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Joint Action of Spinosad and Sweet Almond Oil Mixture against the Saw Toothed Grain Beetle, *Oryzaephilus surinamensis* (L.)

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Abstract

Bioassay tests were conducted to determine the combined action of spinosad and sweet almond oil against the adults of *Oryzaephilus surinamensis* (Coleoptea, Silvanidae), at 28 ±2°C and 65±5% RH and 21 days exposure period. The tests were applied at different concentrations, 6 for spinosad, 5 for sweet almond oil and 4 for their mixtures. The results indicated that the mortality of tested insect increased with increasing in the concentration and the exposure period. The mortality of *O. surinamensis* adults reached 98.0% using a concentration of 1×10^{-3} % (w / w) of spinosad on the day 21 of the exposure. Data also revealed that, the spinosad pesticide was very toxic for the treated insect, and it gave LC_{50} of 8.6×10^{-4} % (w/w), for the adults of *O. surinamensis* (after 7 days exposure period). The mortality effect of sweet almond oil on *O. surinamensis* adults reached 98.0% at concentration of 5% (v/w) on the day 21 of exposure. Data showed that, the sweet almond oil gave LC_{50} of 4.521% (v/w), for the adults of *O. surinamensis* (after 7 days exposure period). The efficacy of the two tested compounds as a mixture at the various concentrations indicated that spinosad and sweet almond oil mixture of LC_{20} spinosad + LC_{20} sweet almond was the most effective compared with other mixtures against *O. surinamensis* on the basis of co-toxicity factor.

Key words: spinosad, sweet almond, co-toxicity factor, combination, *Oryzaephilus surinamensis*.

Introduction

Cereals have great nutritional value in developing countries but due to attack of pests, a loss of 20-60% has been reported (**Arthur and Throne 2003**). Stored products are attacked by different insect species and mites. These pests caused contamination of food commodities and serious quantitative and qualitative losses (**Rajendran and Sriranjini 2008**). The harmful entomofauna includes the saw-toothed grain beetle *O. surinamensis* (Coleoptera: Silvanidae), which is the subject of this study. It is currently a very common pest, and one of the most frequently found pests of grain and cereal products. Compared with other pests of stored-products, this species does not feed very intensively. However, because it lives in the bottom layers of infested food products, it is particularly difficult to detect. The species is a cosmopolitan store pest and is found in various products and habitats, particularly in mills, fodder storages, and shops (**Sinha and Watters 1985; Trematerra and Sciarretta 2004; Laszczak-Dawid *et al.* 2008**). The saw-toothed grain beetle is a polyphagous species that feeds primarily on ground cereal products, but also dried fruits and seeds, nuts, yeasts, sugar, tobacco, dried meat, and less often on processed foodstuffs, such as bread and confectioneries. Conventional insecticides such as pyrethroids, organophosphates and fumigants such as phosphine products play an important role for controlling stored product insects. However, extensive use of those fumigants for decades caused some environmental and health problems including insect resistance (**Pimentel *et al.* 2010**), insecticide residues in food, toxic effects on human and animals. Thus, it is crucial to find new alternatives control methods for stored products.

One of the newest active ingredients (AIs) that is registered for direct application on grains is spinosad, which consists of secondary metabolites produced by the bacterium *Saccharopolyspora spinosa* (Bacteria: Actinomycetales). Spinosad belongs to bio-insecticides, which are suitable for use in Integrated Pest Management strategies. Spinosad has been successfully evaluated against several insect species on several commodities (**Hertlein *et al.* 2011**).This pesticide has low mammalian toxicity and can be used at relatively low doses **(Thompson *et al.* 2000).**

The use of essential oils extracted from aromatic plants to control the stored product insects has been investigated and is well documented. Many spices and herbs, and their extracts, are known to possess insecticidal properties that are frequently present in the essential oil fraction (**Brattsten 1983; Schmidt *et al.* 1991**). The toxicity of a large number of essential oils and their constituents has been evaluated against a number of stored-product insects. Over the past 15 years, interest in botanical insecticides has increased as a result of environmental concerns and insect populations becoming resistant to conventional chemicals. The insecticidal activity of essential oils and plant extracts against different stored-product pests has been evaluated (**Shaaya *et al.* 1991; Sarac and Tunc 1995; Kim *et al.* 2003; Lee *et al.* 2003**).

The present study aimed to evaluate the efficacy of the bio-pesticide spinosad and the sweet almond plant oil either singly or as binary mixtures at different mixing concentrations against the adults of *O. surinamensis* at 28 ± 2°C and 65±5% RH in the laboratory.

Materials and Methods

Insect

The stored product insect species, namely the saw toothed grain beetle, *Oryzaephilus surinamensis* (L) (Silvanidae, Coleoptera) was used in this study. Tests were performed in the stored product insect laboratory at the Plant Protection Department, Faculty of Agriculture Benha University.

Rearing technique of stock culture for supplying the development insect stage required for the tests

The insect was reared in glass jars (approx. 500 ml) containing about 200g of sterilized and conditioned crushed wheat grains. The glass jars were covered with muslin. Insect cultures were kept under controlled conditions of 28±2°C and 65±5% RH at the rearing room of the laboratory. Wheat grains were treated by freezing at -18°C for 2 weeks before application to eliminate any possible infestation by any insect species. About 1000 adults of insect (1-2 weeks old) were introduced into the jars for laying eggs and then kept at 28±2°C and 65±5% RH, three days later, insect was separated from the food, and the jars were kept again at the controlled conditions in the rearing room. This procedure was repeated several times in order to obtain large number of the adults needed to carry out the experiments during this study. The foods in the jars were renewed when it was necessary.

Compounds tested

1. Bio-insecticide (spinosad)

Spinosad contains a mix true of two spinosyns, spinosyn A, (the major component), and spinosyn D (the minor component), in a roughly 17:3 ratio.
Spinosad formulation was spintor (24% SC), which was produced by Dow Agro – Sciences.

2. Botanical oil (sweet almond)

Sweet almond botanical oil (*Prunus amygdalus*) was used during these investigations, which belongs to plant family; Rosaceae. The oil was bought from the Department of oil, National Research Centre, Egypt.

Bioassay tests

Twenty adults of *O. surinamensis*, (1-2 weeks old) were added to the treated crushed wheat grains. For the control, the food was treated without the tested compound only. Three replicates were carried out for each treatment. The treated crushed wheat grains were kept at the same rearing conditions of 28±2°C and 65 ±5% RH. Mortalities were recorded at 1, 2, 3, 5, 7, 10, 14 and 21days after treatment. Mortality percentages were corrected by **Abbott's formula (1925).**

Treatments

1. Bio-insecticide (spinosad)

Crushed wheat grains (10g) were treated with 1ml of various insecticide (spinosad) concentrations, mixed well to obtain the following concentrations: 1×10^{-3}, 7.5×10^{-4}, 5×10^{-4}, 2.5×10^{-4}, 1×10^{-4} and 5×10^{-5} % (w/w).

2. Botanical oil (sweet almond)

45 ml of the pure oil was diluted with 50 ml water to obtain 90% (v/v) stock concentration which diluted to obtain 80, 70, 60, 50 and 40 % (v/v) concentrations. From each concentration, one ml was taken and added to 10g crushed wheat grains to obtain 8, 7, 6, 5and 4% (v/w) concentrations.

3. Combined action of spinosad and the sweet almond oil

1 ml of a mixture [(LC_{20} spinosad: LC_{20} oil) or (LC_{30} spinosad: LC_{30} oil) or (LC_{50} spinosad: LC_{10} oil) and (LC_{10} spinosad: LC_{50} oil)] was added to 10 g crushed wheat grains (**Table 1**).

Table 1. Concentrations (%) used in the bioassay mixture tests on the adults of *O. surinamensis***.**

Compound			Concentration(%) used
Spinosad	**Alone**		**1.3×10^{-4} , 2.7×10^{-4}, 8.6×10^{-4} and 4.8×10^{-5} (w/w)**
Sweet almond			**3.9, 4.1, 3.68 and 4.5 (v/w)**
Spinosad + Sweet almond	**Mixture**	**A**	**1.3×10^{-4} (w/w) + 3.9 (v/w)**
		B	**2.7×10^{-4} (w/w) + 4.1 (v/w)**
		C	**8.6×10^{-4} (w/w) + 3.68 (v/w)**
		D	**4.8×10^{-5} (w/w) + 4.5 (v/w)**

Where: A: LC_{20} spinosad + LC_{20} oil. B: LC_{30} spinosad + LC_{30} oil.
C: LC_{50} spinosad + LC_{10} oil. D: LC_{10} spinosad + LC_{50} oil.

Calculation of Joint Action:

For the evaluation of the joint action of the mixture of spinosad and sweet almond oil, the following equation was adopted as reported by **Mansour *et al.* (1966)**:

Co-toxicity Factor = [(% Observed Mortality - % Expected Mortality) / % Expected Mortality] × 100

This factor was used to classify the results into three categories. A positive factor of +20 or more meant potentiation effect, a negative factor of –20 or more meant antagonism, and any intermediate value, i.e. between +20 and –20 was considered an additive effect.

Statistical analysis

A probit computer program of **Noack and Reichmuth (1978)** and **Finney (1971)** was used for determining the dosage mortality response for the bio-insecticide (spinosad), botanical oil (sweet almond) and their mixtures.

Results and Discussion

1-Mortality effect of the bio-insecticide (spinosad) and sweet almond botanical oil against the adults of *Oryzaephilus surinamensis* at 28 ± 2°C and 65±5% RH.

In **Table (2)** the results showed that the mortality increased by increasing the spinosad concentration and period of exposure. At concentration 1×10^{-3} % (w/w) the adult mortality of *O. surinamensis*, after 2 day exposure period was 21.5%, while the mortality increased after 21 days post treatment to reach 98.0%. At 7.5×10^{-4} % (w/w) the mortality was 11.5% after 2 day exposure period and increased after 21 days to 87.5 %. At 5×10^{-4} % (w/w) the mortality was 10.0% after 2 day exposure period and increased after 21 days post treatment to 70.0%. At 2.5×10^{-4} % (w/w) the mortality was 5.0% after 2 day exposure period and increased after 21 days post treatment to 60.0%. At 1×10^{-4} % (w/w) the mortality was 2.5% after 2 day exposure period and increased after 21 days post treatment to 35.0 %. At 5×10^{-5} % (w/w) the mortality was 1.5% after 2 day exposure period and increased after 21 days post treatment to 32.5 %.

Results listed in **Table (3)** indicated that the mortality increased by increasing the concentration and period of exposure. At concentration of 8% (v/w), the adult mortality of *O. surinamensis* after 1day exposure period was 50.0%, while the mortality increased after 3 days post treatment to reach 100.0%. At 7% (v/w), the mortality was 42.5% after 1 day exposure period and increased after 3 days to 100.0%. At 6% (v/w), the mortality was 40.0% after 1 day exposure period and increased after 10 days post treatment to 100.0%. At 5% (v/w), the mortality was 10.0% after 1 day exposure period and increased after 21 days post treatment to 98.0%. At 4% (v/w), the mortality was 0.0% after 1 day exposure period and increased after 21 days post treatment to 17.5%.

Table 2. Efficacy of spinosad against *O. surinamensis* adults at 28 ± 2°C and 65±5 RH**.**

Concentration % (w/w)	Accumulative adult mortality (%) after indicated days							
	1	2	3	5	7	10	14	21
1×10^{-3}	0.0	21.5	33.0	60.0	65.0	70.0	78.0	98.0
7.5×10^{-4}	0.0	11.5	25.0	35.0	37.5	43.0	53.0	87.5
5×10^{-4}	0.0	10.0	25.0	35.0	35.7	42.5	50.0	70.0
2.5×10^{-4}	0.0	5.0	18.0	22.5	25.0	27.5	35.0	60.0
1×10^{-4}	0.0	2.5	10.0	18.0	20.0	20.0	27.5	35.0
5×10^{-5}	0.0	1.5	10.0	12.5	17.5	20.0	25.0	32.5

Table 3. Efficacy of sweet almond botanical oil against *O. surinamensis* adults at 28±2°C and 65±5 RH.

Concentration % (v/w)	Accumulative adult mortality (%) after indicated days							
	1	2	3	5	7	10	14	21
8	50.0	90.0	100.0	100.0	100.0	100.0	100.0	100.0
7	42.5	87.5	100.0	100.0	100.0	100.0	100.0	100.0
6	40.0	78.0	85.0	95.0	95.0	100.0	100.0	100.0
5	10.0	40.0	58.0	85.0	95.0	98.0	98.0	98.0
4	0.0	2.5	5.0	5.0	12.5	12.5	15.0	17.5

2. Toxicity parameters of the tested bio-insecticide (spinosad) and sweet almond botanical oil against the adults of *Oryzaephilus surinamensis* at 28 ± 2°C and 65±5 RH.

The lethal concentrations of spinosad to adults of *O. surinamensis* are shown in **Table (4),** the results indicated that after 7 days post-treatment for adults , the LC_{10} was 4.8×10^{-5} % (w/w), the LC_{20} was 1.3×10^{4} % (w/w), the LC_{30} was 2.7×10^{-4} % (w/w), the LC_{50} was 8.6×10^{-4} % (w/w), the LC_{90} was 1.5×10^{-2} % (w/w) and LC_{95} was 3.5×10^{-2} % (w/w). The results showed also that spinosad was very effective against *O. surinamensis.* Spinosad has also been tested against stored grain insect pests by other research workers. **Toews and Subramanyam (2003)** evaluated the contact toxicity of spinosad to adults

Tribolium castaneum. Mortality of *T. castaneum* ranged 12 to 48% when adults were exposed to 0.001–0.79 mg cm^{-2}. **Nikpay (2007)** found that mortality of *T. castaneum* was 65% when treated with spinosad at the rate of 1 mg /kg of wheat. Progeny production was significantly lower in comparison with the untreated ones. In other studies, **Yousefnezhad-Irani and Asghar (2007)** reported that young larvae and adults of *T. castaneum* were more susceptible to spinosad than the old larvae. **Daglish *et al*. (2003)** indicated that an application of 1 mg/kg of spinosad in wheat may be suitable for controlling *R. dominica* strains that are resistant to organophosphates, pyrethroids or the insect growth regulator methoprene. **Fang and Subramanyam (2003)** revealed that all adults of *Rhyzopertha dominica* were killed when treated with spinosad at the rate of 0.1 and 1 mg/kg of wheat. **Huang and subramanyam (2007)** found that on spinosad-treated corn, adult mortality of *Cryptolestes ferrugineus, Rhyzopertha dominica*, *Oryzaephilus surinamensis*, *Sitophilus oryzae*, and *S. zeamais* was > 98% at 1 and 2 mg/kg after 12 days and almost complete suppression of progeny production and kernel damage of all species after 49 days. Also, they showed that a single application of spinosad at 1 mg/kg is effective for managing common stored-grain insects, including *R. dominica,* for at least 6 months. According to the above said authors spinosad is an effective grain protectant and also have great effect on progeny reduction of stored grain insect pests.

The lethal concentrations of sweet almond oil to adults of *O. surinamensis* are shown in **Table (4)**, the results revealed that the corresponding values at 7 days were 3.681% (v/w) at LC_{10}, 3.941% (v/w) at LC_{20}, 4.156% (v/w) at LC_{30}, 4.521% (v/w) at LC_{50}, 5.551% (v/w) at LC_{90} and 5.884% (v/w) at LC_{95}.

The mortality rate of *O. surinamensis* adults is associated with the concentrations of oil and the period of exposure, where the mortality rate is increased by increasing the concentration of tested oil and period of exposure.

The results coincide with the reports of other authors investigating the biological activity of botanical oils and other plant products towards cereal storage pests. Oils obtained from different plants have a different composition and concentration of components, which is connected with a varied effect on insects; they can act as insect repellents, discourage from feeding, as well as affect the growth process, disturbing or inhibiting it, which can lead to death **(Jilani *et al*.1988; Shaaya *et al*.1991; Ho *et al*.1996 and Regnault-Roger, 1997).**

Table 4. The lethal concentrations of the tested bio-pesticide spinosad and sweet almond oil against the adults of *Oryzaephilus surinamensis* at 28 ± 2°C and 65±5 RH**.**

Exposure period (days)	Lethal concentrations and their 95% confidence limits						Slope ± SD	R
	LC_{10}	LC_{20}	LC_{30}	LC_{50}	LC_{90}	LC_{95}		
Spinosad % (w/w)								
7	4.8×10^{-5} (2×10^{-5} - 1×10^{-4})	1.3×10^{-4} (5.8×10^{-5} - 2.9×10^{-4})	2.7×10^{-4} (1.2×10^{-4} - 5.9×10^{-4})	8.6×10^{-4} (3.8×10^{-4} - 1.9×10^{-3})	1.5×10^{-2} (6.8×10^{-3}– 3.4×10^{-2})	3.5×10^{-2} (1.5×10^{-2}–7.8×10^{-2})	1.04±0.96	0.780
Sweet almond oil % (v/w)								
7	3.681 (3.389-3.998)	3.941 (3.637-4.290)	4.156 (3.827-4.513)	4.521 (4.163-4.909)	5.551 (5.112-6.029)	5.884 (5.418-6.390)	16.35±0.06	0.798

SD=Standard deviation.
R= Correlation coefficient of regression line.

3. Efficacy of combined action of the bio-pesticide spinosad and sweet almond oil against the adults of *Oryzaephilus surinamensis* at 28±2°C and 65±5% RH.

The results of the effect of efficacy of combined action of spinosad pesticide and sweet almond oil on the adult mortality of *O. surinamensis* at 28 ± 2°C and 65±5% RH were presented in **Tables (5, 6, 7 and 8)**. The results showed that the mortality increased by increasing the concentration and period exposure of the mixture. At concentration LC_{20} (spinosad 1.3×10^{-4} % (w/w) +sweet almond 3.9% (v/w)) the adult mortality of *O. surinamensis* after 2 day exposure period was 10.0% , while the mortality increased after 21 days post treatment to reach 76.5% **(Table 5)**. At LC_{30} (spinosad 2.7×10^{-4} % (w/w) +sweet almond 4.1% (v/w)) the mortality was 15.0 % after 2 day exposure period and increased after 21 days to 92.5% **(Table 6)**. At concentration LC_{50} (spinosad 8.6×10^{-4} % (w/w)) + LC_{10} (sweet almond 3.68% (v/w)) the adult mortality of *O. surinamensis* after 2 day exposure period was 20.0%, while the mortality increased after 10 days post treatment to reach 85.0% **(Table 7)**. At LC_{10} (spinosad 4.8×10^{-5} %

(w/w)) + LC_{50} (sweet almond 4.5% (v/w)) the mortality was 31.5 % after 2 day exposure period and increased after 10 days to 100.0% **(Table 8)**.

The Co-toxicity factors of spinosad pesticide at LC_{20} 1.3×10^{-4} % (w/w) and LC_{20} 3.9% (v/w). Potentiation effect of sweet almond against *O. surinamensis* adults during exposure periods was observed in **Table (5)**, the values of Co-toxicity factors ranged between 22.6 and 100.0

The Co-toxicity factors of spinosad pesticide at (LC_{30}) 2.7×10^{-4} % (w/w) and (LC_{30}) 4.1% (v/w) sweet almond against *O. surinamensis* adults during exposure period revealed that an additive or potentiation effect was observed in **Table (6)**, the values of Co-toxicity factors ranged between -14.3 and 35.2

The Co-toxicity factors of spinosad pesticide at (LC_{50}) 8.6×10^{-4} % (w/w) and (LC_{10}) 3.68% (v/w) sweet almond oil against *O. surinamensis* adults during exposure period revealed that an additive or potentiation effect was observed in **Table (7)**, the values of Co-toxicity factors ranged between 0.0 and 60.7

The Co-toxicity factors of spinosad pesticide at (LC_{10}) 4.8×10^{-5} % (w/w) and (LC_{50}) 4.5% (v/w) sweet almond oil against *O. surinamensis* adults during exposure period revealed that an additive or potentiation and antagonism effect was observed in **Table (8),** the values of Co-toxicity factors ranged between -100.0 and 65.7

Accordingly, the mixture of LC_{20} spinosad: LC_{20} sweet almond was the most effective compared with other mixtures against *O. surinamensis*, where the co-toxicity value of this mixture on the second day of treatment was the highest (100.0).

Regarding the additive and potentiation effects of the results of the Co-toxicity of the spinosad and sweet almond plant oil treatments against adults of *O. surinamensis* were similar to some investigators such as **Obeng-Ofori and Amiteye, (2005)** who showed that the mixing of oils with malathion enhanced chemical toxicity and persistence resulting in higher mortality of adult weevils in maize grains treated with the mixtures.

Similar results were observed by **Sridevi and Dhingra (1996 and 2000)** as for testing oils in binary mixtures with insecticides evaluated the variation in the efficacy of deltamethrin formulated alone and in combination with five non-toxic vegetable oils viz., sesame, karanj, neem and citronella oil in four rates (1:11: 21:41: 8) against susceptible and resistant strains of *T. castanium* by direct spray and residue film methods and observed that all the vegetable oils proved additive effect when combined with deltamethrin except neem oil which showed antagonistic effect.

Table 5. Efficacy of a mixture of spinosad + sweet almond oil on the adult mortality of *O. surinamensis* at 28 ± 2°C and 65±5% RH.

Days after treatment	Mortality (%) of spinosad alone at LC_{20} (1.3×10^{-4} % w/w) (mean)	Mortality (%) of sweet almond oil alone at LC_{20} (3.9% v/w) (mean)	Observed mortality (%) spinosad + sweet almond oil (mean)	Expected mortality (%) spinosad + sweet almond oil (mean)	Co-toxicity factor	Type of joint action
1	0.0	0.0	3.0	0.0	-	-
2	3.0	2.0	10.0	5.0	100.0	P
3	11.0	4.5	25.0	15.5	61.3	P
5	19.0	4.5	33.0	23.5	40.4	P
7	20.0	11.0	38.0	31.0	22.6	P
10	22.0	11.5	51.5	33.5	53.7	P
14	28.0	14.5	65.0	42.5	52.9	P
21	36.0	16.5	76.5	52.5	45.7	P

P: Potentiation effect.

Table 6. Efficacy of a mixture of spinosad + sweet almond oil on the adult mortality of *O. surinamensis* at 28 ± 2°C and 65±5% RH.

Days after treatment	Mortality (%) of spinosad alone at LC_{30} (2.7×10^{-4} % w/w) (mean)	Mortality (%) of Sweet almond oil alone at LC_{30} (4.1 % v/w) (mean)	Observed mortality (%) spinosad + sweet almond oil (mean)	Expected mortality (%) spinosad + sweet almond oil (mean)	Co-toxicity factor	Type of joint action
1	0.0	0.0	0.0	0.0	0.0	D
2	7.0	10.0	15.0	17.0	-11.8	D
3	20.0	15.0	30.0	35.0	-14.3	D
5	25.0	17.5	57.5	42.5	35.2	P
7	30.0	30.0	65.0	60.0	8.3	D
10	33.0	45.0	72.5	78.0	-7.0	D
14	37.5	55.0	85.0	92.5	-8.1	D
21	61.0	60.0	92.5	100.0	-7.5	D

P: Potentiation effect. D: Additive effect.

Table 7. Efficacy of a mixture of spinosad + sweet almond oil on the adult mortality of *O. surinamensis* at 28 ± 2°C and 65±5% RH.

Days after treatment	Mortality (%) of spinosad alone at LC_{50} (8.6×10^{-4} % w/w) (mean)	Mortality (%) of sweet almond oil alone at LC_{10} (3.68 % v/w) (mean)	Observed mortality (%) spinosad + sweet almond oil (mean)	Expected mortality (%) spinosad + sweet almond oil (mean)	Co-toxicity factor	Type of joint action
1	0.0	0.0	15.0	0.0	-	-
2	15.0	2.0	20.0	17.0	17.6	D
3	30.0	3.0	41.5	33.0	25.8	P
5	40.0	4.5	71.5	44.5	60.7	P
7	50.0	10.0	83.0	60.0	38.3	P
10	60.0	11.5	85.0	71.5	18.9	D
14	75.0	14.0	95.0	89.0	6.7	D
21	90.0	16.5	100.0	100.0	0.0	D

P: Potentiation effect. D: Additive effect.

Table 8. Efficacy of a mixture of spinosad + sweet almond oil on the adult mortality of *O. surinamensis* at 28 ± 2°C and 65±5% RH**.**

Days after treatment	Mortality (%) of spinosad alone at LC_{10} (4.8×10^{-5} % w/w) (mean)	Mortality (%) of sweet almond oil alone at LC_{50} (4.5 % v/w) (mean)	Observed mortality (%) spinosad + sweet almond oil (mean)	Expected mortality (%) spinosad + sweet almond oil (mean)	Co-toxicity factor	Type of joint action
1	0.0	5.0	0.0	5.0	-100.0	A
2	1.5	17.5	31.5	19.0	65.7	P
3	7.0	21.5	43.0	28.5	50.9	P
5	8.0	30.0	61.5	38.0	61.8	P
7	10.0	50.0	97.5	60.0	62.5	P
10	12.0	65.0	100.0	77.0	29.9	P
14	18.0	73.0	100.0	91.0	9.9	D
21	23.0	83.0	100.0	100.0	0.0	D

P: Potentiation effect. D: Additive effect. A: Antagonism effect.

Conclusion

The findings of present study suggested that bio-pesticide spinosad and sweet almond plant oil may be potentially used as eco-friendly pest control agent against insect pests of stored products either singly or as binary mixtures.

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التأثير المشترك لكل من مبيد سبينوساد وزيت اللوز الحلو ضد حشرة خنفساء الحبوب المنشارية (السورينام).

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أجري هذا البحث لدراسة التأثير الإبادى لمبيد سبينوساد وزيت اللوز الحلو وفاعلية خلط تركيزات مختلفة من مبيد سبينوساد مع زيت اللوز الحلو علي حشرة خنفساء الحبوب المنشارية (السورينام) حيث أجريت تجارب التقدير الحيوي باستخدام 6 تركيزات من مبيد سبينوساد و 5 تركيزات من اللوز الحلو و4 تركيزات لمخلوطهما معاً. وأجريت الاختبارات لمدة21 يوم تحت درجة حرارة 28 ±2° م ورطوبة نسبية 65 ±5%؛ وقد أشارت النتائج أن زيادة نسبة موت الحشرات ترجع إلي زيادة تركيز مبيد سبينوساد وتركيز زيت اللوز الحلو أو بزيادة مدة التعريض, حيث أمكن الحصول علي نسب موت وصلت إلى 98% باستخدام تركيز 1×10^{-3} % (وزن/وزن) من مبيد سبينوساد في اليوم 21من المعاملة ,وكانت الجرعة النصفية LC_{50} لمبيد سبينوساد علي حشرة السورسنام 8.6×10^{-4} % (وزن/وزن) بعد 7 أيام من المعاملة ,وعند أختبار تأثير زيت اللوز الحلو علي تلك الحشرة وصلت نسبة الموت إلى 98% عند تركيز 5% في اليوم 21 من المعاملة, وعند أختبار مخاليط التركيزات المختلفة من مبيد سبينوساد مع زيت اللوز الحلو كان خليط (تركيز مبيد سبينوساد المميت ل20% من التعداد + تركيز زيت اللوز الحلو المميت ل20% من التعداد) هو الأكثر فاعلية بالمقارنة بالمخاليط الأخري المستخدمة على أساس عامل السمية المشتركة.