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The Combined Efficacy of Malathion and Spinetoram against Three Stored Product Insects

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ABSTRACT

The effectiveness of malathion and spinetoram alone and in binary combinations was investigated against the adults of *Sitophilus oryzae* (L.), *Rhizopertha dominica* F. and *Tribolium castaneum* (Herbst.). The obtained results showed that, the toxicity of each insecticide to the adults of the three insect species was concentration and exposure period - dependent. Adults of *S. oryzae* were highly susceptible to malathion alone but, *R. dominica* and *T. castaneum* adults were the least susceptible to the insecticide .While *R. dominica* adults were higher susceptible to spinetoram alone than the two other species . Co-toxicity values resulted from adding LC_{10} of spinetoram to various malathion concentrations showed a potentiation effects on the adults of *T. castaneum* at all concentrations of malathion, on *R. dominica* at the three lowest concentrations and at the lowest concentration(0.25ppm) only on the adults of *S. oryzae*. Meanwhile an additive effect was achieved with other concentrations of malathion and LC_{10} of spinetoram against the three tested insect species.A complete protection for stored wheat seeds was achieved with the Six tested mixtures(Mix_1 - Mix_6) against adults of *S. oryzae* and *R. dominica* up to 6 months. Also, the same effect extended against *T. castaneum* adults to 5, 4 and 2 months with Mix_1, each of (Mix_2 and Mix_3) and Mix_4 ,resp. Contrarily, Mix_5, Mix_6 failed to give a complete mortality for *T. castaneum* adults at all various intervals(months). Data concluded that, stored wheat seeds treated with Mix_3 (4ppmM+5ppmSm) or Mix_4 (4ppm M+4ppm Sm) were protected against the three insects infestation for 3months.

INTRODUCTION

Malathion is an organophosphorus (OP) insecticide is being used as a protectant against stored product insects during storage till now. Several insects now resistant to (Op) insecticides, the lesser grain borer *R. dominica*, adults were resistant to both malathion, pirimiphos- methyl (El-Lakwah *et al*., 2004). Therefore, alternative insecticides or pest management strategies are urgently needed to replace traditional insecticides.

Recently, spinetoram is a mixture of chemically modified spinosyns (spinosyn J and spinosyn L) produced by bacterium *Saccharopolyspora spinosa* colonies, has a unique mode of action on insect nervous system at the nicotinic acetylcholine receptor and GABA receptor cites (Dripps *et al*., 2011). It is abroad spectrum insecticide with low mammalian toxicity (Mertz and Yoa 1990). Two formulations of spinetoram, water dispersible granules (WG), and suspension concentrate (SC) were evaluated, *R. dominica*, *S. oryzae*, *T. confusum* adults in the laboratory. From the species tested, *R. dominica* was the most susceptible, given that immediate and delayed mortality and high reduction in F_1- progeny (Vassilakos, *et al.*, 2012).

Synergism was shown between (OP) and pyrothriod combinations of insecticides and other substances were evaluated against stored product insects have developed resistance (Bengston *et al*, 1987) .

The aims of the present study to make a combinations from malathion and spinetoram with high potentiality to control the main insect species of stored wheat seeds *Sitophilus oryzae* (L.); *Rhizopertha dominica* F. and *Tribolium castaneum* (Herbst.) for 3monrhs at least.

MATERIALS AND METHODS

Insects:

Adults of the rice weevil *S. oryzae*, the lesser grain borer *R. dominica*, and the red flour beetle *T. castaneum*, were used for investigations. All species were reared and maintained under laboratory conditions for several generations at 26 ± 2°C and 60 ± 5% RH.

Insecticides:

Malathion1%dust:0,0dimethyl-s-(1-2dicarboxyethyl) phosphodithioate, produced by Kafr El-Zayat chemical and pesticides company, Egypt.

Spinetoram(Radiant 12%SC): Spinetoram is a mixture of (3-O- ethyl 5,6- dihydro spinosyn J and 3- O-ethyl spinosyn L), formulation was obtained from Shoura chemicals com. under license of Dow Agro Sciences UK.

Grain treatment:

The amount of malathion insecticide was added to jars of about 125 ml volume contains 50 g of media (sterilized and conditioned wheat kernels in case of the rice weevil and the lesser grain borer or wheat flour in case of the red flour beetle) to achieve malathion concentrations 8, 4, 2,1, 0.5 and 0.25 ppm (toxicity of malathion alone), water solution (five ml from each concentration) were added to 50 g media to give 10, 5, 2.5, 1.25, 0.625 and 0.313 ppm for LC_{10} of spinetoram assessment, and left 24 hrs to evaporate the solvent.

In case of mixtures, at first the amount of LC_{10} of spinetoram was added to food and left 24 hrs to evaporate the solvent then mixed with the amount of malathion.

Bioassay:

Batches of 30 adult insects (1weeks old) were introduced to the jars. Three replicates for each concentration were used, the jars were covered with muslin cloth and fixed with rubber band. All replicates of experiment were kept at 26 ± 2°C and 60 ± 5% RH. Mortalities were recorded after 2, 3, 5, 7 and 14 days from treatment. Mortalities were corrected using Abbot's formula (1925).

The lethal concentrations of spinetoram after 7days were estimated using EPA probit analysis program (version1.5).

After 7days from exposure the joint action caused by adding of LC_{10} of spinetoram to the various concentrations of malathion insecticide was determined according to the equation adopted by Mansour *et.al.* (1966):

Co-toxicity factor = [(observed mortality% - expected mortality%) / expected mortality%] x100

This factor was used to classify the results into three categories, appositive factor of 20 or more meant potentiation (synergistic) effect, a negative factor of -20 or more meant antagonism and any value intermediate, i. e. between +20 and -20 was considered only an additive effect.

Persistence of binary mixtures:

The efficacies of six binary mixtures of the two insecticides according (Table 1) were tested against the adults of above insect species for 6 months. Firstly, 30 adult insects were introduced to the treated or untreated samples that were taken monthly from wheat lots stored at 26 ± 2°C and 60 ± 5 RH and adults mortality was recorded after 7 days of exposure to mixtures.

Germination of wheat seeds:

Every month, 25 seeds were cultivated in each of 4 Petri dishes (4 replicates) for 7days and germination% was calculated.

Table 1. Mixture levels and concentration of each insecticide

Mixture	Conc. in ppm	
No. (Mix)	Malathion(M)	Spinetoram(Sm)
Mix_1	(M_1)=5	(Sm_1)=5
Mix_2	(M_2)=5	(Sm_2)=4
Mix_3	(M_3)=4	(Sm_3)=5
Mix_4	(M_4)=4	(Sm_4)=4
Mix_5	(M_5)=4	(Sm_5)=3
Mix_6	(M_6)=4	(Sm_6)=2

RESULTS AND DISCUSSION

Effect of Malathion:

Data illustration in Figure (1) showed that, the effects of malathion alone at different concentrations on mortalities of *S. oryzae, R. dominica* and *T. castaneum* adults after 7 days from treatment.

Results revealed that, malathion at 8, 4 and 2ppm gave complete mortality for *S. oryzae* adults, While only 65.7 % mortality was achieved at the lowest concentration (0.25 ppm). Meanwhile , mortality of *R. dominica* adults reached 62.3% at the highest concentration (8 ppm) and only 5.7% at 0.25 ppm. Adults of *T. castaneum* were relatively less susceptibility to malathion compared with the others species tested, the highest concentration (8 ppm) gave 45.7% only.

The obtained data revealed clearly that adults of *S. oryzae* were highly susceptible to malathion followed by *R. dominica* and *T. castaneum* adults which were the least susceptible to the insecticide.

Effect of spinetoram:

Data of the spinetoram toxicity to the adults of the three tested insects after 7 days from treatment were given in Fig. (2). The results showed that, the highest concentration gave 79.1, 100.0 and 45.1 % kill for *S. oryzae*, *R. dominica* and *T. castaneum*, respectively.

LC_{10} from spinetoram after 7 days were 0.410, 0.032 and 3.18 ppm for the adults of *S. oryzae*, *R.dominica* and *T.castaneum*, respectively.

Results indicated that, the adults of *R. dominica* were highly susceptible to spinetoram than the two tested insects.

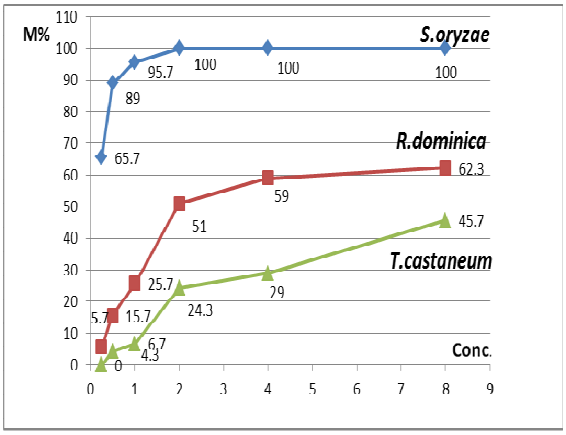

Fig. 1. Toxicity of different concentrations of malathion alone after 7 days against the three insect species

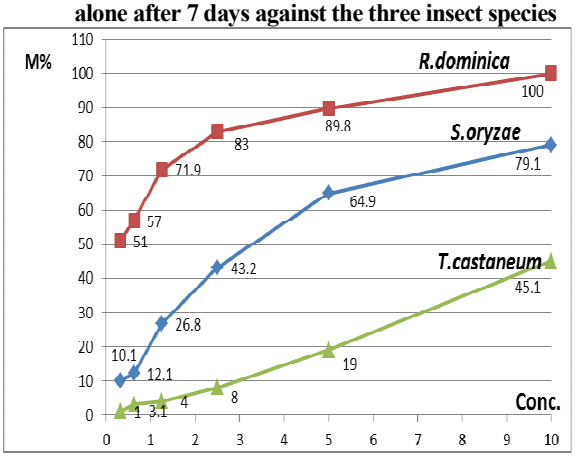

Fig. 2. Toxicity of different concentrations of spinetoram alone after 7 days against the three insect species.

The obtained results are in harmony with the findings of other investigators (Vassilakos and Athanassiou, 2012; At hanassiou and Kavallieratos, 2014 and Nasr, 2015).

Combined action of the LC_{10} of spinetoram and different malathion concentrations:

Co-toxicity values were higher than +20 resulted from adding LC_{10} of spinetoram to malathion concentrations gave a potentiation effects on the adults of *T. castaneum* at all concentrations of malathion, on *R. dominica* adults at the three lowest concentrations and at the lowest concentration(0.25ppm) only on *S. oryzae* adults Table(2).

Meanwhile an additive effect were achieved with other concentrations of malathion and LC_{10} of spinetoram against the three tested insect species.

Persistence of binary mixtures:

The toxic effect and persistence of spinetoram and malathion mixtures to the three insect species was given in Table (3).

Data revealed that, all tested mixtures gave a complete protection for stored wheat seeds against adults of *S. oryzae* and *R. dominica* up to 6 months. Also, the same effect extended against *T. castaneum* adults to 5, 4 and 2 months with Mix_1, each of (Mix_2 and Mix_3) and Mix_4 ,resp.

Contrarily, Mix_5, Mix_6 failed to give a complete mortality for *T. castaneum* adults at all various intervals(months).

No differences obtained in germination % between all mixture levels and control during storage period.

According the protocol of insecticides evaluation in Egypt, insecticide which gave approximate 100% mortality to insect adults after 7dayes for 3months will succeed. The obtained data indicated that, using of Mix_3 (4ppmM+5ppmSm) or Mix_4 (4ppm M+4ppm Sm) as a protectant to stored wheat seeds from stored product insects infestation.

In this respect, (Nighat et.*al*.2007) found that, the mixtures of malathion and deltamethrin were more effective against *R. dominica* adults than each insecticide alone

Therefore, mixture of malathion and spinetoram has for control OP-resistance insect species such as *R. dominica* and *T. castaneum*.

Table 2. Co-toxicity resulted from addition of LC_{10} of Spinetoram to different concentrations of malathion against three stored product insects

(M) Conc. ppm	%mortality after 7(days) ± S.D.								
	S. oryzae			*R. dominica*			*T. castaneum*		
	M alone	M+ LC_{10}	Co-toxic.& action	M alone	M+ LC_{10}	Co-toxic.& action	M alone	M+ LC_{10}	Co-toxic.& action
8	100.0±0.0	100.0±0.0	-9.9d	62.3±0.5	100.0±0.0	-5.7d	45.7±1.2	97.3±0.5	72.5p
4	100.0±0.0	100.0±0.0	-9.9d	59.0±0.5	100.0±0.0	-5.7d	29.0±0.9	90.0±0.8	126.7p
2	100.0±0.0	100.0±0.0	-9.9d	51.0±1.2	100.0±0.0	-5.7d	24.3±0.5	62.3±0.5	78.0p
1	95.7±1.2	100.0±0.0	-6.3d	25.7±0.9	99.0±0.5	212.3p	6.7±0.8	45.7±1.2	162.6p
0.5	89.0±0.5	95.6±0.5	-4.5d	15.7±0.9	93.3±0.0	329.9p	4.3±0.5	24.3±0.5	62.0p
0.25	65.7±1.2	93.3±0.8	21.5p	5.7±0.5	84.3±0.9	515.3p	0.0±0.0	19.0±0.5	77.6p
0.00	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-

a:antagonistic d:additive effect p: potentiation(synergistic) effect

Table 3. Persistence of the binary mixtures from malathion and spinetoram against three stored product insects

Mix.	insect	% adult mortality after 7 days from exposure ± S.D. at various intervals (months)					
		1	2	3	4	5	6
1	*S. oryzae*	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	R. dominica	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	T.castaneum	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	96.5±0.5
2	*S. oryzae*	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	R. dominica	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	T.castaneum	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	88.5±1.2	85.0±0.88
3	*S. oryzae*	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	R. dominica	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	T.castaneum	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	95.0±0.8	93.5±0.9
4	*S. oryzae*	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	R. dominica	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	T.castaneum	100.0±0.0	100.0±0.0	98.5±0.5	83.5±1.2	73.5±0.5	65.2±1.2
5	*S. oryzae*	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	R. dominica	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	T.castaneum	88.5±0.5	81.5±1.2	78.5±0.9	75.0±0.8	73.5±0.9	61.2±1.2
6	*S. oryzae*	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	R. dominica	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	T.castaneum	76.5±0.5	68.5±0.9	66.5±0.5	61.50±0.9	53.5±1.2	52.0±0.8

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الفعالية المشتركة لكل من الملاثيون والاسبينتورام ضد ثلاثة من حشرات المواد المخزونة

محروس السيد حسن نصر

معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الدقى - مصر

تم دراسة فعالية كلا من مبيدى الملاثيون والاسبينتورام منفردين وكذلك مخالطيها المختلفة ضد الحشرات الكاملة لسوسة الأرز وثاقبة الحبوب الصغرى وخنفساء الدقيق الكستنائية وقد أوضحت النتائج أن سمية اى من المبيدين تتوقف على التركيز ومدة التعريض.وجد أن الحشرات الكاملة لسوسة الأرز كانت أكثر حساسية لمبيد الملاثيون منفردا بينما كانت حشرتى ثاقبة الحبوب الصغرى و خنفساء الدقيق الكستنائية اقل حساسية للمبيد. وكانت حشرة ثاقبة الحبوب الصغرى أكثر حساسية لمبيد الاسبينتورام منفردا من الحشرتين الأخرى .وأظهرت قيم التأثير المشترك الناتج من اضافة LC_{10} من الاسبينتورام الى التركيزات المختلفة من الملاثيون تأثير مقوى (منشط) ضد خنفساء الدقيق الكستنائية عند كل تركيزات الملاثيون ، ضد ثاقبة الحبوب الصغرى عند اقل ثلاثة تركيزات وكذلك عند اقل تركيز فقط ضد سوسة الأرز.وتم الحصول على تأثير اضافى من اضافة LC_{10} من الاسبينتورام الى تركيزات الملاثيون المختلفة الأخرى.كما أعطى كل مخلوط من المبيدين (Mix_1- Mix_6) حماية كاملة لحبوب القمح ضد حشرتى سوسة الارز وثاقبة الحبوب الصغرى لمدة ٦شهور، واستمر نفس التأثير ضد خنفساء الدقيق الكستنائية لمدة ٢،٤،٥ شهر مع (Mix_1)،وكلا من (Mix_2، Mix_3)،(Mix_4) على التوالى .ولم يعطى المخلوطين (Mix_5،Mix_6) موت كامل لحشرة خنفساء الدقيق الكستنائية فى اى شهر من فترات الاختبار. ونستنتج انه بمعاملة حبوب القمح (كنقاوى) بأى من المخلوطين(Mix_3 (4ppmM+5ppmSm) أو Mix_4 (4ppm M+4ppm Sm) قد حماها ضد الاصابة بالحشرات الثلاثة ولمدة ٣ شهور.