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EVALUATION OF SPINOSAD AND IVERMECTIN AGAINST THREE OF STORED GRAIN INSECTS IN WHEAT GRAINS

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ABSTRACT

The present study was carried out to evaluate two naturalyte biocides, spinosad and ivermectin, one recommended chemical synthetic insecticide, malathion as reference against three important insects of stored grain, *Sitophilus oryzae*, *Rhyzopertha dominica* and *Tribolium castaneum*. Results obtained show that rates of spinosad or ivermectin from 50-150 ppm and rates of malathion from 1-4 ppm completely prevented emergence of adults of *S.oryzae* and followed that increase the reduction of progeny to 100%. *R.dominica* has the same trend with *S.oryzae*, but the *R.dominica* was more susceptible to biocides and insecticide tested than *S.oryzae*, which gave high mortality ranged from 81-100% at all concentrations. *T.castaneum* was more tolerant than the other tested insects. At the all rates of tested materials, the percentage loss weight of wheat decreased in comparison with control. In generally, *R.dominica* was the most susceptible to the tested materials followed by *S.oryzae* and *T.castaneum* . *S.oryzae* adults exposed to wheat grain diet received half-dose of 50 ppm spinosad or ivermectin, separately gave 96 and 88% mortality after two weeks of exposure, while the one-third dose gave 90 and 63% mortality. The high levels of both spinosad or ivermectin nearly completely prevented the F_1 progeny of *S.oryzae* in half and one third dose. *R.dominica* was higher affected than *S.oryzae* at the same levels of spinosad and ivermectin where spinosad at the all levels of half dose completely prevented the F_1 progeny of *R.dominica* while with the one-third dose the % reduction values ranged from 82.3 to 100%.

INTRODUCTION

Contact insecticides, alongside with fumigants, are still most widely used to control insects of stored products. They were introduced at the end of the 1960 s, and organophosphates were the most frequently used group of these insecticides at the beginning, while pyrethroids have been used more intensvely in the latest period (White and Leesch,1996; Kljajic, 2008;and MacBean, 2012). The indiscriminate use of pesticides for the management of this notorious insect is not only hazardous to human beings but responsible for disturbing the eco-system as well. The use of these synthetic insecticide have also resulted resistance in *T. cateneum* against these insecticides. Shakoori *et al*. (1998) and Lessard *et al.* (1998) have also reported resistance in *T. castaneum* against synthetic pyrethroids, e.g., cypermetrin, deltamethrin, cyfluthrin, fenvalerate and some juvenile hormone analogues. The hazardous nature of fumigants has made it obligatory to test insecticides bearing novel modes of action, e.g., abamectin, spinosad, indoxacarb, azadirachtin and hydrocarbon against *T. castaeum* to minimize the risks and losses

Daglish and Nayak (2006) evaluated the persistence and efficacy of spinosad against *Rhyzopertha dominica* (F.) in wheat stored for 9 months. Spinosad applied at 0.5 or 1 mg kg−1 was effective for 9 months with 100% adult mortality after 14 days of exposure and no live F1 adults produced.

One of the ways to manage the problem of resistance of stored product insects to different insecticides and to alleviate selection pressure in practice is to introduce new insecticides.

The latest studies have shown that natural insecticides spinosad and abamectin are as effective as the contact insecticides used so far (Fang *et al*., 2002. Arthur *et al*., 2004; Athanassiou *et al*., 2008 ; Kavallieratos *et al*., 2009; Andrie *et al*., 2011; and Wakil *et al*., 2013) .

Spinosad is toxic by ingestion and contact,and has a unique mode of action on the insect nervous system at the nicotinic acetylcholine and γ-aminobutyric acid (GABA) receptors sites(Bret *etal*.,1997;Salgado 1998).

Spinosad Is based on the etabolites of the bacterium Saccharopolyspora Spinosad Mertz and Yao(Bacteria:Actinobacteriadae). Spinosad is a broadspectrum insecticide with low mammalian toxicity,and it is effective against many stored- grain insect species(Fang *etal*.,2002b;Nayak *etal*.,2005).

Moreover , Spinosad gives excellent residual control,which makes it an ideal protectant for stored grain commodities(Fang *etal*.,2002a ; Fang And Subramanyam,2003)

In recent years, the toxicity of insecticides to humans and wildlife has caused much public concern, and led to the use of more target-specific chemicals (Paoletti and Pimental 2000). Therefore, the present study investigated the efficiency of Ivermectin and Spinosad relative to recommended malation insecticide against three important insects of stored grain, *S.oryzae* , *T.castaneum* and *R.dominica* with the respect to adult mortality , % reduction in progny and % loss of wheat grain weight by two different methods of mixing with media at two periods of exposure.

MATERIALS AND METHODS

Materials

Insects :-

Three important coleopteran stored grain insects were assessed in the current investigation, Lesser grain borer, *R.dominica* (F.) (Bostrychidae: Coleoptera), rice weevil, *S.oryzae* (L.) (Curculionidae: Coleoptera) and red flour bettle, *T.castaneum* (Herbst) (Tenebrionidae: Coleoptera). The original stock culture of the three insects were obtained from stored product pest laboratory, Plant Protection Research Institute, Sakha Agricultural Research Station.

R.dominica:

Insects were reared on wheat grains, cleaned from dusts, husks and other inert materials and sterilized by heating at 60ºC for one hour, then grains were put in glass jars each containing 400g of wheat and provided with 100-200 adult insects. Jars were covered with muslin cloth secured with

elastic rubber bands and placed under laboratory conditions of 30±2ºC and 65±5% R.H. The newly emerged adults (1-2weeks old) were used for tests.

S.oryzae:

S.oryzae (Egyptian strain) was obtained from the Department of Stored Products Pests Control, Plant Protection, Reaserch Institute Sakha Kafr El-Shiekh. This strain was continuosly reared free of insecticidal contamination for several years at 30±2ºC and 70±5 relative humidity (RH). The cultures were maintained under the same conditions in the Pesticide Department, Faculty of Agriculture, Kafr-El-Shiekh University, Egypt and 200-400 adults from the pervious culture were added in 1000ml glass jars containing 400 gram of wheat as a culture medium. The mouth of the jars were covered with muslin cloth. Then, 7-14d old adults were used for experimental work.

T.castaneum:

Insects were reared on a mixture of wheat grain mixed with wheat flour. Grain were cleaned and sterilizes and put in glass jars each containing 400gm (30% wheat flour) and provided with 100-200 adult insects. Jars were covered and placed under laboratory conditions of 30±2ºC and 65±5% R.H. The newly emerged adults (1-2 weeks old) were used for different tests.

Insecticides

Tracer (Spinosad) (24% S.C.)

Bacterial derived insecticide,mixture of spinosyn A and D,Copping and Menn(2002).

Ivon (Ivermectin) (1% Injectable solution)

Invermectin : is synthesized from avermectin B_1 by reducing the 22,23-double bond producing dihydro avermectin B_{1a} and dihydro avermectin B_{1b} . Avermectin B_{1a} (5-0-dimethyl avermectin A_{1a}) .

Avermectin B_{1b} (5-0-dimethyl-25-de-(1-methyl propyl)-25-(1-methyl ethyl) avermectin A_{1a} .

Malathion (57% EC)

0,0-dimethyl-s-(1,2-dicarboxyethyl) ethylphosphorodi-thioate.

Effect of spinosad and ivermectin by common mixing on tested insects:

Batches of whole wheat grain were weighed (20gm) and placed in glass jars (250ml) for *S.oryzae* and *R.dominica,* or 20g of cracked wheat grains for *T.castaneum.* The tested insecticides,(spinoad, ivermectin and malation) were diluted in water and added to the grains at rates which give the required concentrations (10,50,100 and 150ppm) for spinosad and ivermectin and (0.5, 1,2 and 4 ppm) for malathion, jars were shaken by hand and grains were allowed to dry at room temperature. Twenty unsexed adults of each insect (1-2 weeks old) were introduced to a jar containing treated grain, 3 replicates were set up for each treatment and control. Before introduction *T.castaneum,* part of wheat was ground to flower and returned to the jars after that, 10 adults of *S. oryzae* were transferred to the treated wheat grains which putted in a 85x45 mm plastic jar. and kept at 30±2°C and 70±5 RH. relative humidity, according to the method described by Kestenholz *et al*. (2007). Mortality counts were recorded after 7 and 14 days and corrected by Abbott's formula (1925). The number of progeny was recorded

after 2 months post-treatment. The reduction percentages in adult number after 2 months post-treatment were recorded and calculated according to the following equation of Tapondjou *et al*. (2002).

$$\%IR = (Cn - Tn)\ 100/Cn,$$

where ,

Cn is the number of newly emerged insects in the untreated (control) jar, Tn is the number of newly emerged insects in treatments.The Percentages of wheat weight loss were also recorded 2 months after treatment according to the equation of Harris and Lindblad (1978).

$$\% \text{ loss} = \frac{\text{Initial dry weight of seeds} - \text{seeds dry weight after 2 months}}{\text{Initial dry weight of seeds}} X100$$

Effect of spinosad and ivermectin by modified mixing (mixture of untreated and treated wheat grain) on three tested insects :

The aim of this experiment is minimizing the pollution of grain during control of insects which attack the stored products using common mixing with media method, this method cause high contamination to treated grain, therefore modified method of mixing with diet was used in the present study. To carry out this modified method, two treatments were conducted as the following:

In the first treatment (half-dose): 10 gm wheat grain was treated by spinosad or ivermectin with the required concentrations and allowed to dry at room temperature, then manually mixed with other untreated 10 gm wheat grain to contain final concentration equal the half-dose.

In the second treatment (one-third dose), 10 gm wheat grain treated by the same insecticides with the required concentrations, then were allowed to dry at room temperature, and manually mixed with other untreated 20 gm wheat grain to contain final concentration equal one-third the used dose. In both treatments the mixture of treated and untreated wheat grain was transferred into glass jars 250 ml each covered with muslin. Twenty insects of *S.oryzae* or *R.dominica* were confined with the first mixture (received half-dose). For the second mixture (received one-third-dose) thirty unsexed insects of both tested insects were confined. 20 gm wheat grain for the first treatment and 30 gm for the second treatment have no any insecticides were used as control. Three replicates of each treatment and control were set10 adults of *S. oryzae* and transferred to the treated wheat grains which putted in a 85x45 mm plastic jar. and kept at 30±2°C and 70±5 RH. relative humidity, according to the method described by EL-Tawelah (2005). Mortality counts were recorded at 7 and 14 days post-treatment and corrected by Abbott's formula (1925). The number of progeny was recorded after 2 months post-treatment. The reduction percentages in adult number after 2 months post-treatment were recorded and calculated according the equation of Tapondjou *et al*. (2002)and the percentages of wheat weight loss were also recorded 2 months after treatment . Percentages of wheat weight loss were also recorded 2 months after treatment according to the equation of Harris and Lindblad (1978) as mentiond before.

Statistical Analysis

Data obtained from the experiments were statistically analyzed using the method of analysis of variance(Duncan ,1955) one-way repeated measurement analysis of variance Duncan's multiple range test were used to separate means using SAS program (Version 6.12, SAS Institute Inc., Cary, USA).

RESULTS AND DISCUSSION

Insecticidal activity of insecticides on adult insects *S.oryzae, R.dominica* and *T.castaneum.*

A laboratory experiment was carried out to evaluate two naturalyte biocides, spinosad and ivermectin, one recommended chemical synthetic insecticide, malathion as reference against three important insects of stored grain, *S.oryzae, R.dominica* and *T.castaneum.* Results obtained in Table (1) show that rates of spinosad and ivermectin from 50-150 ppm and rates of malathion from 1-4 ppm completely prevented emergence of adult of *S.oryzae* and followed that increase the reduction of progeny to 100%. Highly significant differences were found between treatments at rate of 10 ppm for both spinosad, ivermectin and control concerned to the emergence of adults of *S.oryzae.* In addition, the concentration of 10 ppm spinosad and ivermectin and 0.5 ppm malathion caused 73.0, 74.3 and 78.9 % reduction in progeny, respectively. There was varied response of *S.oryzae* against either tested biocides and chemical insecticide.

For *R.dominica,* data in Table (2) refer the same trend with *S.oryzae,* but the *R.dominica* was more susceptible to biocides and chemical insecticide tested than *S.oryzae*. Table (3) included the data of *T.castaneum.* From these results, *T.castaneum* was more tolerant than the other tested insects. At the all rates of tested materials, the percentage of loss weight of wheat decreased in comparison with control. In generally, *R.dominica* was the most susceptible to the tested materials followed by *S.oryzae* and *T.castaneum*. In this respect, type of tested species is an important factor. The chemical insecticide malathion was the most efficient agent as compared with the other tested toxic materials. In the present study, results refer to spinosad and ivermectin could be promising alternatives to malathion as protectant agent for stored grain insects control. The biocide, spinosad have low mammalian toxicity and rapid degradation in the environment (Thomposon *et al.,*2000).

Table (1): Effect of insecticides on adults of *S.oryzae* using mixing with media at different indicated periods .

coumpounds	Conc.(ppm)	%Mortality after		LC_{50}		No. of emerged adults after 2 months	% reduction in F1 progeny	%loss of wheat grain weight
		1 week	2 weeks	1 week	2 weeks			
Spinosad	10	40	46	17	12	120.3 f	73.0 c	3.3 gh
	50	63	79			0.0	100 a	2.9 hi
	100	78	94			0.0	100 a	2.5 hi
	150	93	100			0.0	100 a	1.4 i
Ivermectin	10	45	61	12	7.2	114.6 f	74.3 c	4.1 g
	50	76	88			0.0	100 a	3.4 gh
	100	88	100			0.0	100 a	2.2 hi
	150	100	100			0.0	100 a	1.8 hi
Malathion	0.5	50	76	0.42	0.06	94.0 g	78.9 b	5.6 e
	1	73	95			0.0	100 a	3.3 gh
	2	83	93			0.0	100a	2.1 hi
	4	88	98			0.0	100 a	1.4 i
Control	0	0	0			446.3 a		72.1 a

Mean followed by the same letters in the column are not significantly different (P< 0.05).

Table (2): Effect of insecticides on adults of *R.dominica* using mixing with media at different indicated periods .

Treatment	Conc.(ppm)	Mortality %		LC_{50}		No. of emerged adults after 2 months	% reduction in F1 progeny	%loss of wheat grain weight
		1	2	1	2			
Spinosad	10	63	81	3.6	0.57	0.0	100 a	2.9 efg
	50	81	86			0.0	100 a	2.0 gh
	100	86	96			0.0	100 a	1.3 hi
	150	100	100			0.0	100 a	0.9 i
Ivermectin	10	75	83	1.0	0.8	0.0	100 a	3.4 ef
	50	85	91			0.0	100 a	3.1 ef
	100	95	98			0.0	100 a	2.8 efg
	150	96	100			0.0	100 a	2.0 gh
Malathion	0.5	53	81	0.41	0.22	108.3 c	67.6 d	3.4 ef
	1	76	93			0.0	100 a	2.7 fg
	2	85	100			0.0	100a	1.6 hi
	4	93	100			0.0	100 a	1.1 hi
Control	0	0	0			335 a		76.0 a

Mean followed by the same letters in the column are not significantly different (P< 0.05).

Table (3): Effect of insecticides on adults of *T.castaneum* using mixing with media at different indicated periods.

coumpounds	Conc.(ppm)	%Mortality after		LC_{50} after		No. of emerged adults after 2 months	% reduction in F1 progeny	%loss of wheat grain weight
		1 week	2 weeks	1 week	2 weeks			
Spinosad	10	38	57	25	8.8	93 de	52.3 e	13.6 e
	50	41	72			22.3 g	88.5 c	5.7 fg
	100	86	93			0.0	100 a	2.7 hij
	150	90	98			0.0	100 a	1.7 j
Ivermectin	10	15	30	56	26	101.0 d	48.2 f	16.1 d
	50	28	43			69.6 f	64.3 d	11.9 e
	100	70	71			14.3 gh	92.6 b	3.9ghi
	150	85	95			0.0	100 a	2.1 ij
Malathion	0.5	28	61	2.4	0.23	12.3 h	93.6 b	7.5 f
	1	40	73			11.6 h	94.0 b	4.3 gh
	2	48	91			0.0	100 a	2.4 hij
	4	56	95			0.0	100 a	1.3 j
Control	0	0	0			195.0 a		41.5 a

Mean followed by the same letters in the column are not significantly different (P< 0.05).

Our results are in agreement with (Fang *et al.,* 2002b) they found that spinosad, as a grain protectant, is highly effevtive against a very of stored product insects. Spinosad residues applied to indoor surfaces, such as those found in empty bins, warehouses, retail stores and food processing facilities, may persistent and exert insecticidal activity for extended periods (Toews *et al,.* 2003). Many research workers investigated the effectiveness of spinosad, ivermectin and malathion against some important of stored product insects (Abo-Arab and El-Hamady, 1998; Nayak *et al.,*2005; Kljajic and Peric, 2007; Athanassiou *et al.* 2009; Fouad,2013 and Gonzalez *et al.,* 2014). Daglish *et al.* (2003) suggested that an application rate of 1 mg/kg spinosad in wheat may be suitable for controlling *R.dominica* strains that are resistant to organophosphates, pyrethroids or the insect growth regulator, methoprene. Subramanyam *et al.* (2007) demonstrated 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.

Effect of spinosad and ivermectin by modified mixing (mixture of untreated and treated wheat grain) on three tested insects :

To evaluate the modified method of mixing with media on mortality, emerged adults, reduction in F1 progeny and loss of wheat grain, a laboratory experiment was conducted, including three treatments, in the first, batches of wheat grain received the complete dose (10,50,100 and 150 ppm). In the second treatment, batches of wheat grain divided into two equal groups, the first group received the complete dose and mixed with the other untreated group to obtain final rate equal the half-dose. In the third treatment batched of wheat grain divided into three equal groups, one of them treated with the complete dose and mixed with the two untreated groups to obtain final rate equal the one-third dose.

Efficacy of nsecticides on F1 progeny of tested insects:

Based on some of criteria (latent effect) number of emerged adults, reduction in F1 progeny and loss of wheat weight, in respect to, a laboratory experiment was carried out to evaluate the modified method of mixing with media mentioned before. Data obtained in Table (4) showed that *S.oryzae* adults exposed to wheat grain diet received half-dose of 10 ppm spinosad or ivermectin, separately highly affected, where produced 233 and 172 adults in F1 progeny, respectively, compared to control which produced 427 adults in F1 progeny. The remained levels of spinosad or ivermectin almost completely prevented F1 progeny compared to the untreated treatment (control). For the one-third dose, results in Table(5) were similar to that of half-dose treatment where the low level of 10 ppm greatly decreased the number of F1 progeny compared to control, while the high levels of both spinosad or ivermectin nearly completely prevented the F1 progeny of *S.oryzae* with % reduction values of (82.3, 97.2, 100%) and (82.3, 100, 100%) at rates of 50,100 and 150ppm of spinosad and ivermectin, respectively. For *R.dominica,* with the wheat grain diet which received either half or one-third dose, results obtained in Tables (6 and 7) cleared that *R.dominica* was highly affected than *S.oryzae* at the same levels of spinosad and ivermectin where spinosad at the all levels of half-dose completely prevented the F1 progeny of *R.dominica* while with the one-third dose the % reduction values ranged from 82.3 to 100%. To what limit, ivermectin had low effect on *R.dominica* compared to spinosad where its half-dose values achieved % reduction of progeny rates ranged from 76.6 to 100%, while the one-third dose rates (10-150 ppm) exhibited % reduction values ranged from 54.4 to 100%. These fining parallel the results of initial kill (% mortality) in Tables (6 and 7).Results tabulated in Tables (4 to 7) concerned to the effect of tested doses (half and one-third dose) of spinosad or ivermectin on loss of whaet grain by *S.oryzae* or *R.dominica* demonstrated that the all rates of tested biocides greatly decreased the percent loss of wheat grain compared to control and these loss values parallel with the % reduction of F1 progeny of both tested insect-species in this study.

Table (4): effect of half-dose treated media on *S.oryzae* adults at different exposure periods .

coumpounds	Conc. (ppm)	%Mortality after		LC_{50}		No. of emerged adults after 2 months	% reduction in F1 progeny	%loss of wheat grain weight
		1 week	2 weeks	1 week	2 weeks			
Spinosad	10	26	29	23	18	233 b	45.4 d	8.3 b
	50	73	96			0.0	100 a	3.3 d
	100	85	96			0.0	100 a	2.3 de
	150	95	100			0.0	100 a	1.2 e
Ivermectin	10	38	56	19	8	172 c	59.7 c	7.9 b
	50	63	88			14.3 d	96.6 b	6.2 c
	100	86	96			0.0	100 a	3.0 d
	150	95	100			0.0	100 a	2.1 de
Control	0	0	0			427 a		72.6 a

Mean followed by the same letters in the column are not significantly different (P< 0.05).

Table (5): Effect of one-third dose treated media on *S.oryzae* adults at different indicated periods .

Treatment	Conc.(ppm)	%Mortality after		LC_{50}		No. of emerged adults after 2 months	% reduction in F1 progeny	%loss of wheat grain weight
		1 week	2 weeks	1 week	2 weeks			
Spinosad	10	10	46	28	11	283.6 b	59.9 d	16.3 b
	50	80	90			124.6 d	82.3 b	4.0 d
	100	90	96			19.3 e	97.2 ab	2.6 ef
	150	95	100			0.0	100 a	1.8 f
Ivermectin	10	18	41	70	17	229.0 c	67.6 c	7.6 c
	50	35	63			124.6 d	82.3 b	4.0 d
	100	55	83			0.0	100 a	2.5 ef
	150	71	96			0.0	100 a	2.2 f
Control	0	0	0			707.3a		70.4a

Mean followed by the same letters in the column are not significantly different (P< 0.05).

Table (6): Effect of half-dose treated media on *R.dominica* adults at different indicated periods.

Treatment	Conc.(ppm)	%Mortality after		LC_{50}		No. of emerged adults after 2 months	% reduction in F1 progeny	%loss of wheat grain weight
		1 week	2 weeks	1 week	2 weeks			
Spinosad	10	78	90	3.3	0.47	0.0	100 a	3.2 c
	50	95	98			0.0	100 a	2.1 de
	100	100	100			0.0	100 a	1.1 f
	150	100	100			0.0	100 a	1.0 f
Ivermectin	10	48	86	13	1.1	77.3 b	76.6 c	11.0 b
	50	68	94			6.3 c	98.0 b	2.9 cd
	100	85	100			0.0	100 a	3.1 c
	150	98	100			0.0	100a	1.9 ef
Control	0	0	0			331 a		75.1 a

Mean followed by the same letters in the column are not significantly different (P< 0.05).

Table (7): Effect of one-third dose treated media on *R.dominica* adults at different indicated periods .

Treatment	Conc.(ppm)	%Mortality after		LC_{50}		No. of emerged adults after 2 months	% reduction in F1 progeny	%loss of wheat grain weight
		1 week	2 weeks	1 week	2 weeks			
Spinosad	10	58	75	7.0	3.4	16.6 d	82.3 b	7.1 d
	50	80	91			13.0 e	98.0 a	3.1 ef
	100	88	100			0.0	100 a	2.6 f
	150	95	100			0.0	100 a	1.9 f
Ivermectin	10	33	41	21	14	29.9 b	54.4 d	29.8 b
	50	66	78			20.5 c	86.7 c	12.3 c
	100	81	96			20.6 e	96.8 a	4.6 e
	150	95	100			0.0	100 a	2.7 ef
Control	0	0	0			659.0 a		79.6 a

Mean followed by the same letters in the column are not significantly different (P< 0.05).

Table (8): Comparative mortality produced from two different methods of mixing with media at two periods of exposure .

Insects	Insecticides	Conc. (ppm)	%mortality (1 week)			%mortality (2 weeks)		
			Common type	Modified type		Common type	Modified type	
			Complete dose	Half-dose	One-third dose	Complete dose	Half-dose	One-third dose
R.dominica	Spinosad	0	0	0	0	0	0	0
		10	63	78	58	81	90	75
		50	81	95	80	86	98	91
		100	86	100	88	96	100	100
		150	100	100	95	100	100	100
	Ivermectin	0	0	0	0	0	0	0
		10	75	48	33	83	86	41
		50	85	68	66	91	94	78
		100	95	85	81	98	100	96
		150	96	98	95	100	100	100
S.oryzae	Spinosad	0	0	0	0	0	0	0
		10	40	26	10	46	29	46
		50	63	73	73	79	96	90
		100	78	85	90	94	96	96
		150	93	95	95	100	100	100
	Ivermectin	0	0	0	0	0	0	0
		10	45	38	18	61	56	41
		50	76	63	35	88	88	63
		100	88	86	55	100	96	83
		150	100	95	71	100	100	96

Mean followed by the same letters in the column are not significantly different (P< 0.05).

From the results summarized in Table (8) the following aspects were observed.

1- At the low level of 10 ppm spinosad or ivermectin there was a different effect (on % mortality) on both tested insects between the three tested doses, complete, half and the one-third dose mixed with media where level of 10 ppm ivermectin achieved 75, 48 and 33% mortality with mentioned doses, respectively, for *R.dominica* .

2- Results also showed that when the levels of tested biocides, spinosad and ivermectin increased the differences between mortality ratios resulted from the effect of the tested doses decreased, where the levels of 100 or 150 ppm ivermectin or spinosad exhibited nearly equal effectiveness (as % mortality) with the three tested does against *R.dominica* at the two periods of exposure. For *S.oryzae* the results demonstrated the same trend either with the low level (10 ppm) or with the high levels (100 and 150 ppm) of spinosad or ivermectin at the two periods of exposure.

3- These results established that the type of treatment plays an important role in improving the effect of tested materials, since the modified method of mixing with media (mixture of treated and untreated wheat grain) arised the efficacy of the tested biocides where this method reduced the levels required to give high mortality percentages. In contrast, using the common method, mixing with media (complete dose mixed with the all wheat grain) requires high concentrations to gain high mortality. Porbability, this success of the modified method in achieving high mortality by low concentration will be dependent on the mobility of insects either upword or downword through the treated and untreated wheat grain to pick the dose required to achieve high insect mortality. On the other side, use of common mixing with media restricts the mortality of insects to avoid the contact with treated media. Athanassiou *et al.* (2009) showed that while spinosad has some effectiveness as a layer treatment on column of wheat, efficacy will be dependent on the target species, the depth of the treated layer, and the upward or downward mobility of the insect species.

4- The present results show that modified method of mixing with media is likely to be an effective method for grain protection against *R.dominica* and *S.oryzae* in mixture of treated and untreated media.

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تقييم فعالية الا سبينوزاد والايفرمكتين ضد ثلاثة من حشرات الحبوب المخزونة في حبوب القمح

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أجريت هذه الدراسة بغرض تقييم مركبين وهما سبينوساد ، أفيرمكتين بجانب مبيد الملاثيون كمقارنة علي ثلاثة حشرات هامة من حشرات الحبوب المخزونة وهم سوسة الأرز ، ثاقبة الحبوب الصغري وخنفساء الدقيق الصدئية – وقد تم تطبيق المواد المستخدمة في البحث عن طريق خلطها مع البيئة الغذائية وأخذ نسب الموت بعد فترات زمنية مختلفة وكذلك الحشرات الناتجة من الجيل الأول والنسبة المئوية للفقد في وزن الحبوب .

وأوضحت النتائج أن إستخدام تركيزات من ٥٠ – ١٥٠ جزء في المليون لمبيدي سبينوساد وأيفرمكتين وتركيزات الملاثيون من ١-٤ جزء في المليون أدت إلي إحداث نسبة موت ٧٩ – ١٠٠ % بعد أسبوعين من المعاملة – كذلك منعت التركيزات المستخدمة خروج الحشرات الكاملة تماماً لحشرة سوسة الأرز

كما أظهرت النتائج أن حشرة ثاقبة الحبوب الصغري كانت أكثر حساسية للمبيدات مقارنة بحشرة سوسة الأرز حيث تراوحت نسب الموت من ٨١ – ١٠٠ % عند كل التركيزات المستخدمة أما بالنسبة لخنفساء الدقيق الصدئية فكانت أكثر تحملاً من الحشرات المختبرة الآخري .

كما أدي إستخدام المواد المختبرة في الدراسة إلي إحداث خفض ملحوظ في نسبة الفقد في وزن الحبوب مقارنة بالكنترول .

وأدت المعاملة بنصف الجرعة (المستخدمة في الدراسة) علي حشرة سوسة الأرز بتركيز ٥٠ جزء في المليون لمبيد سبينوزاد أو ايفرمكتين إلي تحقيق نسبة موت ٩٦ ، ٨٨ % لكلا المبيدين علي التوالي بعد أسبوعين من التعرض – بينما عند المعاملة بثلث الجرعة المستخدمة كانت نسبة الموت ٩٠ ، ٦٣ % عند نفس الظروف .

وأدي إستخدام التركيزات المرتفعه (٥٠ – ١٥٠ جزء في المليون) لكلا المبيدين إلي منع وجود الخلفة تماماً .

وأدي إستخدام التركيزات المرتفعه (٥٠ – ١٥٠ جزء في المليون) لكلا المبيدين إلي منع وجود الخلفة تماماً أما حشرة ثاقبة الحبوب الصغري كانت أكثر تأثراً من سوسة الأرز عند نفس مستويات المبيدين حيث أن سبينوزاد عند كل تركيزاته وبإستخدام المعاملة بنصف الجرعة علي الجيل الاول للحشرة بينما المعاملة بثلث الجرعة أدت إلي نسبة خفض في الخلفة تراوحت بين ٨٢.٣ % إلي ١٠٠ %.