Control of Some Date Palm Insect Pests by Using the Entomopathogenic Nematodes under Aswan Region Conditions, Egypt

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Abstract

Date palms were applied under Aswan field condition in the fruiting season of 2017 with the two entomopathogenic nematodes (EPNs), *Steinernema carpocapsae* and *Heterorhabditis bacteriophora* against palm scarab beetles *Phyllognathus* excavates, the red palm weevil *Rhynchophorus ferrugineus* and the frond palm borer *Phonapate frontalis* (Coleoptera) as well as the lesser date moth *Batrachedra amydraula*, date moth Ephestia calidella and the pomegranate butterfly *Viracola livia* (Lepidoptera). Reduction in the infestation with *Phyllognathus* excavates caused by *S. carpocapsae* and *H. bacteriophora* at the concentration of 4000 IJs/ml after eight weeks were100 and 70.0 %, respectively. It was clear that *S. carpocapsae* influence increased with the passing of the time in opposite to *H. bacteriophora*. As for *Rhynchophorus ferrugineus* reductions in the infestation caused by *S. carpocapsae* and *H. bacteriophora* at the concentration of 4000 IJs / ml after eight weeks were 91.0 and 34.2 %, respectively. It was also clear that *S. carpocapsae* influence increased gradually in the course of the investigation time in opposite to *H. bacteriophora*. The tested EPNs *S. carpocapsae* and *H. bacteriophora* reduced the infestation with *Phonapate frontalis* by 84.7 and 39.9%, respectively at the end of the investigation course (8 weeks after treatment). The tested EPN *S. carpocapsae* and *H. bacteriophora* behaved with Lepidoptera insects oppositely with *Coleopteran* whereas *H. bacteriophora* surpassed *S. carpocapsae* in reducing infestation with *Lepidoptera* insects except with *Ephestia calidella*. For example, after eight weeks from the application with 4000 IJs /ml of H. bacteriophora the reduction in infestation *with Batrachedra amydraula*, *Ephestia calidella* and *Viracola livia* were 85.5, 79.9 and 78.2% opposite to 81.8, 89.4 and 70.4 % reduction caused by *S. carpocapsae* at the concentration of 4000 IJs/ ml. with these insects, respectively.

Keywords: Date palm, insect pests, entomopathogenic nematodes (EPNs)

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Introduction

Several insects from different orders infesting date palms such as the red palm weevil *Rhynchophorus ferrugineus*, palm scarab beetles *Phyllognathus excavatus* , the frond palm borer *Phonapate frontalis* (Coleoptera) as well as the lesser date moth *Batrachedra amydraula*, date moth *Ephestia calidella* and the pomegranate butterfly *Viracola livia* (Lepidoptera). Red palm weevil *Rhynchophorus ferrugineus* (Olivier, 1790) (Coleoptera: Curculionidae) is becoming a serious problem in Mediterranean areas where it is well-adapted, and now is present even in the United States (California). The infestations are primarily in urban areas where chemical control is not advisable and millions of Euros are spent to control it. The effects of the entomopathogenic nematode *Steinernema carpocapsae*

(Nematoda: *Steinernematidae*) on mortality of R. ferrugineus larvae, were investigated (Manachini, 2013). Satheeja Santhi *et al*. (2015) tested the attraction of entomopathogenic nematodes *Steinernema carpocapsae* and *Heterorhabditis bacteriophora* to the red palm weevil (*Rhynchophorus ferrugineus*). Okil *et al*. (2000) studied the effect of *Phyllognathus excavatus* on date palms in Egypt and reported that the infestation with date palm scarab beetle increased 3.35 times in only two years. The activity of beetles was affected positively and significantly by the temperature, but was mostly negatively and significantly affected by the maximum relative humidity. Salah (2003) surveyed 2520 palms in Al Wahat region, Libya and reported that the percentage rates of broken green fronds due to the damage done by the frond palm borer *Phonapate frontalis* from May to August were in the range of 10.2, 11.1, 9.6, and 10.3 % respectively. The damage caused by pomegranate butterfly Viracola livia to date fruits was very severe with larvae penetration reaching 99 and 85% in the untreated palms (Sayed *et al*., 2010). This study aims to evaluate the combat of the date palm insects mentioned above by using the entomopathogenic nematodes *S. carpocapsae* and *H. bacteriophora* under Aswan field conditions.

Materials and methods

1. Propagation of the entomopathogenic nematodes

The entomopathogenic nematodes, *Steinernema carpocapsae* A11 strain and *Heterorhabditis bacteriophora* NC strain were reared in the laboratory of Plant Protection Department, Faculty of Agriculture, Minia University, on the host *Galleria mellonella* according to Dutky *et al*. (1964).

2. Field application

Five palms heavily naturally infested with different insects were chosen in Aswan region for each treatment. Each palm represented one replicate. Treatments were three concentrations of *S. carpocapsae* or *H. bacteriophora*. These concentrations were 1000, 2000 and 4000 IJs/ml. Each palm was sprayed in the mid of May 2017 with 10-liter water of nematode suspension or water free from nematodes as checked by a knap sprayer covering the palm and the soil beneath these palms in surrounded area 3 m in diameter. Each palm and soil beneath and twenty date fruits per bunch were examined before treatment and after two, four, six and eight weeks from application. The numbers of different insects or their symptoms were counted. This experiment was carried out during the fruiting season of 2017.

3. Statistical Analysis

Data were analyzed using SAS, 2004 software (SAS, 2004) Significance for the difference between reduction percentages of the insects' infestation was carried out according to the Chi-square test (P= 0.05).

Results and discussion

Data in Table (1) indicate the reduction percentages in the infestation with date palm scarab beetles *Phyllognathus excavatus* after the field treatments with *S. carpocapsae* or *H. bacteriophora* at different application rates. Infestation reduction ranged between 58.3 to 84.4, 64.3 to 89.8, 68.8 to 92.1 and 75.0 to 100% reduction after two, four, six and eight weeks from the application with rates ranging from 1000 to 4000 IJs / ml of *S. carpocapsae*, respectively. As for *H. bacteriophora* infestation reduction ranged between 72.0 to 87.5, 64.3 to 85.7, 58.3 to 75.0 and 58.3 to 70.0 % after two, four, six and eight weeks from the application with rates ranging between 1000 and 4000 IJs /ml. These data show that the reduction of date palm scarab beetles was increased with the increase of the time from *S. carpocapasae* application in opposite with *H. bacteriophora* that may be due to the persistence of *S. carpocapasae* that surpassed *H. bacteriophora* persistence that attributed to the encapsulation occurred to *H. bacteriophora* with insects of coleopteran than other entomopathogenic nematodes as mentioned by Ebrahimi *et al*. (2011). Statistical analysis showed significant differences between *S. carpocapsae* effects that surpassed *H. bacteriophora* at all tested concentration levels.

Table (2) explain the reduction in the infestation with red palm weevil after, two, four and eight weeks post application with *S. carpocapsae* recording reduction in ascending with the passing of the time after application in opposite with *H. bacteriophora* whereas reduction of infestation was in descending obviously with the passing of the time post-treatment. The reduction of the infestation with red palm weevil ranged between 61.1 to 83.8% with *S. carpocapsae* at the rate of 1000 IJs / ml and between 80.6 to 90.0% at the rate of 4000 IJs / ml after two and eight weeks from application, respectively. While reductions in infestation with red palm weevil by using *H. bacteriophora* were ranged between 53.3 to 30.0% and between 65.4 to 34.2% at the concentrations of 1000 and 4000 IJs/ ml after two and four weeks from treatment, respectively. These results throw light on a problem that may happen with using *H. bacteriophora* against the red palm weevil in contrary to *S. carpocapsae*. Manachini *et al*. (2013) dissolved this mystery when mentioned that *S. carpocapsae* was not encapsulated by *R. ferrugineus hemocytes*. Statistical analysis showed significant differences between *S. carpocapsae* effects that surpassed *H. bacteriophora* at all tested concentration levels.

Data in Table (3) show the effect of the field application with entomopathogenic nematodes on frond palm weevil. Reduction percentages declined with the application by *H. bacteriophora* with the passing of the time from 57.8 to 37.4 and from 73.5 to 39.9 % with the low and high concentrations, 1000 and 4000 IJs, respectively. While these reduction percentages by using *S. carpocapsae* increased in the course of the investigation time (8 weeks) from 61.3 to 75.2 and from 75.2 to 84.7 at the low and high concentrations, 1000 and 4000 IJs, respectively.

Table (1): Evaluation of the field application with entomopathogenic nematodes against date palm scarab beetles *Phyllognathus excavatus* in Aswan region during 2017 season.

Nematode concentration	Mean number of *Phyllognathus excavatus* (Scarabaeidae) or its symptoms								
	Before application	After 2 weeks of application	Reduction (%)	After 4 weeks of application	Reduction (%)	After 6 weeks of application	Reduction (%)	After 8 weeks of application	Reduction (%)
***S. carpocapsae* 1000 IJs/ml**	6	4	58.3 c	3	64.3 c	2	68.8 c	3	75.0 b
***S. carpocapsae* 2000 IJs / ml**	8	2	84.4 a	1	91.1 a	1	92.1 a	1	93..8 a
S.carpocapsae 4000 IJs / ml	7	2	84.4 a	1	89.8 a	1	92.1 a	0	100 a
***H. bacteriophora* 1000 IJs / ml**	6	2	75.0 b	3	64.3 c	4	58.3 c	5	58.3 c
***H. bacteriophora* 2000 IJs / ml**	7	2	82.1 a	2	79.6 b	3	73.2 b	5	64.3 c
***H. bacteriophora* 4000 IJs / ml**	5	1	87.5 a	1	85.7 ab	2	75.0 b	3	70.0 b
Check	5	8		7		8		10	

*Reduction percentages were estimated using Henderson and Tilton formula (1955)

**Reduction percentages followed by the same litter don't differ significantly according to Chi square test (P= 0.05)

Table (2): Evaluation of the field application with entomopathogenic nematodes against date palm red weevil *Rhynchophorus ferrugineus* in Aswan region during the 2017 season

Nematode concentration	Mean number of *Rhynchophorus ferrugineus* (Curculionidae) or its symptoms								
	Before application	After 2 weeks of application	Reduction (%)	After 4 weeks of application	Reduction (%)	After 6 weeks of application	Reduction (%)	After 8 weeks of application	Reduction (%)
***S. carpocapsae* 1000 IJs/ml**	10	83.8 a	3	80.9 a	3	74.5b	4	61.1 bc	5
***S. carpocapsae* 2000 IJs / ml**	11	90.2 a	2	88.4 a	2	82.6 ab	3	78.8 a	3
S.carpocapsae 4000 IJs / ml	12	91.0 a	2	89.4 a	2	89.4 a	2	80.6 a	2
***H. bacteriophora* 1000 IJs / ml**	10	30.0 b	13	42.7 c	9	49.1 c	8	53.3 c	6
***H. bacteriophora* 2000 IJs / ml**	13	33.7 b	16	51 bc	10	56.0 c	9	64.1 b	6
***H. bacteriophora* 4000 IJs / ml**	9	34.2 b	11	57.6 b	6	57.6 c	6	65.4 b	4
Check	7		13		11		11		9

*Reduction percentages were estimated using Henderson and Tilton formula (1955)

**Reduction percentages followed by the same litter don't differ significantly according to Chi square test (P= 0.05)

Table (3): Evaluation of the field application with entomopathogenic nematodes against the frond palm borer *Phonapate frontalis* in Aswan region during the 2017 season

Nematode concentration	Mean number of *Phonapate frontalis* (Bostrichidae) or its symptoms								
	Before application	After 2 weeks of application	Reduction (%)	After 4 weeks of application	Reduction (%)	After 6 weeks of application	Reduction (%)	After 8 weeks of application	Reduction (%)
***S. carpocapsae* 1000 IJs/ml**	75.2 b	4	71.1 b	4	71.1 b	4	61.3 b	5	12
***S. carpocapsae* 2000 IJs / ml**	82.4 a	3	80.0 a	3	80.0 a	3	71.4 a	4	13
S.carpocapsae 4000 IJs / ml	84.7 a	3	82.7 a	3	82.7 a	3	75.2 a	4	15
***H. bacteriophora* 1000 IJs / ml**	37.4 c	9	44.8 d	7	52.7 c	6	57.8 b	5	11
***H. bacteriophora* 2000 IJs / ml**	35.3 c	11	60.0 c	6	60.0 bc	6	64.3 b	5	13
***H. bacteriophora* 4000 IJs / ml**	39.9 c	11	62.9 c	6	69.0 b	5	73.5 a	4	14
Check		17		15		15		14	13

*Reduction percentages were estimated using Henderson and Tilton formula (1955)

**Reduction percentages followed by the same litter don't differ significantly according to Chi square test (P= 0.05)

Results of controlling the lesser date moth *Batrachedra amydraula* by *entomopatogenic nematodes* are explained in Table (4). The entomopathogenic nematode *H. bacteriophora* surpassed *S. carpocapsae* in reducing the infestation with the lesser date moth. These reductions by *H. bacteriophora* increased with the increasing of nematode concentration. The high reduction (94.8%) was realized with the concentration of 4000 IJs of *H. bacteriophora* opposite to the low reduction (68.0 %) that was attained with the low concentration of *S. carpocapsae* after eight weeks from the application.

Table (5) indicates the high susceptibility of *Ephestia calidella* to entomopathogenic nematodes especially *S. carpocapsae* and this result was previously reported by the first record by Dutky and Hough (1955) who mentioned that *Ephestia* was very susceptible to *Neoaplectana carpocapsae*. A high reduction percentage (95.8%) was recorded with 4000 IJs of S. carpocapsae after one week from application opposite to the low reduction percentage, 65.3% recorded after eight weeks from applying with *H. bacteriophora* at 1000 IJs concentration.

Control of the pomegranate butterfly *Viracola livia* on date palm fruit was carried out previously by different insect control regimes without entomopathogenic nematodes. Here as shown in Table (6) the entomopathogenic nematodes *H. bacteriophora* and *S. carpocapsae* were applied under the field condition revealing a high controlling impact of 92.8% by *H. bacteriophora* after one week from the application at the concentration of 4000 IJs. This reduction gradually declined to reach 78.2 % in the eighth week after treatment. Other nematode species *S. carpocapsae* gave less reduction of infestation in the eighth week after treatment especially recording a 59.7 reduction percentage.

Table (4): Evaluation of the field application with entomopathogenic nematodes against lesser date moth *Batrachedra amydraula* in Aswan region during the 2017 season

Nematode concentration	Mean number of *Batrachedra amydraula* (Momphidae, Lepidoptera) or its symptoms								
	Before application	After 2 weeks of application	Reduction (%)	After 4 weeks of application	Reduction (%)	After 6 weeks of application	Reduction (%)	After 8 weeks of application	Reduction (%)
***S. carpocapsae* 1000 IJs/ml**	68.0 c	10	74.2 b	7	77.8 b	6	79.1b	5	25
***S. carpocapsae* 2000 IJs / ml**	73.3 bc	6	79.5 ab	4	79.5 b	4	82.6 b	3	18
S.carpocapsae 4000 IJs / ml	81.8 a	5	83.2 a	4	83.2 ab	4	85.8 a	3	22
***H. bacteriophora* 1000 IJs / ml**	75.6 bc	7	75.9 b	6	79.9 b	5	86.3 a	3	23
***H. bacteriophora* 2000 IJs / ml**	78.9 ab	5	80.1 a	4	85.4 ab	3	89.0 a	2	19
***H. bacteriophora* 4000 IJs / ml**	85.5 a	4	86.1 a	3	90.8 a	2	94.8 a	1	20
Check		30		26		26		23	24

*Reduction percentages were estimated using Henderson and Tilton formula (1955)

**Reduction percentages followed by the same litter don't differ significantly according to Chi square test (P= 0.05)

Table (5): Evaluation of the field application with entomopathogenic nematodes against date moth *Ephestia calidella* in Aswan region during the 2017 season

Nematode concentration	Mean number of *Ephestia calidella* (Pyralidae, Lepidoptera) or its symptoms								
	Before application	After 2 weeks of application	Reduction (%)	After 4 weeks of application	Reduction (%)	After 6 weeks of application	Reduction (%)	After 8 weeks of application	Reduction (%)
***S. carpocapsae* 1000 IJs/ml**	68.0 c	10	74.2 b	7	77.8 b	6	79.1b	5	25
***S. carpocapsae* 2000 IJs / ml**	73.3 bc	6	79.5 ab	4	79.5 b	4	82.6 b	3	18
S.carpocapsae 4000 IJs / ml	81.8 a	5	83.2 a	4	83.2 ab	4	85.8 a	3	22
***H. bacteriophora* 1000 IJs / ml**	75.6 bc	7	75.9 b	6	79.9 b	5	86.3 a	3	23
***H. bacteriophora* 2000 IJs / ml**	78.9 ab	5	80.1 a	4	85.4 ab	3	89.0 a	2	19
***H. bacteriophora* 4000 IJs / ml**	85.5 a	4	86.1 a	3	90.8 a	2	94.8 a	1	20
Check		30		26		26		23	24

*Reduction percentages were estimated using Henderson and Tilton formula (1955)

**Reduction percentages followed by the same litter don't differ significantly according to Chi square test (P= 0.05)

Table (6): Evaluation of the field application with entomopathogenic nematodes against pomegranate butterfly *Virachola livia* in Aswan region during 2017 season

Nematode concentration	Mean number of *Virachola livia* (Lycaenidae, Lepidoptera) or its symptoms								
	Before application	After 2 weeks of application	Reduction (%)	After 4 weeks of application	Reduction (%)	After 6 weeks of application	Reduction (%)	After 8 weeks of application	Reduction (%)
***S. carpocapsae* 1000 IJs/ml**	68.0 c	10	74.2 b	7	77.8 b	6	79.1b	5	25
***S. carpocapsae* 2000 IJs / ml**	73.3 bc	6	79.5 ab	4	79.5 b	4	82.6 b	3	18
S.carpocapsae 4000 IJs / ml	81.8 a	5	83.2 a	4	83.2 ab	4	85.8 a	3	22
***H. bacteriophora* 1000 IJs / ml**	75.6 bc	7	75.9 b	6	79.9 b	5	86.3 a	3	23
***H. bacteriophora* 2000 IJs / ml**	78.9 ab	5	80.1 a	4	85.4 ab	3	89.0 a	2	19
***H. bacteriophora* 4000 IJs / ml**	85.5 a	4	86.1 a	3	90.8 a	2	94.8 a	1	20
Check		30		26		26		23	24

*Reduction percentages were estimated using Henderson and Tilton formula (1955)

**Reduction percentages followed by the same litter don't differ significantly according to Chi square test (P= 0.05)

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مكافحة بعض الأفات الحشرية لنخيل البلح بإستخدام النيماتودا الممرضة للحشرات تحت ظروف منطقة أسوان، مصر

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الملخص العربي

تمت معاملة نخيل البلح فى منطقة أسوان فى موسم الإثمار 2017 بالنيماتودا الممرضة للحشرات إشتاينرنيما كاربوكابسا وهيتيرورابديتيس باكتيروفورا ضد الحشرات غمدية الأجنحة وهى جعل النخيل، سوسة النخيل الحمراء، ثاقبة العراجين أيضا بعض الحشرات من حرشفية الأجنحة وهى فراشة النخيل الصغرى وفراشة النخيل و أبو دقيق الرمان وأظهرت النتائج أن إجراء المعاملة بكل من إشتاينرنيما كاربوكابسا وهيتيرورابديتس باكتيريوفورا عند أعلى تركيز وهو 4000 طور معدى / مل أعطى نسب خفض فى الإصابة بجعل النخيل (100،70 %) على التوالى بعد ثمان أسابيع من المعاملة ، وإتضح أن مع النيماتودا إشتاينرنيما كاربوكابسا حدث تزايد فى التأثير مع مرور الوقت على العكس منه فى حالة النيماتودا هيتيرورابديتيس باكتيريوفورا. إستخدام النيماتودا الممرضة لمكافحة سوسة النخيل الحمراء أعطى نسب خفض فى الإصابة بهذه الآفة بعد ثمان أسابيع عند تركيز 4000 طور معدى / مل لكل من إشتاينرنيما كاربوكابسا وهيتيرورابديتيس باكتيروفورا بمقدار (91، 34.2 %) على التوالى وكذلك كان تأثير إشتاينرنيما كاربوكابسا متزايداً مع مرور الوقت على العكس فى حالة هيتيرورابديتيس باكتيريوفورا. أما فى حالة تقدير الإصابة بثاقبة العراجين فإن نسب الخفض عند أعلى تركيز وهو 4000 طور معدى وفى نهاية فترة الفحص وهى ثمان أسابيع من المعاملة كانت (84.7، 39.9 %) على التوالى. تأثير المعاملة بالنيماتودا الممرضة للحشرات فى هذه الدراسة على الحشرات التابعة لرتبة حرشفية الأجنحة التى تصيب نخيل البلح كان واضحاً حيث أظهرت خفض فى الإصابة بهذه الحشرات عند المعاملة بأعلى تركيز (4000 طور معدى/ مل) وفى نهاية فترة الفحص (ثمان أسابيع) وكانت نسب الخفض لكل من فراشة البلح الصغرى و فراشة البلح و أبو دقيق الرمان (85.5، 79.9، 78.2 %) عند إستخدام هيتيرورابديتيس باكتيريوفورا ونسب الخفض 81.8 و 89.4 و 70.4 % على التوالى.

الكلمات الدالة: النخيل، الآفات الحشرية، النيماتودا الممرضة للحشرات (EPNs)