

Journal of Plant Protection and Pathology

Journal homepage & Available online at: www.jpmp.journals.ekb.eg

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

Abo Arab, R. B. ; Nariman M. El-Tawelh ; Amal M. Hamza and G. M. Nasr*



Plant Protection Research Institute, Dokki, Giza, Egypt.

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). Pyrethrins 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 30°C) 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 20°C. 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

* Corresponding author.

E-mail address: g.morris74@hotmail.com

DOI: 10.21608/jppp.2022.145344.1083

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., Switshzerland)
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* deposits 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. Control numbers 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 kilograms 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 ($28 \pm 2^{\circ}\text{C}$ and $70 \pm 5\%$ 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 half 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-second instar 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 (LC₅₀ 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. granarium*** : Abamectin^(a) (0.5) > Ivermectin^(a) (0.8) (13.3) > Malathion^(c) (69.3) > Pyrethrins^(d) (>352).

LC₅₀ 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 LC₅₀ values, avermectins were nearly (30), (2-4) and (86-138 times) as toxic as Malathion, against adults of *C. maculatus*, *T. granarium*, 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 = (LC₅₀ of the most toxic insecticide/LC₅₀ 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

¹Relative potency = (LC₅₀ of the most toxic insecticide/LC₅₀ 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

¹Relative potency = (LC₅₀ of the most toxic insecticide/LC₅₀ of the candidate insecticide) ×100

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.

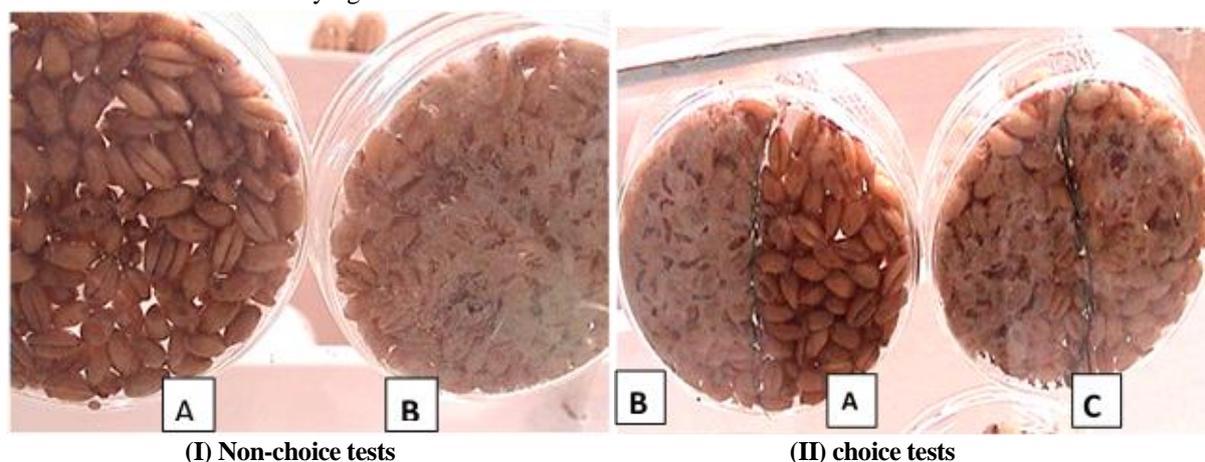


Fig. 2. Feeding deterrent effect of Azadirachtin as indicated by the degree of wheat grain damage caused by larvae of *T. granarium*

(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		Non-choice test
	Treated seeds	Non-treated seeds	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 regarding their 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 LC₅₀ 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 LC₉₉, 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.

REFERENCES

- Abbott, W.S. (1925). Method for computing the effectiveness of insecticides. *J. Econ. Entomol*, 18 (2): 265-273.
- Abo-Arab; R.B.S. and El-Hamady, Sh. E.E. (1998). Ivermectin: as a protectant against stored grain insects. *Alex. Sci. Exch.* 19:49-427.
- Abo-Elghar, G.E.; El-Sheikh, A.E.; El-Sayed, F.M.; El-Maghraby, H.M. and El-Zun, H.M. (2003). Persistence and residual activity of an organophosphate, pirimiphos-methyl, and three IGRs, hexaflumuron, teflubenzuron and pyriproxyfen, against the cowpea weevil, *Callosobruchus maculatus* (Coleoptera : Bruchidae). *Pest-Manag. Sci.* 6: 95-102.
- Abramson, A.S. (1991). Malathion, deletion of certain uses and directions for use. *Fed. Reg.* 56, 11419-11420.
- Anonymous (2001). Technical Recommendations for protection of Agricultural pests. Ministry of agriculture and Land Reclamation, Egypt. P. 230

- Arthur, F.H. (1994). Efficacy of Unsynergised Deltamethrin + Chlorpyrifos-methyl combinations as protectants of stored wheat and stored corn (maize). *J. Stored prod. Res* 30(1): 87-94.
- Attia, M.A., Wahba, T.F., Shaarawy, N., Moustafa, F.I., Guedes, R.N.C., Dewar, Y. (2020). Stored grain pest prevalence and insecticide resistance in Egyptian populations of the red flour beetle *Tribolium castaneum* (Herbst) and the rice weevil *Sitophilus oryzae* (L.). *J. Stored prod. Res*, volume 87, 2020, 101611. <https://doi.org/10.1016/j.jspr.2020.101611>
- Badawy M.E.I, Mahmoud M.S., Khattab M.M. (2020). Residues and dissipation kinetic of abamectin, chlorfenapyr and pyridaben acaricides in green beans (*Phaseolus vulgaris* L.) under field conditions using QuEChERS method and HPLCJ *Environ Sci Health B*. 2020;55(6):517-524. doi: 10.1080/03601234.2020.1726701
- Badawy, A. I. and Naser Ibn Doraeham Y. (1991). Stored grain and products, pests and their control, King Soud Univ., Soudia Arabia (In Arabic).
- Ban, U.; Shahanara, A.K. and Takao, L. (2000). The efficacy of volatile ingredients in neem oil against *Callosobruchus chinensis* (Coleoptera : Bruchidae). *Kagwa Daigaku Nogakubu Gakayutsu okoku*. 52: 67-69.
- Berger-PreiB, E.; Levssen, E.K. and PreiB A. (1997). Analysis of individual natural pyrethrins in indoor matrices by HRG/ECD. *J. High Resol. Chromatogr*. 20 : 284-289.
- Biebel, R.; Rametzhof, E.; klapal, H.; Polheim, D. and Viernstein, H. (2003). Action of pyrethrum based formulations against grain weevils. *International Journal of pharmaceutics (kidlington)*. 256 : 175-181.
- Bomzan DP; Bhavya ML; Manivannan S; G. Lavanya; K. Ramasamy; Akmal Pasha (2018). Potential of pyrethroid-synergised pyrethrum on stored product insects and implications for use as prophylactic sprays. *J. Food Science Technol*. 55(6): 2270–2278.
- Cox, C. (2002). Pyrethrins/pyrethrum. *Journal of pesticide Reform*. Vol. 22, No. 1 pp: 14-20.
- El-Lakwah, F.M., M.K.I. Saleh, E.A. Abd El-Aziz and M.E.H. Nasr, (2004). Studies on persistence and toxicity of two organophosphorus insecticides and plant extracts to stored product insects. Thesis Fac. of Agric. Moshtohor, Banha Univ., A.R.E
- El-Okda, M.; Youssef, K.H. and Tadros, G. (1979). The study of some insecticide dusts against stored grain insects. *Proc. 3rd pesticide Conf. Tanta Univ*. Vol. (1).
- Finney, D.J. (1971). *Probit Analysis*. Cambridge. Univ. Press. PP 333.
- Gerard,P.J. and Ruf, L. (1995). Effect of a neem (*Azadirachta indica* A. Juss, Meliaceae) extract on survival and feeding of larvae of four keratinophagous insects. *J. Stored Prod. Res*. 31: 111-116.
- Gouamane-Lamine, C.N.; Yoon, K.S. and Clark J.M. (2003). Differential susceptibility to abamectin and two bioactive avermectin analoges in abamectin resistant and susceptible strains of Colorado potato beetle, *Leptinotarsa decemlineata* (Say) (Coleoptera : Chrysomelidae). *Pesticide –Biochemistry and Physiology*. 76: 15-23.
- Guray A. Ferizli, Sadi Pamuk, Mevlut Emekci (2018). Insecticidal efficacy of abamectin against red flour beetle *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae): influence of dose, exposure interval, relative humidity and temperature. 12th International Working Conference on Stored Product Protection (IWCSPP) in Berlin, Germany, October 7-11, 2018.
- Haliday, W.R.; Arthur, F.H. and Zettler, J. (1988). Resistance status of red flour beetle (Coleoptera : Tenebrionidae) infesting stored peanuts in the south eastern united states. *J. Econ. Entomol* 81: 74-77.
- Huseyin Cetin; Oner Koçak; Emre Oz; Samed Koc. (2019). Evaluation of some Synthetic Pyrethroids and Piperonyl Butoxide Combinations against Turkish House Fly (*Musca domestica* L.) Populations. *Pakistan J. Zool.*, vol. 51(2),pp 703-707,2019
- Isman, M.B.(1994). Botanical insecticides. *Pesticide outlook*, June, P: 26-30.
- Jilani, G. and Malik, M. (1973). Studies on neem plant as a repellent against stored grain insects. *J.Sci. Ind. Res*. 16: 251-254.
- Jilani, G. and Saxena, G. (1990). Repllent and feeding deterrent effects of turmeric oil, sweetflag oil, neem oil, and a neem based insecticide against lesser grain borer (Coleoptera : Bostrchidae). *J. Econ, Entomol*. 88 : 628-680.
- Kabita Kharel, Frank H. Arthur, Kun Yan Zhu, James F. Campbell, Bhadriraju Subramanyam, Evaluation of Synergized Pyrethrin Aerosol for Control of *Tribolium castaneum* and *Tribolium confusum* (Coleoptera: Tenebrionidae), *Journal of Economic Entomology*, Volume 107, Issue 1, 1 February 2014, Pages 462–468, <https://doi.org/10.1603/EC13355>
- Kavallieratos, N.G., Athanassiou, C.G., Vayias, B.J., Mihail, S.B., and Tomanovic, Z.(2009). Insecticidal Efficacy of Abamectin Against Three Stored-Product InsectPests: Influence of Dose Rate, Temperature, Commodity,and Exposure Interval. *J. of Econ. Entomol*. 102(3):1352-1359.
- Kayode Lawrence, A., Arotiowa, A.R., Ete, A.J. (2021). Impacts of changes in temperature and exposure time on the median lethal concentrations (LC50) of a combination of organophosphate and pyrethroid in the control of *Culex quinquefasciatus*, say (Diptera: Culicidae) *Scientific African*, Volume 12, 2021, Article e00743 doi.org/10.1016/j.sciaf.2021.
- Kayode, J. and Adanlawo, I. G. (2002). Pesticidal potentials of *Azadirachta indica* and *Gmelina arborea* on cowpea weevil (*Callosobruchus maculatus*). *Journal of Tropical forest Products*. 8 : 130-134.
- M. Paramesha; S. Manivannan; S. J. Aditya Rao; Bhagyalakshmi Neelwarne; Nandini P. Shetty (2018). Augmentation of pyrethrins content in callus of *Chrysanthemum cinerariaefolium* and establishing its insecticidal activity by molecular docking of NavMS Sodium Channel Pore receptor.: *3 Biotech* 8, 367 (2018). <https://doi.org/10.1007/s13205-018-1387-8>

- Mohsen Taleh, Hooshang Rafiee Dastjerdi, Bahram Naseri, Asgar Ebadollahi, Aziz Sheikhi Garjan, Khalil Talebi Jahromi (2021). Toxicity and biochemical effects of emamectin benzoate against *Tuta absoluta* (Meyrick) alone and in combination with some conventional insecticides. *Physio. Ento. Vol.46, Issue3-4, Pages 210-217. doi.org/ 10.1111/phen.12360*
- Mossa A.T.H. (2016): Green pesticides: essential oils as biopesticides in insect-pest management. *Journal of Environmental Science and Technology, 9, 354–378.*
- Mossa, A. T. H., Mohafrash, S. M., Chandrasekaran, N. (2018). Safety of natural insecticides: toxic effects on experimental animals. *BioMed research international, 2018. https://doi.org/10.1155/2018/4308054*
- Muda, R. and Cribb, B.W. (1999). Effect of uneven application of azadirachtin on reproductive and anti-feedant behaviour of *Rhyzopertha dominica* (Coleoptera :Bostrichidae). *Pestic. Sci. 55 : 983-987.*
- Noble, P.M.; Hamilton, D.J. and Osborne, W.J. (1982). Stability of pyrethroids on wheat in storage. *Pestic. Sci. 13, 246-252.*
- Oudejans, J.H. (1991). Agro-pesticides, properties and functions in integrated crop protection. United Nations, Bangkok, 4th ed.
- Qiang Wang; Peng Xu; Felipe Andreazza; Yahui Liu; (2021). Identification of multiple odorant receptors essential for pyrethrum repellency in *Drosophila melanogaster*. *PLoS Genet 17(7): e1009677. doi.org/10.1371/journal.pgen.1009677*
- Qin D, Zhang P, Zhou Y, Liu B, Xiao C, Chen W, Zhang Z (2020). Antifeeding effects of azadirachtin on the fifth instar *Spodoptera litura* larvae and the analysis of azadirachtin on target sensilla around mouthparts. "Arch Insect Biochem Physiol"[jour]. 103(4): doi: 10.1002/arch.21646.
- Riaz, T., Shakoori, F. R., Mansoor, H., Khan, S., & Saleem, M. A. (2019). Efficacy of Mixture of Pesticides on the Mortality and Energy Reserves of a Stored Grain Pest *Trogoderma granarium* Everts. *Pakistan Journal of Zoology, 51(6).*
- Shoop, W.L., Mrozik, H. and Fisher, M.H. (1995). Structure and activity of avermectin and milbenycin in animal health. *Vet. Parasitol, 59: 139-156.*
- Speirs, R.D.; Redlinger, L.M. and Boles H.P. (1967). Malathion resistance in the red flour beetle. *J. Econ. Entomol. 60: 1373-1374.*
- Srivastava, C., Sinha, S. R., and Singh, D. (2001). Susceptibility of red flour beetle *Tribolium castaneum* (Herbst) to malathion. *Indian J. Entomol., 63(2): 176-178.*
- Subramanyam, B.; Harein, P.K. and Cutkomp (1989). Organophosphate resistance in adults of red flour beetle (Coleoptera : Cucuidae) infesting barley stored on farms in Minnesota. *J. Econ. Entomol. 82 : 989-995.*
- Tulashie, S.K.; Adjei, F.; Abraham, J.; Addo, E. (2021). Potential of neem extracts as natural insecticide against fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae). *Case Studies in Chemical and Environmental Engineering, Volume 4, 2021, Article 100130. doi.org/10.1016/j.csee.2021.100130*
- Vincent, L.E. and Lindgren (1967). Susceptibility of laboratory and field-collected cultures of the confused flour beetle and red flour beetle to malathion and pyrethrins. *J. Econ. Entomol. 60: 1763-1764.*
- Vishal V. Dawkar; Sagar H. Barage; Ranjit S. Barbole, Amol Fatangare, Susana Grimalt; Saikat Haldar, David G. Heckel, Vidya S. Gupta, Hirekodathakallu V. Thulasiram, Aleš Svatoš, and Ashok P. Giri. (2019). Azadirachtin-A from *Azadirachta indica* Impacts Multiple Biological Targets in Cotton Bollworm *Helicoverpa armigera*. *ACS Omega 4(5): 9531–9541.*
- White, N.D.G. (1984). Residual activity of organo-phosphorus and pyrethroid insecticides applied to wheat stored under simulated western canadian conditions. *Canadian-Entomol 116 (10): 1403-1410.*
- WHO and FAO (2000). Pesticide residues in food. 2000 evaluations. Part 1. Residues. FAO plant production and protection paper 165.
- Zaka, S.M.; Iqbal, N.; Saeed, Q.; Akrem, A.; Batool, M.; Khan, A.A.; Anwar, A.; Bibi, M.; Azeem, S.; Rizvi, D.-E.-N.; Bibi, R.; Khan, K.A.; Ghramh, H.A.; Ansari, M.J.; Latif, S. (2019). Toxic effects of some insecticides, herbicides, and plant essential oils against *Tribolium confusum* Jacquelin du val (Insecta: Coleoptera: Tenebrionidae) Saudi Journal of Biological Sciences, 26(7): 1767-1771.
- Zettler, J.L. and Cuperus, G.W. (1990). Pesticide resistance in *Tribolium castaneum* (Coleoptera : Tenebrionidae) and *Rhyzopertha dominica* (Coleoptera : Bosonidae) in wheat. *J. Econ. Entomol. 83: 1677-1651.*
- Zlatko Korunic and Paul G. Fields (2020). Evaluation of three new insecticide formulations based on inert dusts and botanicals against four stored-grain beetles *Journal of Stored Products Research, Volume 88, 2020, Article 101633.*

مقارنه كفاءه لمبيدات كيميائيه وحيويه مختاره ضد بعض حشرات الحبوب المخزونه رأقت بدر ابو عرب ، ناريمان محمد الطويله ، امل مصطفى حمزه و جورج موريس نصر معهد بحوث وقاية النبات – مركز البحوث الزراعية – الجيزة – مصر

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* وفي هذا الصدد تم تقسيم الاتجاهات الآتية في مكافحة الآفات المذكورة وهي مركبات ذات سمية حادة على الحشرات وهي غالباً من أصل طبيعي وهي الأفيرمكتينات (الأبامكتين، الإفيرمكتين) والبيرثرينات الطبيعية وذلك بالمقارنة بالمبيدات التقليدية المستخدمة في نفس الغرض وهي الملاثيون. كما تم تقييم مستحضر يحتوي على الأزاديرختين 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 والأكثليك خصوصاً ضد خنفساء اللوبيا وخنفساء الصعيد. والأكثر من ذلك أظهرت هذه المركبات تأثيراً متيقناً طويلاً وصل إلى أكثر من ثمانية أشهر أما البيرثرينات الطبيعية والمعروفة بقصر فترة أعمار النصف لها في البيئة المفتوحة فقد أظهرت تأثيراً متيقناً 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 الأزاديرختين تأثيراً جيداً مانعاً للتغذية ضد يرقات خنفساء الصعيد (الخابر) عند تركيزات ≤ 125 ملليجرام/كجم حبوب معاملة.