicae*) على محصول البطاطس/البطاطا. أوضحت النتائج أنّه كان لأعداد منّ القطن ذروتين على محصول البطاطس/البطاطا خلال موسمي الدراسة، وذلك في الأسبوع الثالث من شهري آذار/مارس ونيسان/أبريل خلال الموسمين الأول (2020) والثاني (2021)؛ كما أظهرت النتائج وجود ذروتين لمنّ الخوخ خلال موسمي الدراسة وذلك في الأسبوع الرابع من شهر آذار/مارس والثالث من شهر نيسان/أبريل خلال موسم 2020، وفي الأسبوع الثالث من شهري آذار/مارس ونيسان/أبريل خلال موسم 2021. كذلك تمّ حصر خمسة أنواع من المفترسات في حقول البطاطس/البطاطا، وهي: أبو العيد ذو الإحدى عشرة نقطة، وأسد المنّ، وأبو العيد ذو السبع نقاط، وحشرة السيرفس، وأبو العيد الأسود. وبيّنت النتائج أن للمفترسات ذروة واحدة خلال الأسبوع الثاني من شهر آذار/مارس (60 مفترس/25 ورقة) في الموسم الأول (2020)، في حين سجّل وجود ذروتين في الموسم الثاني (2021) خلال الأسبوع الثالث من شهر آذار/مارس والأسبوع الثاني من شهر نيسان/أبريل (53 و 38 مفترس/25 ورقة) على محصول البطاطس/البطاطا. وأوضحت النتائج أن للمعاملة الحيوية بنواتج الأيض الفطرية والمعلق البوغي لفطر *L. lecanii* تأثير على حشرات المنّ، فقد سجّل الفطر أعلى نسبة موت عند استخدام المعلق البوغي بتركيز 10^8 بوغ/مل، و50% من محلول نواتج الأيض الفطرية لفطر *L. lecanii* على كلٍّ من حشرتي منّ الخوخ ومنّ القطن بعد 8 أيام من المعاملة.

من ناحية أخرى، فقد تمّ تسجيل أعلى تأثير كامن لفطر *L. lecanii* في تقليل فترة طول عمر الحشرة وعدد أفراد الحوريات عند استخدام تركيز 50% من محلول نواتج الأيض الفطرية مقارنة باستخدام المعلق البوغي بتركيز 10^8 بوغ/مل على حشرات المنّ (منّ الخوخ ومنّ القطن).

كلمات مفتاحية: *A. gossypii*، *M. persicae*، مفترسات، البطاطا/البطاطس.

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Received: August 3, 2022; Accepted: October 31, 2022

تاريخ الاستلام: 2022/8/3؛ تاريخ الموافقة على النشر: 2022/10/31