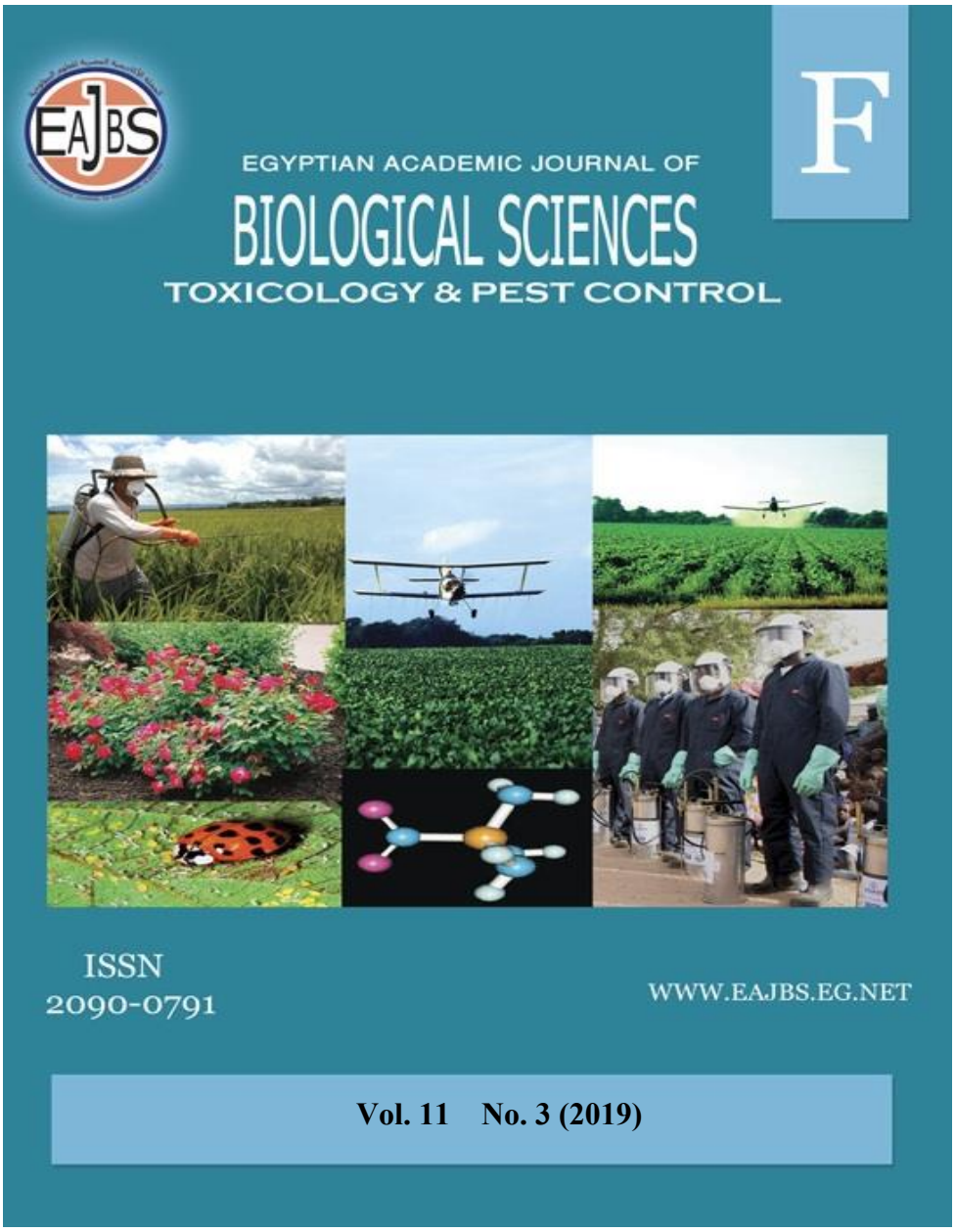

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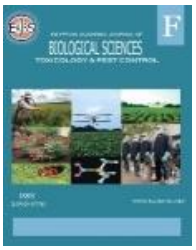

Protection of Irradiated Stored Maize against Angoumois Grain Moth, *Sitotroga cerealella (S)* And Zea Weevil, *Sitophilus zeamais (L)* by Using some Botanical Oils

Mikhaiel1, A. A.; Attia[1], A.I .and Mehany[2], A.L.
1. Biological Application Department, Nuclear Research Center -, Atomic Energy Authority.P.O .Box 13759, Abo-Zaabal, Egypt
2. Plant Research Department, Nuclear Research Center -, Atomic Energy Authority.P.O .Box 13759, Abo-Zaabal, Egypt
E-mail: Ashraflahzy1960@yahoo.com

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ABSTRACT

The 3KGy dose caused complete mortality for *Sitophilus zeamais* adults 48h post-irradiation. The eggs of *Sitotroga cerealella* failed to hatch at both doses 1.5&3KGy. Usually the newly hatched larvae from irradiated eggs with 0.75 KGy died soon after hatching without passing through metamorphosis. Different concentrations (0.5, 1, 2, 4 and 8 %) from four selected oils of onion, clove, and orange were tested for their toxicity activity against eggs and weevils. Experiments conducted revealed that garlic oil at 4% concentration was more efficient against the adult weevil than the egg moth and exposure period 48h, which gave 100% and 76.66 % mortality, respectively. It was noticed that the same trend of toxicity for the three other oils held for both species. The reduction in the percent eggs hatched; pupation and emergence were directly proportional to the level of concentrations of tested oils and the time of exposure. Also, the reduction in the F_1 progeny weevils was positively correlated with concentration and exposure time. It is possible using both favorite oils garlic and clove at LC95% to spraying polypropylene sacs for protection irradiated maize grains with a dose 3KGyfrom reinfestation by the tested insect within the storage period tested.

INTRODUCTION

The Angoumois grain moth, *Sitotroga cerealella*(Lepidoptera: Pyralidae) and the zea weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) are the most widespread and destructive insect pests infesting stored food grains like maize, wheat, rice, oat, and barleycorn (NgamoTinkeu,2007). Both pests are capable of causing significant economic damage every year in stored grains. They are primary, internal feeder insect and consume endosperm causing considerable loss to cereals affecting the quantity as well as quality of the grains. This problem is greatest in third world countries. The severe troubles caused by these pests encouraged investigations to find out safe methods achieving satisfactory control. With a greater outreach of the hazards associated with the use of chemical insecticides there has been an increased need to explore suitable alternative methods of pest control. More selective plant pesticides can decline the use

of chemicals in warehouses (Isman 2000) and (Martínez, *et al.*, 2015).
Among the promising methods with some advantages over conventional ones is the application of ionizing irradiation. This method is characterized by quick and complete efficiency if proper doses are used. Irradiation of grains to disinfest them is more effective to penetrate the grains.

The goal of this research is to determine the possible toxicity activities of the tested essential oils on eggs of Angoumois grain moth, *Sitotroga cerealella (S)* and zea weevil, *Sitophilus zeamais*, adult and minimize re-infestation for irradiated stored maize grains.

MATERIALS AND METHODS

Rearing Technique:

The original population of stock cultures of the *Sitotroga cerealella* (S) and *Sitophilus zeamais* (L) was obtained from Unite of Stored Products Pests, Biological Application Department, Atomic Energy Authority. The two pests were reared on maize grains in incubator at 30±2 ºC and 70-75% (R.H). The experiments were run out under the same circumstance.

Irradiation Technique:

Gamma cell irradiation unit (^{60}Cobalt source) located at the Cyclotron Project-Nuclear Research Center, Atomic Energy Authority. The dose rate was 1 Gray/5.1 second.One hundred eggs of *Sitotroga cerealella* (3-day old) and twenty unsexed adults of *Sitophilus zeamais* (1 week old) for each replicate were exposed to three doses 0.75, 1.5 and 3 KGy. Three replicates were used for each insect tested and control. Percent un-hatched eggs and *Sitophilus zeamais* mortality was recorded every day for 4 days from exposure.

The suitable amounts of maize grains were irradiated with 3KGy the lethal dose for weevils after 48h were used for storage experiments.

Source of Plant Oils:

Four natural plant oils onion, clove, orange, and garlic were obtained from the Egyptian company for oils and soap, Cairo, Egypt (Table1).

Application of Four Plant Oils:

The crude plant oils were diluted by adding distal water and Tween 80 as an emulsifier to obtain five concentrations (0.5, 1, 2, 4, and 8%). Two millimetres of each concentration of tested oils were distributed on maize grains (20g) in jars then were shaken by hand and allowed to dry in room temperature for control no oil was added.
Ten unsexed adults of *Sitophilus zeamais* (1 week old) and50newlylaid eggs (1-day old) were placed in glass vials (3mm in diameter) was introduced into the treated and untreated maize grains, the jars were covered with muslin cloth fixed with rubber bands and kept in incubator at 30±2 ºC and 70-75% (R.H).Three replicates were prepared for control and for each concentration of tested oils.

Evaluation of the Toxicity of Four Plant Oils on *Sitophilus zeamais* Adult:

Percent mortality was recorded at 24, 48 and 72 hours post-treatment for each concentration of tested plant oils. The reduction percentage in progeny was recorded after 2 months post-treatment and was calculated according to the following formula.

$$\% \text{ Reduction} = \frac{\text{control-treated}}{\text{Control}} \times 100$$

Table (1): List of plant oils and the part used in these experiments

English Name	Scientific Name	Extracted part
Onion	*Allium cepa*	Fruit
Clove	*Syzygiuma romaticum*	Seeds
Orange	*Citrus sinensis*	Peel
Garlic	*Allium sativum L*	Fruit

Evaluation of the Toxicity of Four Plant Oils on *Sitotroga cerealella* Eggs:

The percent hatched and unhatched eggs were calculated after exposure period24,48 and 72 h. Newly hatched larvae were transferred to the rearing medium to study the latent effect of tested oils on eggs.

Percent Penetration for Packaging during Storage Periods*:*

Polypropylene material selected to simulate the large traditional ones, which commonly used for packing or storing grains and grains products. Polypropylene sacs were prepared as (15 x 15 cm), each sac was sprayed with the highest LC_{50} or LC_{95} from garlic or clove within 48 h. Sacs used for control were sprayed by water and Tween 80 only. After drying at room temperature, an equal quantity of irradiated maize with 3KGy, (20gm) was placed in each sac. These sacs were tightly closed and then each placed in a jar was used for two concentrations of clove or garlic oil and for the control.

Fifty eggs of *S. cerealella* (S) and 3 pairs of adults *S. zeamais* were together placed in each jar and stored for 60 days at 30 ± 2 ºC, 70% R.H. Three replicates were used for each treatment. Every two weeks from the beginning the storage period the percentage of penetration was recorded. The remaining insects were removed and the same number of new insects was introduced.

Germination:

Germination maize grains were assessed by randomly taking twenty maize grains from the total grains irradiated with 3 kGy or treated with two favorite plant oils (garlic or clove) at LC_{95} either separately or combined. Maize grains were placed on 8 rolls of filter paper for germination and rewetted with distilled water. Germination percent was registered after 4 days**.**

$$\% \text{ Germination} = \frac{\text{Number of grains that germinated}}{\text{Total number of grains planted}} \times 100$$

Statistical Analysis*:*

Percentage mortality values for different concentrations of the two tested oils and exposure times against each insect species were subjected to analysis of variance (two-way ANOVA) and were separated and by Duncan's range test ($P>0.05$).

RESULTS

The Lethal Dose Of Gamma Radiation for *S. cerealella* Eggs and *S. zeamais* Adults:

The resistance of insect stages to radiation varies as development progresses from egg to adult (Table, 2). The egg stage is generally the most radiation-sensitive and the adult weevils were tolerant to radiation. The mortality of *Sitotroga cerealella* eggs due to irradiation was relatively high, and all eggs failed to hatch at both does 1.5 &3 kGy. The hatched larvae from irradiated eggs with 0.75 KGy, usually died soon after hatching without passing through metamorphosis. The dose 1.5KGy caused 100% mortality for *Sitophilus zeamais* weevils within 4 days, whereas dose 3 KGy caused 100% mortality 2 days after treatment.

Table (2): Effect of gamma irradiation on the percent mortality of *Sitotroga cerealella* eggs and *Sitophilus zeamais* adults

Dose (KGy)	% Mortality							
	***Sitotroga cerealella* egg**				***Sitophilus zeamais* adult**			
	24h	**48h**	**72h**	**96h**	**24h**	**48h**	**72h**	**96h**
0.0	0.0 b	0.0 c	0.0 c	0.0 b	0.0 b	0.0 d	0.0 d	0.0 c
0.75	0.0 b	23.3 b	86.7 b	100.0 a	0.0 b	23.66 c	41.0 c	93.33b
1.5	100.0 a	100.0 a	100.0 a	100.0 a	0.0 b	40.0 b	52.0 b	100.0 a
3	100.0 a	100.0 a	100.0 a	100.0 a	89.0 a	100.0 a	100.0 a	100.0 a

Means followed by the same letter in each column are not significantly different at (p> 0.05)

Effect of Tested Plant Oils Admixed with Maize Grains on the *S. Zeamais* Adults*:*

Table (3) summarizes the percent mortality of *S. zeamais*a adults when exposed tomaize grain treated with onion, clove, orange or garlic at different concentrations ranging between 0.5 to 8%at three exposure periods. The percentage of adult mortality was low up to 48h after exposure to maize grains treated with concentration 0.5% of clove, onion and orange oils. At the same concentration of garlic oil, the percentage of adult mortality was 50.0after 72h exposure period.

By increasing the concentration to 4% or 8% the *S. zeamais* adult mortality showed the same trend, were 90.0% and100% for garlic, and 53.33% and 83.33% for clove, 60.0% and80.0% for onion, respectively, after application 24h. It is clear that the garlic oil was the most efficient followed by clove and onion with all tested concentrations. Orange oil was moderately toxic.

Table (3): The relationship between applied concentrations and exposure periods on the toxicity of four plant oils against *Sitophilus zeamais* adults

	% Mortality																				
Conc	**0.0**	**0.5 %**				**1 %**				**2 %**				**4 %**				**8 %**			
oils	**Control**	**Garlic**	**Clove**	**Onion**	**Orange**	**Garlic**	**Clove**	**Onion**	**Orange**	**Garlic**	**Clove**	**Onion**	**Orange**	**Garlic**	**Clove**	**Onion**	**Orange**	**Garlic**	**Clove**	**Onion**	**Orange**
24h	0.0 l	40.0 ef	16.7 ijk	10.0 jkl	6.7 kl	53.3 cd	30.0 fgh	23.3 ghi	16.7 ijk	63. 3 c	43.3 de	36.7 ef	20.0 hij	90.0 ab	53.3 cd	40.0 ef	33.3 efg	100.0 a	83.3 b	56.7 c	43.3 de
48h	0.0 h	43.3 fgh	23.3 i	16.7 i	10.0 j	60.0 e	46.7 fg	33.3 h	20.0 i	73.3 cd	50.0 f	43.3 fgh	36.7 gh	100.0 b	63.3 e	60.0 e	43.3 fgh	100.0 a	90.0 b	80.0 c	66.7 de
72h	0.0 h	50.0 e	33.3 f	23.3 g	16.7 g	63.3 cd	53.3 de	36.7 f	23.3 g	86.7 b	60.0 cde	53.3 de	50.0 e	100.0 a	80.0 b	66.7 c	53.3 de	100.0 a	100.0 a	90.0 ab	80.0 b

Means followed by the same letter in each row are not significantly different at (p> 0.05)

The Latent Effect of Tested Plant Oils on S. zeamais Adults:

The obtained results are graphically illustrated in (Fig. 1) which shows the four tested oils at all concentrations have the potential to reduce F_1 adult emergence of *Sitophilus zeamais* adult, as compared with control. In all cases, the percent reduction of progeny was concentration-dependent. Garlic, clove or onion oils caused 94.93%, 78.06% and 71.33 depressions in progeny, respectively; at 2% concentration and 72h exposure time. The toxicity activity of orange was less than the other tested oils. At concentration 4% of garlic completely suppressed progeny and reduction reached 100% after 24h exposure period. While, orange oil suppressed progeny by 75.1% at the highest concentration 8% post 72h exposure period, (Fig.1).

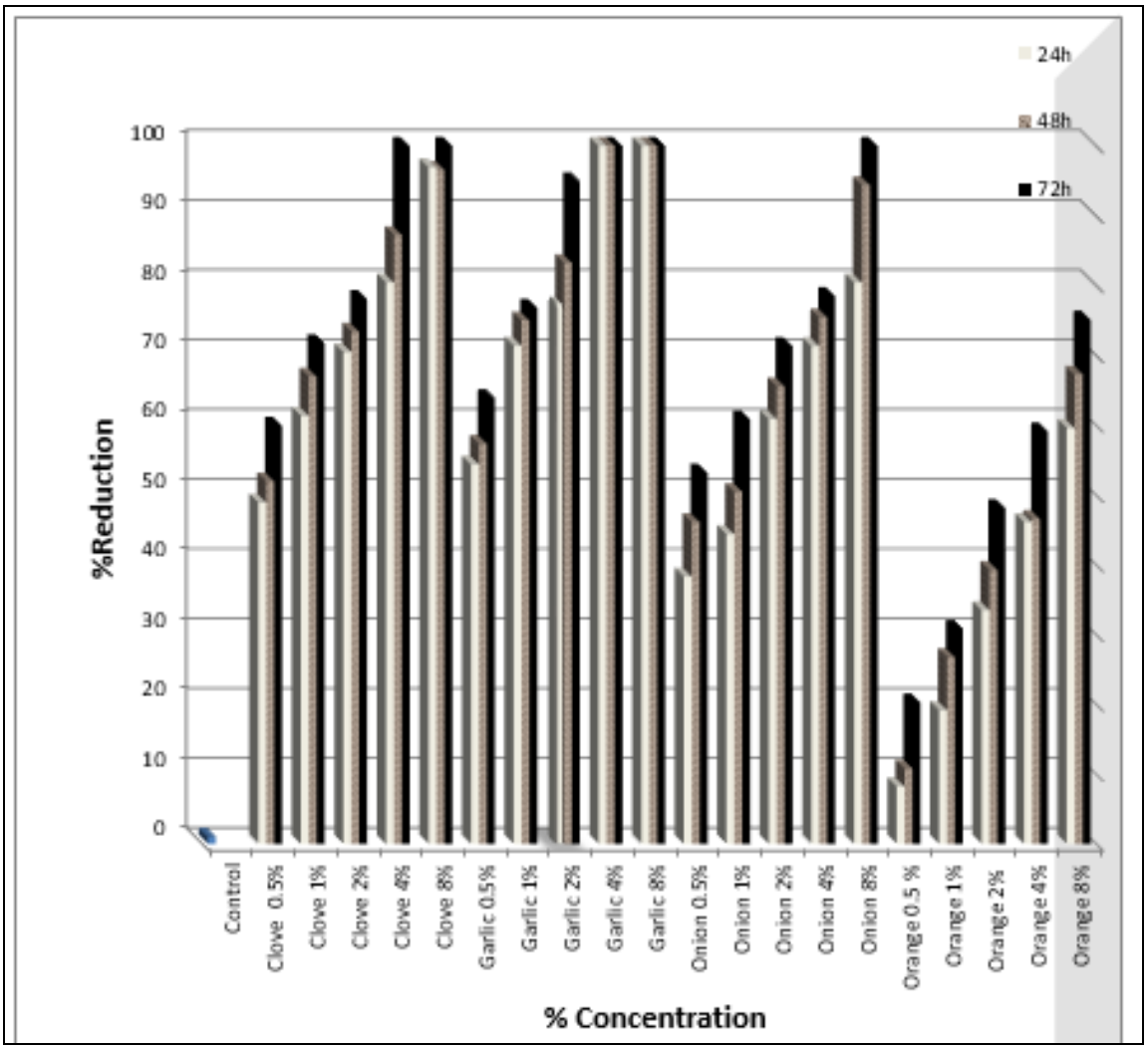

Fig.1: Effect offoue plant oils on the percent of reductionin F1 progeny of *Sitophilus zeamais*

Effect of Tested Plant Oils Admixed with Maize Grains on the S. cerealella Eggs:

All tested oils were reduced egg viability of *Sitotroga cerealella*at all concentrations and three exposure periods, table 4. The results proved that there was a significant difference in egg mortality among treatments of plant oils. When maize grains treated with garlic, clove, onion or orange at 2% concentration, the percent toxicity was 42.66, 40.66, 36.66 and 25.33, respectively, after 24h exposure period, as corresponding to control was about 14.0%. By increasing concentration to 8% and exposure period to 72h, the percent egg mortality increased and reached to 100& 92.0% for garlic and clove oils, respectively. In general, toxicity activity increases significantly with increase in concentration of tested oils. It was noticed that the garlic oil was superior in reducing egg viability, followed by clove and onion. Orange oil showed a slight reduces in egg mortality (Table 4).

Table (4): The relationship between applied concentrations and exposure periods on the toxicity of four plant oils against *Sitotroga cerealella* eggs

% Mortality																					
Conc,	0.0	0.5%				1%				2%				4%				8%			
Oils	Control	Garlic	Clove	Onion	Orange	Garlic	Clove	Onion	Orange	Garlic	Clove	Onion	Orange	Garlic	Clove	Onion	Orange	Garlic	Clove	Onion	Orange
24h	14.0 l	21.7 jk	20.7 jk	20.0 k	18.7 kl	34.00 fg	29.33 gh	27.3 hi	22.7 ijk	42.7 cd	40.7 de	36.7 ef	25.3 hij	48.0 b	46.0 bc	42.7 cd	33.3 fg	58.7 a	56.7 a	49.3 b	36.7 ef
48h	14.0 o	30.0 kl	26.0 m	27.0 lm	21.3 n	41. 3 hi	38.7 ij	32.3 k	25.3 m	63.3 e	60.7 ef	58.0 f	36. 6 j	76.7 c	74.7 c	62.0e	44.0 gh	88.0 a	82.0 b	67.3 d	47.3 g
72h	14.0 o	54.0 h	38.0 j	30.0 k	24.0 l	76.0 e	48.0 i	42.7 j	28.0 kl	82.0 cd	67.3 f	62.0 g	40.0 j	90.0 bc	82.0 cd	68.7 f	48.7 i	100.0 a	92.00 b	80.7 d	56.7 h

Means followed by the same letter in each row are not significantly different at (p> 0.05)

The Latent Effect of Tested Plant Oils on Certain Biological Aspects of *Sitotroga cerealella* Eggs:

Data presented in table (5) clearly shows the effects of four tested oils treated maize grains on some biological aspects of *Sitotroga cerealella eggs*. The percent egg hatch, pupation and adult emergence was inversely proportional to concentrations of oils and exposure times. The percentage of viability eggs showed a significant decrease as compared with control.

Also, the results revealed that the garlic oil stopped pupation at 4% concentration, with exposure period 24h. On the other side, clove and onion oils inhibited the pupation at 8%concentration after 72h exposure period. The same effect holds true in percentage of emergence was prevented at2% concentration of garlic oil post 72h exposure period, while clove at4% concentration with the same exposure period.In general, there was a significant difference between the treatments and the control.

Table (5): The latent effect of four plant oils on certain biological aspects of *Sitotroga cerealella eggs*

Oil	Concentration (%)	24h			48h			72h		
		% hatch	% pupation	% emergence	% hatch	% pupation	% emergence	% hatch	% pupation	% emergence
onion	0.5	80-0 bc	83.31f	79.44abcd	72.66cd	44.9f	77.45ab	70.00c	42.89ef	73.55ab
	1	72.66de	44.01g	70.74abcdef	67.33e	41.41g	68.31abc	57.33d	40.70f	68.68ab
	2	63.33gh	37.86h	66.50abcdef	42j	34.88h	63.09abc	38.00g	28.02g	56.66bc
	4	57.33ijk	29.06k	59.72defgh	38.00k	24.59j	56.66bcd	31.33hi	21.95h	00.00e
	8	50.66l	10.46m	44.44hi	32.66m	6.05k	33.33de	19.33kl	00.00j	00.00e
Orange	0.5	80.0 bc	74.59b	85.69ab	78.66b	72.04b	83.53a	76.00b	71.03b	77.75ab
	1	77.33bcd	67.24c	80.74abc	74.66c	65.06c	78ab	72.00bc	63.53c	73.87ab
	2	74.66cde	60.86d	72.06abcdef	63.33f	59.65d	63.08abc	60.00d	57.77d	55.77bc
	4	66.66fg	51.01e	52.83fgh	56.00hi	49.37e	49.82cde	51.33e	45.43e	48.48bcd
	8	63.33gh	35.83hi	44.18hi	52.66l	31.66i	11.66e	43.33f	27.85g	5.0e
Garlic	0.5	78.00bcd	43.58g	76.41abcde	69.33de	41.34g	72.05abc	46.00f	39.97f	67.77ab
	1	66.66fg	32.31j	71.57abcdef	58.66gh	31.83i	67.77abc	24.00jk	25.11gh	55.55ab
	2	57.33ijk	25.57l	85.76efgh	36.66kl	24.45j	53.33bcde	18.00lm	11.20i	33.33cd
	4	52.0 kl	0.0m	0.0k	30.66m	00.00l	00.00f	10.66no	00.00j	00.00e
	8	30.66l	0.0m	0.0k	00.00n	00.00l	00.00f.	00.00o	00.00j	00.00e
Clove	0.5	79.33bc	47.06f	73.10abcde	74.00c	45.03f	71.93abc	62.00d	43.14ef	65.74ab
	1	70.66ef	43.40g	64.44cdefg	61.33fg	41.31g	63.03abc	52.00e	39.77f	61.31bc
	2	59.33hij	33.71ij	59.72defg	39.33jk	30.25i	50.00cde	32.66h	28.26g	50.0 bc
	4	54.00jkl	25.77l	46.82gh	33.33lm	21.91j	37.77de	27.33lj	14.69l	33.33cd
	8	43.33m	7.70m	16.66jk	31.33m	00.00l	00.00f	13.33mn	00.00j	00.00e
Control	0.0	86.0 a	81.39a	88.57a	86a	81.39a	88.57a	81.39a	81.39a	88.57a

Means followed by the same letter in each column are not significantly different at (p> 0.05

Determine LC50 and LC95 for Both Tested Insects:

Data presented in Table (6) demonstrated that LC50 value of four tested oils ranged from 1.75 to 9.41 % for egg moth and 0.700 to 4.22% for weevil. The lowest LC50 and LC95values were observed in garlic oil for weevils. The highest LC95 value was noticed in orange 148.737for *S. Cerealella* eggs.

Table (6): LC50 and LC95 of the tested oils after exposure time 48 h.

Concentration	Onion	Clove	Garlic	Orange
***Sitotroga cerealella* eggs**				
LC50	3.2883	2.0985	1.7536	9.4131
LC95	41.2844	12.1907	10.01214	148.737
Slope	1.1664±0.0831	1.6772± 0.0797	1.6834± 0.0834	1.0692±0.0898
***Sitophilus zeamais* adults**				
LC50	2.3451	1.585	0.7005	4.228
LC95	18.8804	13.107	3.0066	37.6599
Slope	1.4148± 0.0852	1.3969±0.0825	2.0257±0.0834	1.3494±0.0876

Percent Penetration of Tested Insects for Polypropylene Sacs during Storage Periods:

The percentage of sacs penetration was varied according to the tested insect species, storage periods and lethal concentration of two favourite oils (Table, 7). After one month from storage period, the percent penetration was 17.37% of *Sitotroga cerealella* hatched larvae occurred inside sacs treated with Lc50 of clove and no *S. zeamais* adults were found inside sacs. On the other side, after 45 days the percent larvae penetrate sacs treated with LC50 of garlic was 26.1, this percent increase to 45.7 at the end of storage period (60 days). No penetration was detected inside sacs treated with LC95 of garlic or clove oil during storage period.

Table (7): Percent penetration of both of tested insects during storage period.

Storage period (day)	Oil	% penetration			
		Sitotroga cerealella larvae		*Sitophilus zeamais* adults	
		Lc50	Lc95	Lc50	Lc95
15	Garlic	0.0 g	0.0 b	0.0 d	0.0 b
30		0.0 g	0.0 b	0.0 d	0.0 b
45		26.1 e	0.0 b	0.0 d	0.0 b
60		45.70 c	0.0 b	25.0 c	0.0 b
15	Clove	0.0 g	0.0 b	0.0 d	0.0 b
30		17.37 f	0.0 b	0.0 d	0.0 b
45		30.49 d	0.0 b	0.0 d	0.0 b
60		50.40 b	0.0 b	36.11 b	0.0 b
15	Control	76.82 a	76.82 a	60.0 a	60.0 a
30		76.82 a	76.82 a	60.0 a	60.0 a
45		76.82 a	76.82 a	60.0 a	60.0 a
60		76.82 a	76.82 a	60.0 a	60.0 a

Effect of Tested Plant Oils and Gamma Radiation on Germination of Maize Grains:

When irradiated maize grains with dose 3000 Gy the germination percentage was decreased to 90.0%, as compared with the control (98.0%), this means that high dose reduced the viability of maize grains (Fig.2).

When treated maize grains with LC95 of favorite oils garlic or clove, the percent

germination was 92.33 and 94.33, respectively,(Figure 2). Also, the germination percentage of maize grains after exposure to dose level 3KGy and treated with LC95 of garlic or clove oils, was around 90.0 and 91.0 %, respectively.

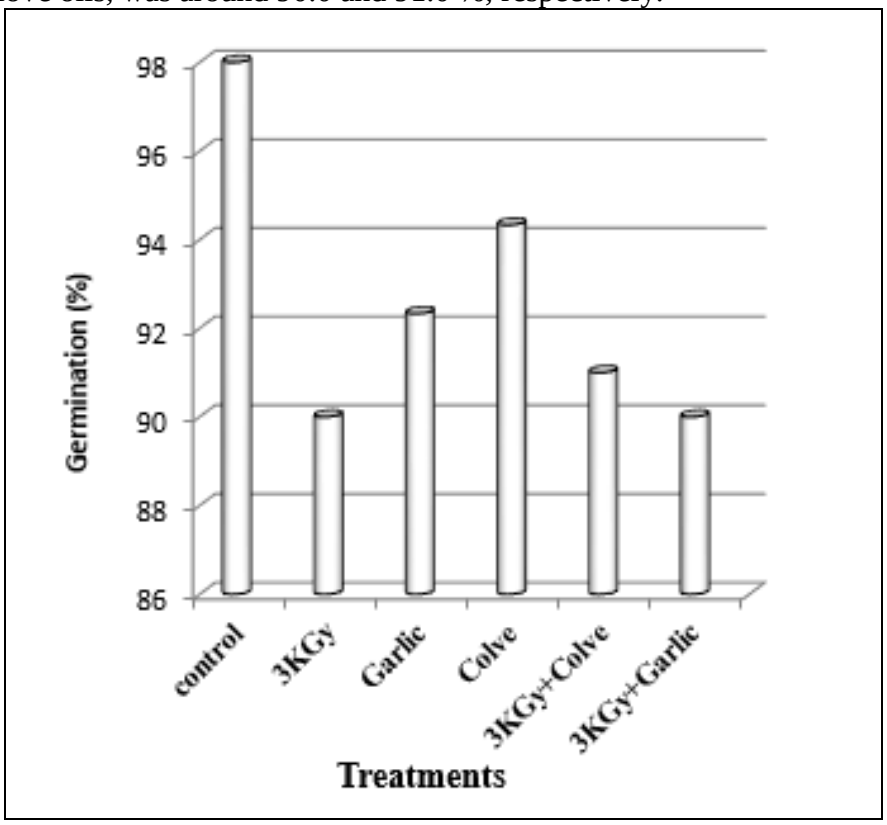

Fig. 2 : Effect of certain treatment on percent germination of maize grains

DISCUSSION

The target of an irradiation quarantine treatment is usually to cause mortality of immature stages before development to the adult or, where the present stage is an adult, to stop further reproduction.The present results show that irradiation doses required to inhibit the development of egg stage to adult moths are around 0.75 kGy within 24 hours. These results agree with those reported by Ozyardimci et al. (2006) on eggs of *Plodia interpunctella* and *Ephestia cautella*, also, Ayvaz et al. (2008) and Abbas et al.(2011) on *Plodia interpunctella* .

Also, the mentioned results of *S. zeamais* adult are comparable with Coleopteran group from those Castro (2005) on *S. oryzae* (L.); Mikhaiel and Rizk (2008) on *O. surinamensis* Follett et al. (2013) on *S. oryzae*; Mikhaiel et al. (2016) on *R. dominica* , *T. castaneum*, *O. surinamensis* and *S. zeamais.*

Four plant oils (onion, clove, orange or garlic) were tested directly by sparing maize grains against *S. zeamais* adult. The percent mortality of weevils was different according to a type of oil, concentration and exposure periods. The result proved that the garlic oil was the most efficient followed by clove, onion, and orange with all tested concentrations. The adult mortality might be attributed to the contact toxicity or to the abrasive effect on the pest cuticle (Mathur, et al.1985) which might also interfere with the respiratory mechanism of insects (Agarwal and Gupta 1988). Also, essential oils cause reducing insect acetylcholine esterase (AChE) and thus, ultimately blocking the nerve

functions. This is in agreement with studies by Obeng- Ofori, and Amitaye. (2005) who observed some signs of paralysis of insects as flexed legs and clinging to the grain, outstretched metathoracic wings from the elytra or dying insects. Our results are in harmony with those obtained by Suthisut et *al.* (2011) *on S. zeamais, T. castaneum* and *A. calandrae*; also, Flores- Dávila *et al.* (2017) on maize weevils.

In addition to toxicity action against weevils, it is clear that the effect of tested volatile oils on reducing the resulting progeny was due to plant oils have ovicidal action. The tested oils caused high reduction in egg deposition or hatch larvae failed to penetrate the maize grains. The results of the present study are agreement with the other workers on other species of insects. Asawalam *et al.* (2008)*;* Betancur *et al.* (2010), Ortiz,*et al.* (2012) and Wahedi *et al.* (2017) on *S. zeamais*. Also, Abdulmalik, and Abdullahi (2017) they found that maize grains treated with the *Psidium guajava* and *Ocimum gratissimum* leaves oil extract significantly reduced the number of *S. zeamais* emerged of both FI and F2. Also, our results are indicative of the potential of using these plant oils especially garlic for the management of *Sitotroga cerealella eggs.* The mortality rate of eggs was high when exposed to volatiles oils due to easy penetration through delicate covering of vitellin and chorion membrane. Also, percentage of egg mortality increased by the active ingredients present in oils, which might have imbalanced blastokinesis and induced damaging for newly hatched larvae. Presumably, the volatiles liberated from these oils interfused the eggs, through the shell (Chapman, 1982), or volatiles entered into eggs via tiny holes in the chorion which connected them with respiration of embryos (Sehnul, 1985).

Also, Gurusubramanian and Krishna (1996) attributed loss of viability in eggs of *Earias vittella* Fab., *Dysdercus koenigii* Fab., *Spodoptera litura* (Fab.) and *Helicover paarmigera* (Htibner), to the main chemical ingredients present in the garlic volatiles, namely, allicin , thioacrolein, ajoene, 2-propene sulfenic acid, 2-propene thiol and propylene which may have spread into the eggs, so, they effecting on the vital physiological and biochemical processes associated with embryonic development. Miron (*et al.* 2000) reported that allicin especially in garlic has been shown to be readily membrane permeable, and thus able to rapidly penetrate cellular in biological systems. The findings of the present study are also in agreement with that of Dwivedi and Garg (2003) on *Sitotroga cerealella* eggs, Khani *et al.* (2012) and Verma and Pathak (2018) on *C. cephalonica*..

The direct effect of tested oils on *Sitotroga cerealella* eggs was the decline in percent egg hatchability, on the other side, indirect effect showed a sharp decline in larval, pupation and offspring emergence. This was probably due to the larvae hatching from the eggs must penetrate the maize grains to survive, but are unable to do this, no feeding then leads to the death. These results are in agreement with Mikhaiel and Rizk (2008) on *P. interpunctella,* Sharaby *et al.* (2009) on *Ph. Operculella, Mesbah, et al.* (2014) on. *Agrotis ipslion.* Borzoui, *et al*. (2016) on *Plodia interpunctella* and *Naseri, et al*.(2017) *Sitotroga cerealella.*

One of the goals of storing grain is to ensure seed availability and viability. The data obtained from the storing experiment showed that the good preservation was provided to store irradiated maize grains for up to 45 days by LC95 of both oils, garlic, and clove against infestation by tested insects. The favourite oils were strong enough to decline insect immigration into polypropylene. The result obtained from this study agreement with some authors recorded their results on certain botanical oils for protection different packages during storage period as Anwar *et al.* (2005), Wong *et al.* (2005), Yang *et al.* (2009), Mikhaiel (2011), Pardeshi and Zambare (2012), Pessoa *et al.* (2016) Suthisut *et al.* (2018).

The germination percentage of maize grains after exposure to dose level 3KGy was decreased to 90.0%, as compared with the control; this means that a high dose reduced the viability of maize grains. Similar results were obtained by Amjad *et al.* (2008) on desi and kabuli chickpea seeds; Marcu *et al.(*2013), Yadav *et al.* (2015) and Mendoza (2017) on maize grain.

The germination rates of maize grains treated with LC95 of favorite oils garlic or clove were not much different from the control. Many authors reported their results on some essential oils as Adjalian, *et al.* (2014), Pizarro *et al.* (2014) and Kumar et *al.* (2017) on maize grains who reported that when treated maize seeds with six plant essential oils not effect on germination. Also, El-Bakry *et al*. (2016) on wheat grains.

It could be concluded that the combined effect of irradiation sterilizing maize grains and the treatment of polypropylene sacs with the favorite oils can assist in reducing the infestation by stored product pests.

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ARABIC SUMMARY

حماية الذرة المشععة المخزنة من عثة الحبوب وسوس الذرة باستخدام بعض الزيوت النباتية

أميرة عبد المسيح ميخائيل[1] وايمن ابراهيم عطية[1] وأشرف لحظى مهنى[2]

1-قسم التطبيقات البيولوجية مركز البحوث النووية هيئة الطاقة الذرية أبو زعبل

2-قسم البجوث النباتية مركز البحوث النووية هيئة الطاقة الذرية أبو زعبل

يهدف هذا البحث الى تشعيع محصول الذرة بأشعةجاما ليموت جميع الأطوار الحشريةقبل دخولها المخزن ثم معاملتها ببعض الزيوت النباتية لحميتها من الأصابة داخل المخزن.

تسبب الجرعة 3KGy بعد 48h من التشعيع الى موت جميع الحشرات الكاملة ثم تم أختبار أربعة زيوت مختارة من البصل، والقرنفل ، والبرتقال وتم اختبار نشاطها السمي ضد البيض والسوس. كشفت التجارب التي أجريت أن زيت الثوم كان أكثر فعالية ضد سوسة االذرة من عثة االحبوب فأوصى بالثوم لحماية حبوب الذرة من اعادة الأصابة اثناء التخزين بعد معاجتها بالأشعاع.