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Comparative Efficiency of Selected Chemical and Bio Pesticides against some Stored Grain Insects

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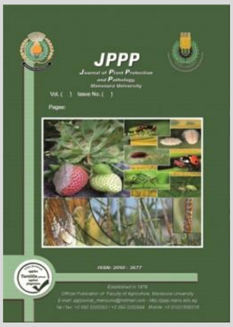

ABSTRACT

Stored grain insect pests cause a high risk to the grains and seeds in storage such as weight loss, less germination, and reduced nutrition values of grains. Heavily use of synthetic insecticides resulted in a lot of problems for humans and the environment. Therefore, the present study aimed to evaluate new approaches for controlling certain stored product insects. In this respect, the following approaches were investigated: Acutely toxic chemicals, mostly of natural origin, i.e. Avermectins and pyrethrins against stored insect pests. In addition to Azadirachtin, the main constituent of neem kernels is a feeding deterrent. Some toxicological and environmental aspects of some tested chemicals were also evaluated. The results showed considerable and remarkable insecticidal activity. Avermectins, in particular, Ivermectin exhibited a noticeable insecticidal potency against the stored grain insects (i.e. cowpea weevil, *Callosobruchus maculatus* F., and khapra beetle, *Trogoderma granarium* E.) under storage conditions (viz. lacking direct light and other weathering factors). yrethrins revealed a long residual toxicity when applied on grains. Azadirachtin, the principal phytochemical of neem kernels, has markedly antifeedant properties. Also, Azadirachtin showed considerable feeding deterrent effect against larvae of khapra beetle, *T. granarium* at concentrations ≥ 125 mg/kg grains. Moreover, the results showed that Abamectin was highly effective.

Keywords : Bio Pesticides; Malathion; stored grain; toxicity; antifeedant

INTRODUCTION

Stored grain of almost any kind is subject to attack by insects, which are highly specialized and in most cases are of small size with high reproductive potential. Acceptable pesticides for the environment are known for their relatively low toxicity to non-target organisms and biodegradability . This makes it possible to integrate pest management programs (Samuel *et al* 2021). Organophosphorus (OP) insecticide such as Malathion is being used as a protectant substance against stored grain insects during storage till now. Also, several pests now resistant to (OP) insecticides, Rhyzopertha dominica were resistant to Malathion (El-Lakwah *et al*., 2004). Subsequently, resistance to Malathion was noticed from different parts of the countries (Srivastava *et al*.2001). The potential hazards for mammals from the conventional insecticides, the ecological consequences and the increase of insect resistance to these insecticides have led to a search for newer advantageous classes of insecticides (Mossa 2016). Avermectins, a family of macrocyclic lactones are natural product pesticides isolated from the fermentation of the soil microorganism, Streptomyces avermitilis and they have potent anthelmintic, acaricidal as well as insecticidal properties (Shoop *et al*., 1995; Abdel-Tawab *et al* 2018). Syed *et al* (2019) used avermectin; cypermethrin against Tribolium confusum and the comparison of toxicity include calculating LC50 and LT50 values. Based on LC50 values avermectin was the premier following cypermethrin and neem. The efficacy of abamectin was assessed on wheat and maize under two temperatures (25 and 30ºC) against adults of Rhyzopertha dominica, Sitophilus oryzae and Tribolium confusum, the efficacy of abamectin was higher in maize than in wheat against all species tested. (Kavallieratos *et al*, 2009). Guray *et al* (2018) reported that abamectin had insecticidal efficacy against Tribolium castaneum adults in 20ºC. However; little was reported about such compounds as stored-grain protectants. In spite of the fact that most botanicals are less efficacious than the best synthetic products, public mistrust in synthetic chemicals is creating a political environment favorable for botanicals. This political environment has already been well exploited by manufacturers of microbial insecticides (Viz. Bacillus thuringiensis and Beauveria bassiana products). Azadirachtin is a tetranortriterpenoid compound belonging to the limonoids, which can be isolated from the Neem tree, Azadirachta indica A. Juss. The potential of azadirachtin and azadirachtin-containing extracts has been explored for use in integrated control programs for many agricultural field pests, especially those concerned with lepidopteran species (Vishal *et al* 2019). Insect pests of stored products, however, received relatively minor attention. On the other hand, Pyrethrum is a botanical insecticide extracted from dry flowers of Tanacetum cinerariifolium (also known as Chrysanthemum cinerariifolium) (Qiang Wang *et al* 2021) pyrethrum and pyrethrins have been used as insecticides since at least 1800, and for decades have been the most commonly used as home and garden insecticides. Recently, M. Paramesha *et al* (2018) indicated that pyrethrum extracts of flower and callus on insect Tribolium sp., showed higher repellency and early knock-down effect. There are more registered uses for pyrethrins than for any other insecticides (Ware, 2000). Other than home and garden uses, pyrethrins are used on a variety of agricultural crops and for structural and public health pest control. The

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amount used in agriculture is small relative to the other uses (Cox, 2002).

The present study was planned to evaluate the insecticidal potency of Abamectin, ivermectin pyrethrins, Malathion and Azadirachtin against cowpea weevil, khapra beetle adults and its larvae through some bioassay methods included contact toxicity, residual toxicity, and anti-feedant activity.

MATERIALS AND METHODS

Pesticides used

1. **Abamectin:** (Vertimec 1.8% EC) (prod. Novartis Agro., Swithzerland)
2. **Ivermectin:** (Ivomic 1% aq.) (prod. Merck Sharp & Dohme BV, Harlem, Holland)
3. **Pyrethrins (Natural) :** (Agrothrin 0.11% D) (prod. Agropharm Limited)
4. **Malathion** : (Malason 1% D) (prod. KZ, Egypt)
5. **Azadirachtin :** (Neemix 4.5% EC) (prod. Thermo Trilogy, Grace Drive, Columbia)

Insects tested

All tested insects were obtained from the Department of Stored-Product Pests, Plant Protection Research Institute, Agricultural Research Center, Dokki, Egypt. Insect species tested and their life cycles identified according to Badawy and Doraeham (1991).

1- Cowpea weevil, *Callosobruchus maculatus* (F.) (Fam: Bruchidae).

Insects were maintained in small glass jars containing 150-200 unsexed adults and approximately 200 gm of cowpea seeds each. Jars were covered with muslin kept in position with rubber bands. The cowpea seeds used for insect culture and experiments were previously sterilized by freezing at -18°C for one week to kill any prior insect infestation, then stored in sealed polyethylene bags at 5°C until required for experiments. Newly emerged adults (0-24 hrs old) were used in the experiments. To obtain the adults, the culture medium was sieved to remove the old beetles therein and the emerged insects were collected for experiments.

2- Khapra beetle, *Trogoderma granarium* (Everts), (Fam. Dermestidae).

Female of T. granarium deposites 30-60 eggs inside grains or between them. Proper conditions for growth are 35°C and 70% RH. Larval period ranges 16-19 days, whereas life span duration ranges 24-27 days. Insects were maintained in the laboratory at 70 ±5 RH%, in small jars each contained 200-400 adults and 400 gm of crushed wheat grain. Jars were covered with muslin cloth fixed with rubber bands to be tightly closed. Newly emerged larvae of T.granarium and adults (0-24 hours old) were used in the experiments.

Preparation of grains .

Wheat grains, Triticum aestivum var, Sakha 61 and cowpea seeds, Vigna unguiculate (L.), var. Azmerly, were used as a medium, carrying the tested insects. Grains were sterilized by freezing at -18°C for 1 week to kill off any prior infestation.

Toxicity to insects.

An 400 gm of grains (cowpea seeds or wheat grains of moisture contents, 12.5 and 8.5% for cowpeas and wheat, respectively) were placed in 1 L. glass jar. 20 ml of aqueous dilution (containing the desired quantity of the test compound) were pipetted onto the grain surface. Jars were then sealed and thoroughly shaken and tumbled for two minutes to ensure complete mixing. The treated grains were spread over polyethylene sheeting and left to dry at room temperature. Serial concentrations of each toxicant (mg a.i/kg grains) were made. For each concentration, 20 gm of treated grains were placed in a petri dish (9-cm diameter) and replicated four times. Ten adults or larvae of the tested insects were transferred to each dish. Controlnumbers of insects were transferred to petri-dishes containing grains treated with water only. Mortality counts were recorded 24 hours after treatment and corrected by concentration-mortality response lines (Abbott's formula, 1925). LC_{50} and slope values were calculated according to the method of Finney (1971).

Residual toxicity assays.

Two kilogrms of wheat grains or cowpea seeds were treated with the tested insecticides. Grains were weighed and placed in wide-mouth glass jars. Each insecticide was diluted in water and added to the grains in which the final concentration was equivalent to the LC_{99} of the insecticide to be used against the tested insect. Jars were vigorously hand-shaken for adequate time to ensure complete mixing. The treated grains were allowed to dry at room temperature then packed in tightly closed jute sacks (20×30 cm) and stored at room conditions (28 ± 2°C and 70 ± 5% R.H.) under complete darkness. Samples, each consisted of 20 gm of treated grains were withdrawn at various periods (i.e. 1, 2, 4, 6, 8, 10, and 12 months) and placed in Petri-dishes (9 cm diameter). Twenty adults or larvae of the tested insect were transformed to each dish contained the treated grains for 24 hours, and then mortality counts were recorded. Three replicates were made for each treatment. Time was plotted against mortality percentages on log-probit paper, and Residue haff life (RHL) were calculated according to the statistical method of Finny, (1971).

Preparation of the tested pesticides as dusts and their toxicity testing against insects.

Abamectin (1.8% EC and Ivermectin (1% SL) were prepared in the laboratory as 1% Dust. The proper volume of the original formulation containing the desired quantity of the active ingredient was dissolved in 500 ml of acetone (Technical grade) placed in a 1L beaker. 400 gm of pharmaceutical talcum powder was added and mixed thoroughly with a glass rod. The resultant slurry was spread on a plain glass surface and left to dry at room temperature for 72 hours. The semi-dried mass was then dried at 40°C for 48 hours by means of an oven, powdered, and subjected to fine mesh sieving. The prepared dust was tested for their toxicity to the tested insects in comparison with the commercial, Malathion 1% D. Each dust was mixed thoroughly with grains at concentrations equivalent to fractions of LC_{99} of each original formulation (i.e. E.C., for abamectin and S.L. for ivermectin) for each tested insect. Treated grains were packed in polyethylene bags (Fig. 1) each containing 300 gm. Twenty adults of the insect tested were confined in each bag. Bags were tightly closed. Two controls were made, i.e. non-treated grains and grains treated only with talcum powder. Four replicates were made for each treatment. Bags were stored for 24 hours under complete darkness and laboratory conditions, after which mortality counts were recorded.

Fig. 1. Polyethylene bags containing grains treated with the tested pesticides as dusts.

Antifeedant effect of Azadirachtin.

The antifeedant effect of wheat grains treated with Azadirachtin on larvae of the khapra beetle, *T. granarium* was evaluated. Two types of tests were carried out in this respect, choice and non-choice tests. In choice tests, a petri-dish (9-cm in diameter) was divided into two equal parts separated by a simple barrier that allows insects to move freely from one part to the other. The first part received 20 gm (about 350 grains) of treated grains, whereas the second one received 20 gm of non-treated grains. A number of 50-secondinstar larvae were confined to the treated portion. In the non-choice test, the same procedure was conducted with the exception that dishes contained treated grains only without being divided into parts. For both tests, controls were made using non-treated grains. Four replicates were performed for each treatment. Dishes were stored for 20 days under previously mentioned laboratory conditions with complete darkness, then percent of damaged grains was calculated.

RESULTS AND DISCUSSION

Results

The acute toxicity of the insecticides against tested insects.

Toxicity after 24 h. exposure.

The toxicity of the tested insecticides against insects was evaluated using the technique of mixing the toxicant with a feeding medium of insects (i.e. cowpea seeds or wheat grains, of moisture contents, 12.5 and 8.5%, respectively). Results are recorded in Tables (1-3). Based on median lethal concentrations (LC_{50} values), the potency of the tested insecticides could be ranked descendingly as follows.

- **Against adults of *C. maculatus* :** Ivermectin [(a)] (0.19) > abamectin [(a)] (0.20) > Pyrethrins [(b)] (0.40) > (0.50) > Malthion[(c)]. (6.1).
- **Against adults of *T. granarium* :** Abamectin[(b)] (1.2) > Ivermectin [(c)] (2.1) > Pyrethrins [(c)] (2.6) > Malathion[(d)] (5).
- **Against larvae of *T. granerium* :** Abamectin[(a)] (0.5) > Ivermectin[(a)] (0.8) (13.3) > Malathion[(c)] (69.3) > Pyrethrins[(d)] (>352).

LC_{50} values (mg a.i./kg grains) are shown in parenthesis. Based on the overlapped values of confidence limits, insecticides carrying the same letters have no significant differences. It is clear that avermectins (Abamectin or Ivermectin) showed considerable toxicity to the tested insects that surpassed the toxicity of Malathion. However, Abamectin was the most toxic compound against the adults of Khapra beetle, *T. granarium*. According to the obtained LC_{50} values, avermectins were nearly (30), (2-4) and (86-138 times)as toxic as Malathion, against adults of *C. maculatus*, *T. granasium*, and larval of *T. granarium*, respectively.

The obtained results revealed also that pyrethrins (Agrothrin 0.11% D) exhibited reasonable toxicity to the tested insect (relative potencies were 48,% versus and 3.11% for malathion) (Table1). Pyrethrum has been in general use for many years, but supplies are limited and so to reduce the cost and extend its usefulness, low concentrations of pyrethrins are mixed with a synergist (often, piperonyl butoxide) which enhances their activity. Pyrethrins like all members of the pyrethroid insecticide family kill Insects by disputing their nervous systems.

Table 1. Toxicity of the tested pesticides against adults of cowpea weevil, *C. maculatus* (F) after 24 hr. exposure to treated cowpea seeds.

Pesticide	Formulation	LC_{50} (mg/kg seeds)		LC_{99} (mg/kg seeds)		slope	Relative[1] potency (%)
		Value	Fiducial limits	Value	Fiducial limits		
Abamectin	EC	0.20	0.17-0.29	2.1	1.10-8.10	2.3	95.00
Ivermectin	SL*	0.19	0.15-0.26	2.2	1.10-8.70	2.2	100.00
Pyrethrins	D**	0.40	0.30-0.50	2.5	1.50-8.90	3.0	48.00
Malathion	D**	6.10	4.90-7.50	36.3	23.4-80.5	3.3	3.11

*** SL. Soluble liquid** **** D. Dust**

[1] Relative potency = (LC_{50} of the most toxic insecticide/LC_{50} of the candidate insecticide) ×100

Table 2. Toxicity of the tested pesticides against adults of khapra beetle, *T. granarium* Everts, after 24 hr. exposure to treated wheat grains.

Pesticide	Formulation	LC_{50}(mg/kg seeds)		LC_{99}(mg/kg seeds)		slope	Relative[1] potency (%)
		Value	Fiducial limits	Value	Fiducial limits		
Abamectin	EC	1.2	0.9-1.6	15.9	8.00-54.2	2.1	50.0
Ivermectin	SL*	2.1	1.7-2.7	17.8	10.2-51.4	2.5	28.6
Pyrethrins	D**	2.6	2.1-3.3	17.2	10.5-41.7	2.8	23.1
Malathion	D**	5.0	4.1-6.2	24.0	15.7-51.9	3.4	12.0

*** SL. Soluble liquid** **** D. Dust**

[1]Relative potency = (LC_{50} of the most toxic insecticide/LC_{50} of the candidate insecticide) ×100

Table 3. Toxicity of the tested pesticides against 2nd instars larvae of khapra beetle, *T. granarium* Everts, after 24 hr. exposure to treated wheat grains.

Pesticide	Formulation	LC_{50}(mg/kg seeds)		LC_{99}(mg/kg seeds)		slope	Relative[1] potency (%)
		Value	Fiducial limits	Value	Fiducial limits		
Abamectin	EC	0.50	0.4-0.6	5.9	3.1-17.2	2.1	100.00
Ivermectin	SL*	0.80	0.7-1.1	5.5	3.2-15.0	2.9	62.50
Pyrethrins	D**	>352	-	>352	-	-	0.14
Malathion	D**	69.3	56.9-85.5	356.4	232.6-761.7	3.3	0.72

*** SL. Soluble liquid** **** D. Dust**

[1]Relative potency = (LC_{50} of the most toxic insecticide/LC_{50} of the candidate insecticide) ×100

The residual toxicity

Results are recorded in Table (4). In general, the tested compounds exhibited a long residual effect (RHL ranged 5.2 - 25.4 months). It was noted that, nearly, complete mortality was achieved for the test insect exposed to treated grain within the first four months of storage, then the loss of the residual activity of insecticides over time seemed to be linear. Avermectins showed adequate residual toxic action currently required for effective protection against stored-grain insect (RHL 17.1, 10 months) for Abamectin and Ivermectin against adults of *C. maculatus*, respectively (Table 4).

From the results obtained, it was obvious that pyrethrins mixed with grains showed a long residual effect (LT_{50} values: 15.7 months, against adults of *C. maculatus*. Pyrethrins are known to have very short half-lives, but the long residual effect is observed in the present study.

Table 4. Residual toxicity of pesticides against adults of cowpea weevil, *C. maculatus* following, 24 hr. exposure to treated cowpea seeds, stored for different periods.

Pesticide	Formulation	% Mortality at storage periods(months							R.H.L (months)	
		1	2	4	6	8	10	12	Value	C. limits
Abamectin	EC	100	100	100	92	85	77	70	17.1	14.1-24.9
Ivermectin	SL*	100	100	94	87	75	50	30	10.0	9.40-10.8
Pyrethrins	D**	100	100	100	100	100	90	80	15.7	13.7-24.6
Malathion	D**	100	100	100	98	96	90	85	25.4	17.7-68.5

*** SL. Soluble liquid** **** D. Dust** **R.H.L. Residue half life**

Table 5. Residual toxicity of pesticides against adults of khapra beetle, *T. granarium* following, 24 hr. exposure to treated wheat grains, stored for different periods

Pesticide	Formulation	% Mortality at storage periods (months							R.H.L (months)	
		1	2	4	6	8	10	12	Value	C. limits
Abamectin	EC	100	100	100	98	92	85	78	17.7	14.8-25.4
Ivermectin	SL*	100	100	100	100	98	92	89	19.3	15.4-35.1
Pyrethrins	D**	100	100	100	95	83	70	52	12.9	11.8-18.0
Malathion	D**	100	100	100	90	79	67	44	11.5	10.7-12.7

*** SL. Soluble liquid** **** D. Dust**

Table 6. Residual toxicity of pesticides against 2nd instar larvae of khapra beetle, *T. granarium* following, 24 hr. exposure to treated wheat grains, stored for different periods

Pesticide	Formulation	% Mortality at storage periods (months							R.H.L (months)	
		1	2	4	6	8	10	12	Value	C. limits
Abamectin	EC	100	100	93	87	66	45	31	9.6	8.90-10.4
Ivermectin	SL*	100	100	100	89	75	67	46	11.6	10.7-12.9
Pyrethrins	D**	-	-	-	-	-	-	-	-	---
Malathion	D**	100	100	100	100	95	90	81	17.2	14.5-25.8

*** SL. Soluble liquid** **** D. Dust** **(-) Not tested**

Toxicity of insecticides tested as dusts

Abamectin (EC) and Ivermectin (SL) were roughly prepared in the laboratory as dust and tested for their toxicity against adults of cowpea weevil, *C. maculatus*, and rice weevil, *S. oryzae*, in comparison with the commercial Malathion 1% D. Talcum powder was the inert material used to prepare dust. Insects were confined to grains (Cowpeas or wheat) treated with insecticides at certain concentrations. These concentrations were calculated as fractions of LC_{99} of the original formulation against the tested insect. Exposure continued for 24 hr., then mortality counts were recorded. Results are recorded in Table (7). It was found that when Abamectin and ivermectin were formulated as dust, the toxicity was greatly improved especially against, cowpea weevil, *C. maculatus.* Concentrations of abamectin and ivermectin equivalent to 0.4 LC_{99} caused (100, 77%) and (100, 60%) mortalities against *C. maculatus* and *S. oryzae*, respectively. Malathion, the standard commercial dust was less toxic in this respect (0.4 LC_{99} caused 75 and 67% mortality against *C. maculatus* and *S. oryzae*, respectively. Thus, insects are more susceptible to avermectins when applied to grains as dust than being applied as aqueous liquids. No doubt the situation will be better if these dust are produced officially using proper inert materials and fillers.

Table 7. Toxicity of the tested pesticides prepared in the laboratory as dusts against adults of cowpea weevil *C. maculatus* and rice weevil, *S. oryzae* following 24 hr. exposure to treated grains.

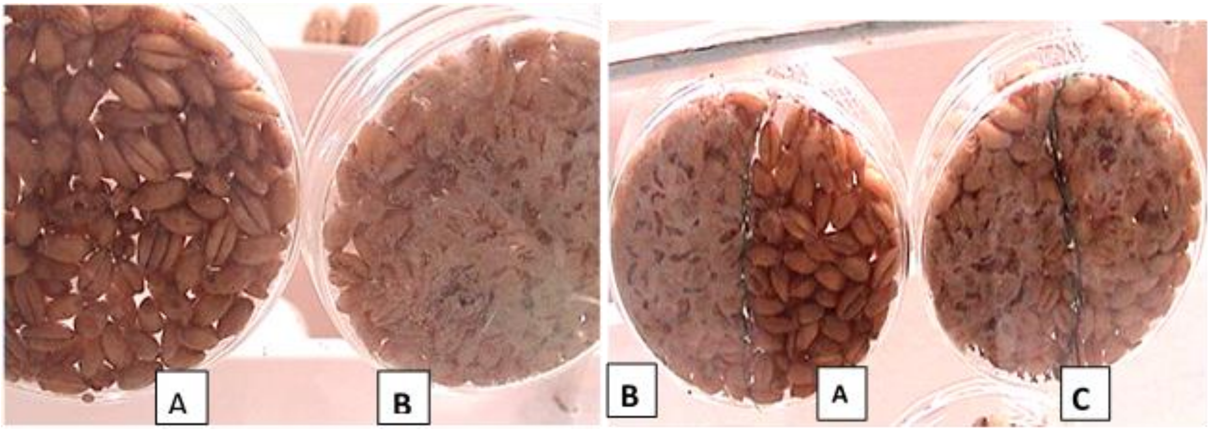
Pesticide	% Mortality at concentrations (mg a.i/kg grains)							
	0.1 LC_{99}		0.2 LC_{99}		0.4 LC_{99}		LC_{99}*	
	C. maculatus	*S. oryzae*	*C. maculatus*	*S. oryzae*	*C. maculatus*	*S. oryzae*	*C. maculatus*	*S. oryzae*
Abamectin(1)	29	37	59	60	100	77	100	100
Ivermectin(1)	23	17	60	23	100	60	100	86
Malathion(2)	17	11	38	35	75	67	100	100
Talcum powder(3)	0	0	0	0	0	0	0	0
Control	0	0	0	0	0	0	0	0

(1): prepared in the laboratory as 1% D;
(2): the commercial formulation 1% D
(3): insects were exposed to grains mixed only with talcum powder.
*** : LC_{99} for the original formulation**

Antifeedant effects of Azadirachtin:

1-Feeding deterrent effects of Azadirachtin:

The antifeedant activity of Azadirachtin against larvae of khapra beetle, *T. granarium* was evaluated. Two types of tests were performed, i.e. choice and non-choice tests. Larvae were confined to treated or non-treated wheat grains at Petri dishes for 20 days. Food consumption expressed as damaged grains were used as an indicator of the antifeeding activity. Results, are recorded in Table (8) and Fig. (2). Results show that Azadirachtin exerts a considerable antifeedant activity against the tested larvae. The effect was increasing with increasing the concentration of Azadirachtin.



(I) Non-choice tests **(II) choice tests**

Fig. 2. Feeding deterrant effect of Azadirachtin as indicated by the degree of wheat grain damage caused by larvae of *T. granasium*

(A) treated grains (at 500 mg/kg grain). **(B), (C): untreated grains.**

Azadirachtin at concentration, 500 mg/kg grain completely prevented food consumption (% of damaged grains was (0.0, 0.7) versus (31.1, 31.5) in control, for choice and non-choice tests, respectively). We suggest the concentration of 30-125 mg/kg grain as an economic threshold for protecting grains against insect infestation. Luckily,

Table 8. Feeding deterrent effect of Azadirachtin as indicated by the degree of wheat grains damage caused by larvae of khapra beetle, *T. granarium*

Concentration (mg/kg grains)	Damaged grains (%) Choice test Treated seeds	Choice test Non-treated seeds	Non-choice test Treated seeds
0.125	23.9 ^{b}	29.4 ^{ab}	26.8 ^{ab}
0.5	14.7 ^{c}	28.1 ^{abc}	12.8 ^{c}
2	10.3 ^{d}	27.2 ^{abc}	5.80 ^{d}
8	7.20 ^{e}	26.3 ^{abc}	5.10 ^{d}
30	4.70 ^{f}	25.6 ^{bcd}	4.20 ^{d}
125	1.90 ^{g}	24.2 ^{cd}	1.50 ^{e}
500	0.00 ^{h}	22.5 ^{d}	0.70 ^{f}
Control	31.7 ^{a}	31.1 ^{a}	31.5 ^{a}

In the same column, values followed by a common letter are not significantly different.

Discussion

Malathion resistance in *T. castaneum* is first reported in the united states by Speirs *et al.* (1967) and Vincent and Lindgren (1967). Since that time, many reports have shown that malathion resistance in this insect pest has grown in both scope and intensity (Haliday *et al*., 1988; Subramanyam *et al*., 1989; Zettler and Cuperus, 1990; and Attia *et al*., 2020). Although malathion could be considered as a standard insecticide for stored grain insects (Oudejans, 1991), the future status of malathion is organophosphorus insecticide registered in the united states, is questionable because of registration procedures required by the Environmental Protection Agency (Arthur, 1994). Malathion is registered as a protectant of stored grains and most if not all labels will soon be drowning (Abramson, 1991). However, Malathion D (1%) is recommended by the Egyptian Ministry of Agriculture to be mixed with stored grains as a protectant against their insects (Anonymous, 2001).

The obtained result are consistent with those of Gouamene-Lamine *et al.* (2003) who found that adults of the susceptible strain of the colorado beetle, *Leptinotarse decemlineata* (Say) were less sensitive to the toxic action of abamectin and two of its analogs when compared to susceptible larval stages. The authors concluded that abamectin resistance in colorado beetles may be mainly due to the enhanced oxidative metabolism of abamectin since adults are more tolerant to abamectin due to an enhanced level of oxidative detoxification. Thus, from the acute toxicity point of view, avermectin might be regarded as a promising stored grain-protectant that can replace malathion (taking into considerations regardingtheir toxicological, environmental, and economical variables). kavallieratos *et al.* (2009) studied the efficacy of abamectin on wheat and maize against adults of *rhyzopertha dominica, sitophilus oryzae*, and *tribolium confusum*. The found that the efficacy of abamectin was higher in maize than in wheat against all species tested. Tanzeela *et al.* (2019) showed that LC_{50} for larval instars of *T. granarium* was 172 ppm with abamectin. Also, Mohsen *et al.* (2021) reported that abamectin had the most toxicity followed by azadirachtin against second-instar larvae of *Tuta absoluta* after 72 hr.

Paramesha (2018) concluded that pyrethrins are toxic to the “sodium channel” of the cellular structure that allows sodium ions to enter a cell as part of the process of transmitting a nerve impulse. This leads to repetitive discharges by the nerve cell which causes paralysis and death.

For residual toxicity, Abo-Arab and El-Hamady (1998) found that the residual toxicity of ivermectin on grains (wheat or cowpea) treated with LC_{99}, effectively lasted for 3-9 months against adults of *S. oryzae* and *C. maculatus*. The variations in duration of residual toxicity might be due to differences in the initial concentration of the toxicant on grains leading to varied half-life values. Mohamed *et al*. (2020) estimated the dissipation rates of abamectin, chlorfenapyr, and pyridaben acaricides in green beans (*Phaseolus vulgaris* L.) found that the lowest residues, at different time intervals of field application rate of each pesticide, were observed with abamectin.

The residual effect of pyrethrins might be due to the indoor conditions, in particular, the complete darkness in which the treated grains were stored. Outdoors, pyrethrins persist only for a short time For example, after application of pyrethrins to bare soil, the half-life was two hours or less (WHO and FAO, 2000). Pyrethrins persist much longer indoors than they do outdoors. Berger *et al.* (1997) found that pyrethrins persisted in carpet dust for over two months after treatment. A large family of insecticides, the synthetic pyrethroids, are structurally similar to pyrethrins but have been chemically modified to make them more toxic and more persistent. Pyrethrin insecticides often contain piperonyl butoxide, a chemical that increases their potency. Also, Biebel *et al.* (2003) reported that pyrethrum extract has a long history of successful application in the control of stored products. The synergized pyrethrin had efficacy when applied as an aerosol against eggs, larvae, pupae, and adults of *Tribolium castaneum* (Herbst), and *Tribolium confusum* Jacquelin du Val (Kabita *et al*., 2014). pyrethroids combination with pyrethrum is effective against storage insect pests (Bomzan *et al*., 2018). Several pyrethroids applied in combination with piperonyl butoxide synergist have been effected against House Fly (*Musca domestica* L.) (Huseyin Cetin *et al*. 2019). Its low environmental hazard makes it an ideal pesticide for outdoor pre-harvest treatment. However, the disadvantages of its low light stability then become apparent. This drawback can be overcome by the complexation of pyrethrum extract with δ cyclodextrin. To slow down the quick metabolism of the pyrethrum by the insect microsomal system synergistic substances were added. Additional to the already well-known piperonyl butoxide, two natural synergies, sesamol and tocopherol acetate was combined with pyrethrum extract and found to enhance the toxicity. Storage conditions, i.e. temperature and moisture content can also affect the stability of pyrethrins. Noble *et al.* (1982) reported that permethrin on treated wheat and stored at 25°C (12% moisture) or 35°C (15% moisture) had a half-life of 252 and 44 weeks, respectively also, Kayode *et al.* (2021) noticed that temperature changes also affect insecticide toxicity on *C. quinquefasciatus* to toxicities of pyrethroid it was 89 ppm at 37 °C. The half-life, being dependent on the wheat storage conditions, decreased as the temperature and moisture increased.

The conventional insecticide, Malathion showed also, long residual toxicity. The duration of the residual toxic action of Abamectin was shorter than that of Malathion particularly against adults of *C. maculatus* (RHL 17.1) months versus 25.4 months for Malathion. Abo-Elghar *et al.* (2003) found that malathion applied at 25 mg a.i./kg cowpea seeds showed residual activity against *C. maculatus* extended up to 8 months post-treatment. Also, Malathion gave nearly 100% control of adults of *T. castaneum* (confined to treated wheat grain) for 9 months at 4 ppm and 11 months at 8 ppm (White, 1984).

Dust formulations of insecticides have held obvious attractions in stored products against insect infestation. They are usually of lower mammalian toxicity and have stable shelf storage life and good residual quality (El-okda *et al.*, 1979). Malathion 1% D is recommended in Egypt to be mixed with stored grains to protect them from insect infestation (Anonymous, 2001). Zlatko and Paul (2020) concluded that applying pyrethrins as powders is an effective insecticide, against *Tribolium castaneum* and *Rhyzopertha dominica* with 50% mortality ranging from 430 to 1000 ppm depending on the species after 2–3 days. Muda and Cribb (1999) found that the antifeedant effect of Azadirachtin on adults of *Rhyzopertha dominica* was unaffected by unevenness of treating grains, provided that 50% of the grain was treated. The fact that Azadirachtin remains effective when the application to grain is uneven may be of great interest when it is desired to reduce the concentration needed for good protection. Jilani and Saxena (1990) reported that neem compounds were too complex to be synthesized for practical purposes.

Azadirachtin was originally isolated owing to its outstanding antifeedant effect against the desert locust, *Schistocerca gregaria* and this finding ushered in the concept of non-toxic crop protectants based on feeding deterrence (Isman, 1994). Azadirachtin and Azadirachtin–based insecticides were also found to be an antifeedant effect on coleopteran and lepidopteran insect species infesting stored products (Jilani and Saxena, 1990; Gerard and Ruf, 1995; Muda and Cribb 1999). The repellent effects of these insecticides against coleopteran species were demonstrated as well (Jilani and Saxena 1990; Ban *et al.*, 2000; Kayode and Adanlawa, 2002). Qin *et al.* (2020) found that the larvae *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae) showed an obvious antifeeding effect with 4 mg/kg azadirachtin.

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مقارنه كفاءه لمبيدات كيميائيه وحيويه مختاره ضد بعض حشرات الحبوب المخزونه

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الملخص

استهدف هذه الدراسة تقييم الكفاءة الإبادية لبعض آليات مكافحة بعض حشرات الحبوب المخزونة والتي تسبب خسائر فادحة في الإنتاج المخزون من الحبوب والبقول مثل خنفساء اللوبيا *C. maculatus* وخنفساء الصعيد *T. granarium* وفى هذا الصدد تم تقييم الاتجاهات الآتية في مكافحة الآفات المذكورة وهي مركبات ذات سمية حادة على الحشرات وهى غالباً من أصل طبيعي وهى الأفيرمكتينات (الأبامكتين، الإفيرمكتين) والبيرثرينات الطبيعية وذلك بالمقارنة بالمبيدات التقليدية المستخدمة في نفس الغرض وهى الملاثيون. كما تم تقييم مستحضر يحتوى على الأزادرختين المستخرج من نبات النيم المعروف حيث تم دراسة فعله كمانع لتغذية الحشرات. وبتلخيص النتائج المتحصل عليها وجد أن مركبات مجموعة الأفيرمكتينات لها سمية معقولة على الحشرات المختبرة والتي تفوقت أحياناً على سمية المبيدات التقليدية المختبرة مثل الملاثيون والأكتليك خصوصاً ضد خنفساء اللوبيا وخنفساء الصعيد. والأكثر من ذلك أظهرت هذه المركبات تأثيراً متبقياً طويلاً وصل إلى أكثر من ثمانية أشهر أما البيرثرينات الطبيعية والمعروفة بقصر فترة أعمار النصف لها في البيئة المفتوحة فقد أظهرت تأثيراً متبقياً طويلاً أيضاً خاصة ضد حشرة خنفساء اللوبيا وربما يرجع ذلك إلى طبيعة الظروف التي أجرى فيها تعرض الحشرات لها خصوصاً الإظلام التام داخل المعمل. كما أظهر الأزادرختين تأثيراً جيداً مانعاً للتغذية ضد يرقات خنفساء الصعيد (الخابرا) عند تركيزات ≤ 125 ملليجرام/كجم حبوب معاملة.