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Lemongrass Oil Enhances the Storage Efficacy of Phosphine-Treated Grains Wheat

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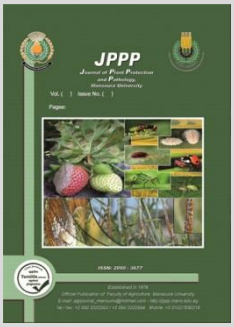

ABSTRACT

Under environmental conditions of Burj El-Arab warehouse, Alexandria Governorate, Egypt, a storage experiment was carried out from 30th May 2020 to 26th February 2021 to become conscious of the effect of treatment with some chemical compounds (insecticides) *i.e.* deltamethrin at 1 and 2 ppm, malathion at 10 and 15 ppm and phosphine at 3 and 5 tablets/m^3 and natural compounds (botanical oils) *i.e.* clove, coriander and lemongrass oils at 10 and 15% on storage efficiency of wheat after 9 months from harvesting time. The experiment had arranged in a factorial experiment in a randomized complete block design (RCBD) with three replications. The lowest insect infestation percentage and grains weight loss percentage and highest number of dead insects/samples were resulted from treating wheat grains with phosphine at 5 tablets/m^3. Treating wheat grains with lemongrass oil at the rate of 15% recorded the lowest insect infestation percentage and grains weight loss percentage and highest number of dead insects/sample. This study recommended treating samples of wheat grains with phosphine at 5 tablets/m^3 besides lemongrass oil at 15% to enhance storage efficacy characters under the environmental conditions of Burj El-Arab district, Alexandria Governorate, Egypt.

Keywords: Wheat, deltamethrin, malathion, phosphine, clove, coriander and lemongrass oils.

INTRODUCTION

Wheat (*Triticum aestivum* vulgare L.) is the main source of human food and constitutes an essential part of its nutritional needs. It is the main winter cereal crop in Egypt. Wheat is one of the most widespread crops in the world because of its distinctive protein properties and is an important source of food and energy (Abedi *et al.* 2010). It is easily processed into various types of food like bread, macaroni, biscuit, and sweets. Although wheat is useful as livestock feed.

Wheat grains must be stored, transported, and conveyed using methods that preserve their quality. The storage time of the stored product can be divided based on the period from short-term storage for drying to long-term storage for strategic reserves. It can also be stored on the farm or in large commercial facilities. Stored wheat grains are vulnerable to insect attack, and an infestation can degrade both the quality and quantity, resulting in a significant decrease in volume, significant weight loss, and reasonable germination damage (Phillips and Throne, 2010). Loss in stored wheat may reach about 50:60%, and this is due to a lack of technical efficiency (Tadesse, 2020). A common method of insect control in stored wheat grain is through the use of some insecticides (e.g. deltamethrin, malathion, or phosphine) in metal containers.

Synthetic pyrethroids, such as deltamethrin are compounds derived from pyrethrins that are extracted from dried chrysanthemum flowers. These compounds are designed to be more toxic and quickly degrade. The formulation that contains pyrethroids also includes synergists that help increase their potency and reduce the body's ability to detoxify these compounds (Khater *et al.*, 2009).

Attia *et al.* (2014) explained that the best treatment for storing wheat grains was the use of deltamethrin at rates ranging between 0.75 and 1.25 ppm. Seadh *et al.* (2014) revealed that treating wheat grains with deltamethrin had a significant impact on the chemical constituents compared to the control treatment, After three to six months of stockpiling.

Malathion is a selective, broad-spectrum insecticide that has low mammalian toxicity (oral LD_{50} =12,500 mg kg^{-1} for rats) (Rengasamy and Parmar 1989). Seadh *et al.* (2014) and Attia *et al.* (2014) found that treating wheat grains with malathion at concentrations around 10 ppm had a significant effect on storage efficiency and preservation of the chemical components of the grains compared to other treatments and controls.

Phosphine is one of the most toxic fumigants to stored grain insect pests. Due to the advantages that phosphine possesses of low cost, ease of use, and the absence of residuals, there are several developments in knowledge of phosphine that lend positive support to the continued use of phosphine as a fumigant (Collins *et al.*, 2001). Ramadan (2016) found that fumigant wheat grains by phosphine (at 3, 5, and 7 tablet phosphine/m^3) before the start of storage, had a significant consequence on storage efficacy characters (number of insects, insect infestation, and weight loss percentages). Badawi *et al.* (2017) stated that the lowest number of insects, insect infestation %, and weight loss %, of wheat grains, were produced by treating with phosphine (at the rate of 8 ppm).

Due to the negative effects resulting from the uncontrolled use of pesticides, such as environmental pollution and toxicity to humans. Attention is turning towards the use of natural products such as plant-derived

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materials and plant essential oils.

Essential oils can be defined as any volatile oils that contain aromatic compounds and are characterized by an odor and flavor characteristic of the plant source for them. These oils are by-products of the metabolic processes within the plant. The oils are found in glandular hairs or secretory cavities of plant-cell walls, as a form of droplets in the leaves, stems, roots, flowers, or even the fruits and bark of many plants.

Essential oils have many functions in plants, including attracting or repelling insects, and protecting the plant from heat or cold. Chemical components in oils are also used as defense compounds against herbivores (Bakkali *et al.,* 2008).

In the bioassay test, (El-Gizawy *et al.,* 2018) found that clove oil was more toxic to stored grain insects when used as a fumigant. They concluded that clove oil can be used as grain protectants or fumigants to control stored products insects. Hamza and Hamza (2018) revealed that clove oil alone showed high efficiency to *R. dominica* concerning mortality, the progeny of the adults, and weight loss of wheat grain. Soe *et al.* (2020) concluded that clove oil can be used as a safe alternative to the use of pesticides in integrated stored grain pest management programs.

The medicinal properties and effectiveness against stored grain insects of coriander essential oil because it contains a Borneol, Cineole, Cymene, Dipentene, Linalool, Phellandrene, Pinene, Terpineol, and Terpinolene (Islam et al., 2008). Sriti Eljazi et al. (2017) showed the possibility of using coriander essential oil in controlling stored grain insects.

Lemongrass essential oils are characterized by their insecticidal and repellent properties, so they can be used in the schemes of stored grain pest management (Plata-Rueda et al., 2020). Binseena et al.(2018) studied the Effect of lemongrass) on the mortality of rice weevil, under laboratory conditions. they found that lemongrass oil had moderate effectiveness against the studied stored grain insect.

From the previous reference review, we can conclude that essential oils can be used to control stored grain insects, therefore, this investigation was established to study the effect of treatment with some chemical and natural compounds (essential oils) on the storage efficiency of wheat under the environmental conditions of Alexandria Governorate, Egypt.

MATERIALS AND METHODS

Pesticides and chemicals used:

All tested insecticides (Table 1) used in this study were in formulated forms and were produced by T. Stanes & Company Limited, India, and obtained from Gaara establishment for import and export Co.

Table 1. Pesticides used in the current study.

Common name	Trade name	Formulation	Rate of application
Aluminium phosphide	Phosphine	Tab 56%	3:5 tab/m^3
Deltamethrin	Deltamethrin	EC 25%	1:2 ppm
Malathion	Malathion	EC 57%	10:15 ppm

Botanical oils:

Coriander, clove, and lemongrass essential oils were introduced by: T. Stanes & Company Limited, India, and obtained from Gaara establishment for import and export Co.

Field study:

Under environmental conditions of Burj El-Arab warehouse, Alexandria Governorate, Egypt, a storage experiment was carried out from 30th May 2020 to 26th February 2021. The purpose of this experiment was to become conscious of the effect of treatment with some chemical insecticides and natural compounds (essential oils) on the storage efficiency of wheat after 9 months from the beginning of storage.

The experiment had arranged in a factorial experiment in a randomized complete block design (RCBD) with three replications.

The first factor included seven treatments with some chemical insecticides before beginning the storage as follows:

1. Storing wheat grains without any treatment (control treatment).
2. Treating wheat grains with deltamethrin(1 ppm).
3. Treating wheat grains with deltamethrin (2 ppm).
4. Treating wheat grains with malathion (10 ppm).
5. Treating wheat grains with malathion (15 ppm).
6. Treating wheat grains with phosphine at the rate of 3 tablets/m^3.
7. Treating wheat grains with phosphine at the rate of 5 tablets/m^3.

The second factor included seven treatments with some natural substances (essential oils) before beginning the storage as follows:

1. Storing wheat grains without any treatment (control treatment).
2. Treating wheat grains with clove oil at the rate of 10%.
3. Treating wheat grains with clove oil at the rate of 15%.
4. Treating wheat grains with coriander oil at the rate of 10%.
5. Treating wheat grains with coriander oil at the rate of 15%.
6. Treating wheat grains with lemongrass oil at the rate of 10%.
7. Treating wheat grains with lemongrass oil at the rate of 15%.

The interaction between these two factors resulted in 49 treatments, and each treatment was replicated 3 times.

In all studied treatments, about 10 kg of wheat grains (mixture of cultivars) with 12-13% moisture content in each replicate were stored in metal containers with sealing directly after supply to Burj El-Arab warehouse, Alexandria Governorate, Egypt. Storage wheat in metal containers with the sealing model was performed as a simulation of the storage in metal silos as a modern model of storage.

Treatment procedures

Phosphine or hydrogen phosphide (PH_3) is one of the most toxic compounds in all forms of life. Therefore, exposure to the least amount of it should be avoided. Here it should be noted that phosphine gas (PH_3) is realized from aluminum phosphide tablets when exposed to moist air. So, the tablets were ground into a powder form using a generic spice grinder and the quantity needed to achieve the desired concentration for each sample (10 kg) was calculated. The grains were placed in metal containers. Then the appropriate amount of aluminum phosphide was placed to obtain the required concentration. Then the grains and aluminum phosphide powder were stirred until they mixed well. Then the metal containers were closed tightly to prevent phosphine gas from leaking.

A concentration of 1% (10^4 ppm) of the two pesticides used (deltamethrin and malathion) was prepared. Then the required volume of the preparation solution was calculated to obtain the desired concentration of both pesticides (1-2 and 10-15 ppm for deltamethrin and malathion respectively). This volume was completed to 100 ml with distilled water. The grains were laid out on a flat, hard surface approximately one grain thick. This volume was sprayed onto the flat grains using an ordinary sprayer. The grains were left to dry completely at ambient temperature. The grains were mixed by stirring them well and then stored in the metal containers.

The studied plant essential oils (clove, coriander, and lemongrass) were dissolved with acetone firstly and then diluted with water to 1% for each plant oil. A 0.5% tween 80 was added to the solution and stirred well to obtain a homogeneous emulsion. The same steps that were used with pesticides were applied literally in the case of plant essential oils.

Studied characters:

After 9 months from beginning storage, 1 kg of wheat grains for each treatment was taken. Four replicates (100 grains) from each treatment were manually picked randomly for inspection and estimation of the following storage efficiency characters:

1. **Insect infestation percentage (%).** Grains which having holes or infestations were collected, also, the grains which showed signs of insect damage were considered infested. The infestation level was expressed as the number and percentage damage grains according to the formula of (Jood *et al.* 1996).

$$\text{Damage grains percent} = \frac{\text{Number of insect da}}{\text{Number of total grains}}$$

2. Number of dead insects found in each replicate.
3. **Grains weight loss percentage (%).** The weight losses in wheat grains caused by insect infestation were calculated as follows according to (Dick 1987).

$$\textbf{Weight loss \%} = \frac{\textbf{(U Nd) - (D Nu)}}{\textbf{U (Nd + Nu)}} \times \textbf{100}$$

Where:

Nu = Number of undamaged grains.
Nd = Number of damaged grains.
U = Weight of undamaged grains.
D = Weight of damaged grains.

Data were subjected to statistical analysis according to the technique of analysis of variance (ANOVA) for a factorial experiment in a randomized complete block design (RCBD) as published by (Gomez and Gomez 1984) by using the "MSTAT-C" computer software package. The least significant difference (LSD) method was used to test the differences between treatment means at a 5 % level of probability as described by (Snedecor and Cochran 1980). Also, Duncan's multiple range tests at a 5 % level of probability as described by (Duncan 1955) were used to compare means of treatment.

RESULTS AND DISCUSSION

Effect of treatment with insecticides:

Statistical analysis of the obtained data presented in Tables 2, 3, and 4 and Figures 1, 2 and 3 showed that treating wheat grains before the beginning of storage with some insecticides at various rates (deltamethrin at 1 and 2 ppm, malathion at 10 and 15 ppm and phosphine at 3 and 5 tablets/m^3) had a significant effect on storage efficiency characters (insect infestation percentage, number of dead insects/sample and grains weight loss percentage) after 9 months from harvesting time.

The highest insect infestation percentage (11.85 %) and lowest number of dead insects/sample (2.9) and the heights grains weight loss percentage (6.38 %) resulted from stored wheat grains without any treatment (control treatment). Whereas, the lowest insect infestation percentage (3.71 %) and grains weight loss percentage (2.00 %), and highest number of dead insects/sample (4.33) were resulted from produced treating wheat with phosphine at the rate of 5 tablets/m^3 (Tables 2, 3 and 4 and Figures 1,2 and 3). The second-best treatment was treating wheat grains with deltamethrin (2 ppm), followed by treating wheat grains with phosphine at the rate of 3 tablets/m^3, then deltamethrin (1 ppm), malathion (15 ppm), and malathion (10 ppm) after 9 months from harvesting time.

The favorable role of treating wheat grains with phosphine before storage (at the rate of 5 tablets/m3) which reduced insect infestation percentage and grains weight loss percentage and increased the number of dead insects/sample may be ascribed to phosphine gas (PH3), that produced by reacting between tablets of aluminum phosphide and air humidity, is prohibited insects piercing and entering into grains by poison effect. Moreover, (Winks, 1984) concluded that the phosphine gas produced from aluminum phosphide works to eliminate the most pesticide-resistant insects until the insect population becomes susceptible again. In this regard, phosphine was the primary fumigant currently being used commercially for stored products (Taylor, 1994). The constructive role of deltamethrin at the rate of 2 ppm may be ascribed to its effectiveness in protecting grains from attack by the major stored product (Korunic *et al.*, 2012). Furthermore, the effects of deltamethrin on the nervous, respiratory and hematological systems of insects (Pimpão *et al.*, 2007). The slight effect of malathion treatment as compared with phosphine or deltamethrin treatments is probably due to malathion being moderately toxic to mammals (WHO, 2020).

Therefore, (Storey *et al.*, 1984) stated that malathion was formerly widely used, but the increasing resistance of many stored product pests to this pesticide has resulted in the need for alternative control agents. On the other hand, Anon (1988) stated that malathion was used extensively to prevent insect infestation in stored grains. These findings are in agreement with those reported by (Seadh *et al.* 2014; Attia *et al.* 2014 and Badawi *et al.* 2017)

Effect of treatment with botanical oils:

The statistical analysis of the obtained data exhibited that studied wheat grains treatment before the beginning of storage with natural substances (botanical oils) *i.e.* clove, coriander, and lemongrass oils at different rates of 10 and 15% on storage efficiency (insect infestation percentage, number of dead insects/sample and grains weight loss percentage) after 9 months from harvesting time (Tables 2, 3 and 4 and Figures 1, 2 and 3).The obtained results of this study cleared that treating wheat grains with lemongrass oil at the rate of 15% recorded the lowest insect infestation percentage (4.33 %) and grains weight loss percentage (2.33 %) and highest number of dead insects/sample (5.76) after 9 months from harvesting time (Tables 2, 3 and 4 and Figures 1,2 and 3).

Table 2. Means of insect infestation percentage (%) as affected by treatment of wheat grains with some insecticides and/or botanical oils as well as their interaction after 9 months from beginning storage

Insecticides		Botanical oils (Means ± S.E)							Overall means (Means ± S.E)
		Control	Clove oil		Coriander oil		Lemon grass oil		
			(10%)	(15%)	(10%)	(15%)	(10%)	(15%)	
Control		14.23 ± 0.619 p	11.76 ± 0.619 mno	10.52 ± 0.619 lm	12.99 ± 0.000 op	12.38 ± 0.619 no	11.14 ± 0.000 lmn	9.90 ± 0.000 kl	11.85 ± 0.31 f
Deltamethrin	(1 ppm)	7.43 ± 0.000 hij	5.57 ± 0.000 efg	4.33 ± 0.619 cde	6.81 ± 0.619 ghi	6.19 ± 0.619 fgh	4.95 ± 0.619 def	3.71 ± 0.619 bcd	5.57 ± 0.32 c
	(2 ppm)	6.81 ± 0.619 ghi	4.33 ± 0.619 cde	3.09 ± 0.619 abc	5.57 ± 0.000 efg	4.95 ± 0.619 def	3.71 ± 0.000 bcd	2.48 ± 0.000 ab	4.42 ± 0.35 b
Malathion	(10 ppm)	8.66 ± 0.619 jk	6.81 ± 0.619 ghi	5.57 ± 0.000 efg	8.04 ± 0.619 ij	7.43 ± 0.000 hij	6.19 ± 0.619 fgh	4.95 ± 0.619 def	6.81 ± 0.31 e
	(15 ppm)	8.04 ± 0.619 ij	6.19 ± 0.619 fgh	4.95 ± 0.619 def	7.43 ± 0.000 hij	6.81 ± 0.619 ghi	5.57 ± 0.000 efg	4.33 ± 0.000 cde	6.19 ± 0.35 d
Phosphine	(3 tablets / m^3)	6.81 ± 0.619 ghi	4.95 ± 0.619 def	3.71 ± 0.000 bcd	6.19 ± 0.619 fgh	5.57 ± 0.000 efg	4.33 ± 0.619 cde	3.09 ± 0.619 abc	4.95 ± 0.32 b
	(5 tablets / m^3)	5.57 ± 0.000 efg	3.71 ± 0.000 bcd	2.48 ± 0.619 ab	4.95 ± 0.619 def	4.33 ± 0.619 cde	3.09 ± 0.619 abc	1.86 ± 0.619 a	3.71 ± 0.32 a
Overal means (Means ± S.E)		8.22 ± 0.61 g	6.19 ± 0.58 d	4.95 ± 0.58 b	7.43 ± 0.57 f	6.81 ± 0.58 e	5.57 ± 0.53 c	4.33 ± 0.53 a	6.21 ± 0.24 c
F test		Insecticides	*		Botinical oils	*	I × B		*
LSD			0.54			0.54			1.43

S.E: Standard errors. Means followed by the same letter (s) are not significantly difference (P= 0.95 level)

Table 3. Means of number of dead insects/sample as affected by treatment of wheat grains with some insecticides and/or botanical oils as well as their interaction after 9 months from beginning storage

Insecticides		Botanical oils (Means ± S.E)							Overall means (Means ± S.E)
		Control	Clove oil		Coriander oil		Lemon grass oil		
			(10%)	(15%)	(10%)	(15%)	(10%)	(15%)	
Control		1.33 ± 0.333 a	2.00 ± 0.000 abc	2.33 ± 0.333 bcd	2.67 ± 0.333 cde	3.67 ± 0.333 fgh	3.33 ± 0.333 efg	5.00 ± 0.333 jkl	2.90 ± 0.19 a
Deltamethrin	(1 ppm)	3.00 ± 0.000 def	3.00 ± 0.000 def	3.33 ± 0.333 efg	3.67 ± 0.333 fgh	4.33 ± 0.333 hij	4.00 ± 0.000 ghi	5.67 ± 0.000 lm	3.86 ± 0.19 cd
	(2 ppm)	2.33 ± 0.333 bcd	3.00 ± 0.577 def	3.67 ± 0.333 fgh	4.00 ± 0.000 ghi	5.00 ± 0.000 jkl	4.33 ± 0.333 hij	6.67 ± 0.333 n	4.14 ± 0.27 de
Malathion	(10 ppm)	1.67 ± 0.333 ab	2.67 ± 0.333 cde	3.00 ± 0.000 def	3.33 ± 0.333 efg	3.67 ± 0.333 fgh	3.33 ± 0.333 efg	5.33 ± 0.333 kl	3.29 ± 0.21 b
	(15 ppm)	2.33 ± 0.667 bcd	2.67 ± 0.333 cde	3.00 ± 0.000 def	3.33 ± 0.333 efg	4.00 ± 0.000 ghi	3.67 ± 0.333 fgh	5.00 ± 0.333 jkl	3.43 ± 0.31 b
Phosphine	(3 tablets / m^3)	2.00 ± 0.577 abc	2.67 ± 0.333 cde	3.00 ± 0.000 def	3.67 ± 0.333 fgh	5.00 ± 0.000 jkl	4.00 ± 0.000 ghi	6.33 ± 0.000 mn	3.81 ± 0.25 c
	(5 tablets / m^3)	3.33 ± 0.333 efg	3.33 ± 0.333 efg	3.67 ± 0.333 fgh	4.00 ± 0.000 ghi	5.00 ± 0.000 jkl	4.67 ± 0.333 ijk	6.33 ± 0.333 mn	4.33 ± 0.22 e
Overal means (Means ± S.E)		2.29 ± 0.20 a	2.76 ± 0.14 b	3.14 ± 0.13 c	3.52 ± 0.13 d	4.38 ± 0.15 e	3.90 ± 0.13 f	5.76 ± 0.19 g	3.68 ± 0.10 c
F test		Insecticides	*		Botinical oils	*	I × B		*
LSD			0.33			0.33			0.88

S.E: Standard errors. Means followed by the same letter (s) are not significantly difference (P= 0.95 level)

Table 4. Means of grains weight loss percentage (%) as affected by treatment of wheat grains with some insecticides and/or botanical oils as well as their interaction after 9 months from beginning storage

Insecticides		Botanical oils (Means ± S.E)							Overall means (Means ± S.E)
		Control	Clove oil		Coriander oil		Lemon grass oil		
			(10%)	(15%)	(10%)	(15%)	(10%)	(15%)	
Control		7.67 ± 0.333 p	6.33 ± 0.333 mno	5.67 ± 0.333 lm	7.00 ± 0.000 op	6.67 ± 0.333 no	6.00 ± 0.000 lmn	5.33 ± 0.000 kl	6.38 ± 0.17 f
Deltamethrin	(1 ppm)	4.00 ± 0.000 hij	3.00 ± 0.000 efg	2.33 ± 0.333 cde	3.67 ± 0.333 ghi	3.33 ± 0.333 fgh	2.67 ± 0.333 def	2.00 ± 0.333 bcd	3.00 ± 0.17 c
	(2 ppm)	3.67 ± 0.333 ghi	2.33 ± 0.333 cde	1.67 ± 0.333 abc	3.00 ± 0.000 efg	2.67 ± 0.333 def	2.00 ± 0.000 bcd	1.33 ± 0.000 ab	2.38 ± 0.19 b
Malathion	(10 ppm)	4.67 ± 0.333 jk	3.67 ± 0.333 ghi	3.00 ± 0.000 efg	4.33 ± 0.333 ij	4.00 ± 0.000 hij	3.33 ± 0.333 fgh	2.67 ± 0.333 def	3.67 ± 0.17 e
	(15 ppm)	4.33 ± 0.333 ij	3.33 ± 0.333 fgh	2.67 ± 0.333 def	4.00 ± 0.000 hij	3.67 ± 0.333 ghi	3.00 ± 0.000 efg	2.33 ± 0.000 cde	3.33 ± 0.19 d
Phosphine	(3 tablets / m^3)	3.67 ± 0.333 ghi	2.67 ± 0.333 def	2.00 ± 0.000 bcd	3.33 ± 0.333 fgh	3.00 ± 0.000 efg	2.33 ± 0.333 cde	1.67 ± 0.333 abc	2.67 ± 0.17 b
	(5 tablets / m^3)	3.00 ± 0.000 efg	2.00 ± 0.000 bcd	1.33 ± 0.333 ab	2.67 ± 0.333 def	2.33 ± 0.333 cde	1.67 ± 0.333 abc	1.00 ± 0.333 a	2.00 ± 0.17 a
Overal means (Means ± S.E)		4.43 ± 0.43 g	3.33 ± 0.33 d	2.67 ± 0.67 b	4.00 ± 0.22 f	3.67 ± 0.67 e	3.00 ± 0.22 c	2.33 ± 0.33 a	3.35 ± 0.13 c
F test		Insecticides	*		Botinical oils	*	I × B		*
LSD			0.29			0.29			0.77

S.E: Standard errors. Means followed by the same letter (s) are not significantly difference (P= 0.95 level)

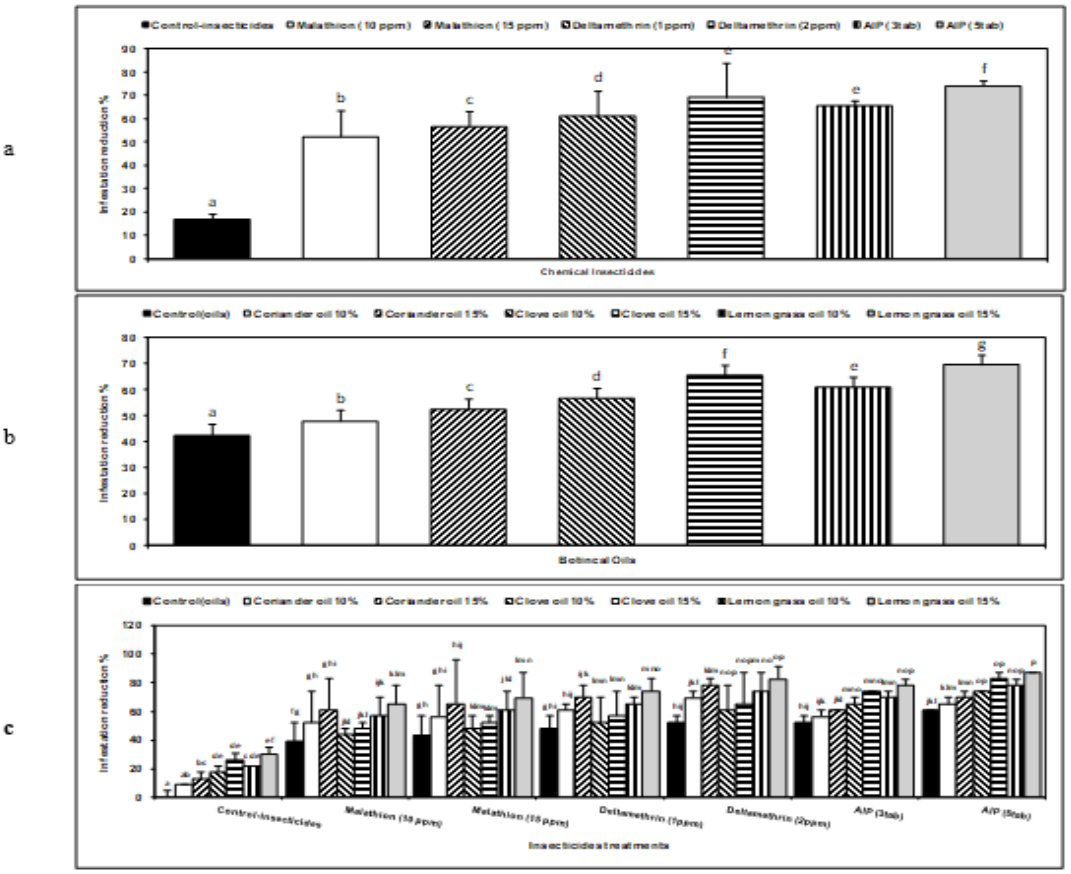

Fig. 1. The effect of treatment wheat grains with some insecticide (a) and/or botanical oils(b) and their combination (c) on insect infestation percentage(%).

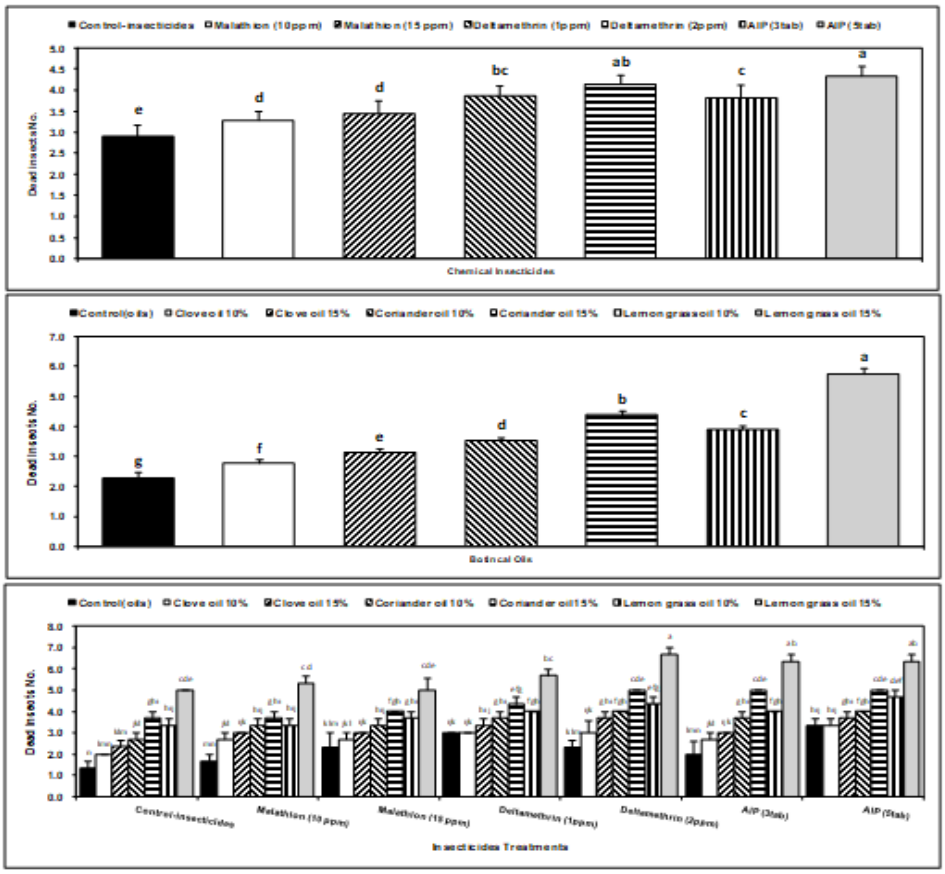

Fig. 2. The effect of treatment wheat grains with some insecticide(a) and/or botanical oils(b) and their combination (c) on dead insects number/sample.

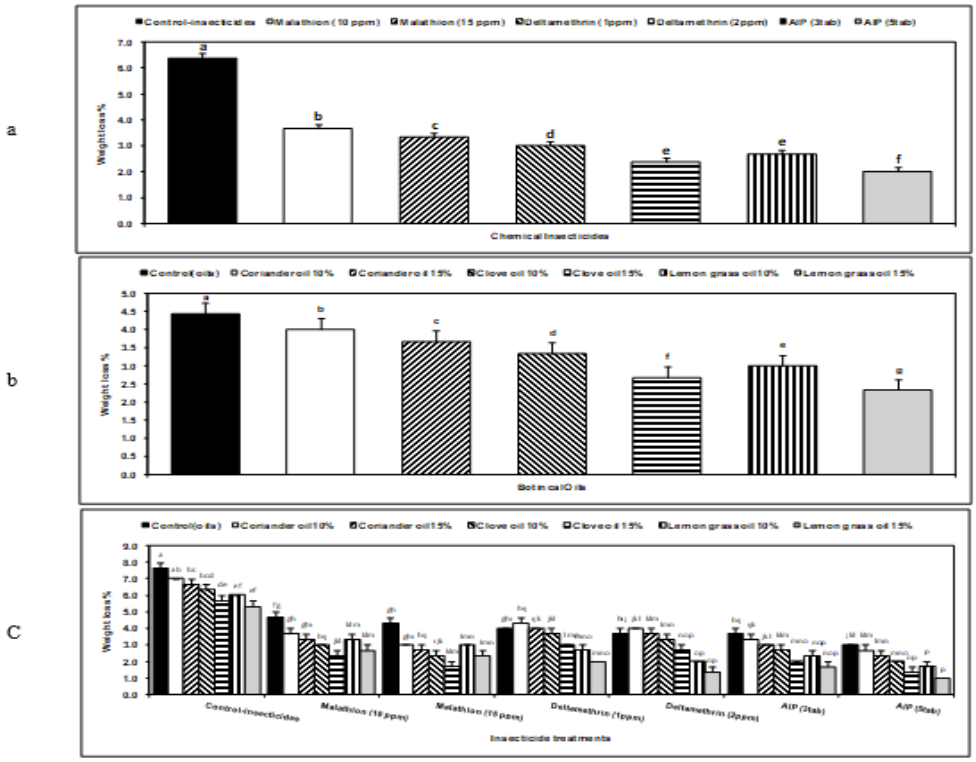

Fig. 3. The effect of treatment wheat grains with some insecticide(a) and/or botanical oils(b) and their combination (c) on Weight loss %.

However, treating wheat grains with clove oil at the rate of 15% ranked secondly after the aforementioned treatment and followed by treating wheat grains with lemongrass oil at the rate of 10%, them treating wheat grains with clove oil at the rate of 10%, coriander oil at the rate of 15% and coriander oil at the rate of 10% after 9 months from harvesting time.

On the other hand, the highest insect infestation percentage (8.22 %) and grains weight loss percentage (4.43 %), and lowest number of dead insects/sample (2.29) were obtained from storing wheat grains without any treatment (control treatment) after 9 months from harvesting time.

The reduction in insect infestation percentage and grains weight loss percentage and an increasing number of dead insects/sample by treating grains with lemongrass oil at the rate of 15% are probably due to the insecticidal and repellent activity of lemongrass oil and their components, therefore, it has the potential for application in stored grain pest management schemes (Plata-Rueda *et al.*, 2020).

In addition, the toxicity of clove oil against insects, so it could be used as a grain protectant or fumigant to control stored products insects (El-Gizawy *et al.*, 2018). The slight effect of coriander oil as compared with treatment with lemongrass oil or clove oil is probably due to its role in repellent and toxic properties against larvae and adult insects (Farhana *et al.*, 2006). These results conform with those stated by (Sriti Eljazi *et al.* 2017 and Soe *et al.* 2020)

Effect of the interaction:

The interaction between the treatment of wheat grains with some insecticides and/or botanical oils had a significant effect on storage efficiency (insect infestation percentage, number of dead insects/sample, and grains weight loss percentage) after 9 months from beginning storage as presented in Tables 2, 3 & 4 and Figures 1, 2 & 3.

The best results of insect infestation percentage (1.86 %), number of dead insects/sample (6.33), and grains weight loss percentage (1.00 %) after 9 months from harvesting time were obtained from samples of wheat grains treated with phosphine at the rate of 5 tablets/m^3 besides lemongrass oil at the rate of 15% (Tables 2, 3 and 4 and Figures 1,2 and 3). The second-best interaction treatment was treating wheat grains with phosphine at the rate of 3 tablets/m^3 in addition to lemongrass oil at the rate of 15%. Although, the highest insect infestation and grains weight loss percentages and lowest number of dead insects/samples were obtained from samples of wheat and grains did not treat without any treatment (control treatment of both studied factors).

CONCLUSION

This study recommended treating samples of wheat grains with phosphine at the rate of 5 tablets/m^3 besides lemongrass oil at the rate of 15% to enhance storage efficacy characters under the environmental conditions of Burj El-Arab district, Alexandria Governorate, Egypt.

REFERENCES

Abedi, T., A. Alemzadeh, and S. A. Kazemeini (2010). Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. Australian journal of crop science. 4, (6) :384–389.

Anon, A. (1988). Imported pesticides 1986-1988, Annual Report. Pest Control Products Board of Kenya.

Attia, A., M. Badawi, S. Seadh, and S. Rojbaiany (2014). Storage efficacy of wheat grains as affected treating with some chemical insecticides. Journal of Plant Production. 5, (9) :1587–1599.

Badawi, M. A., S. E. Seadh, W. A. E. Abido, and R. M. Hasan (2017). Effect of storage treatments on wheat storage. International Journal of Advanced Research in Biological Sciences (IJARBS). 4, (1) :78–91.

Bakkali, F., S. Averbeck, D. Averbeck, and M. Idaomar (2008). Biological effects of essential oils – A review. Food and Chemical Toxicology. 46, (2) :446–475.

Binseena, S. R., N. Anitha, A. Paul, V. S. Amritha, and K. N. Anith (2018). Management of rice weevil, Sitophilus oryzae using essential volatile oils. ENTOMON 43, (4) :277–280.

Collins, P. J., G. J. Daglish, M. K. Nayak, P. Ebert, D. Schlipalius (2001). Combating resistance to phosphine in Australia., in Fresno, CA, USA.

Dick, K. (1987). Pest management in stored groundnuts. ICRISAT Information Bulletin 22,.

Duncan, D. B. (1955). Multiple Range and Multiple F Tests. Biometrics 11, (1) :1.

El-Gizawy, K. KH., S. M. Halawa, and A. L. Mehany (2018). Effect of essential oils of clove and dill applied as an insecticidal contact and fumigant to control some stored product insects. Arab Journal of Nuclear Sciences and Applications (Online). 51, (4) :81–88.

Farhana, K., H. Islam, E. Emran, and N. Islam (2006). Toxicity and repellant activity of three spice materials on *Tribolium castaneum* (herbst) adults. Journal of Bio-Science. 14, :131–134.

Gomez, K. A., and A. A. Gomez (1984). Statistical procedures for agricultural research. John wiley & sons.

Hamza, A., and A. Hamza (2018). Toxicity and combined action of some insecticides and clove oil against *Rhyzopertha dominica* in wheat grain. Journal of Plant Protection Research; 2018; vol. 58; No 2.

Islam, M. S., M. M. Hasan, W. Xiong, S. C. Zhang, and C. L. Lei (2008). Fumigant and repellent activities of essential oil from *Coriandrum sativum* (L.) (Apiaceae) against red flour beetle *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). Journal of Pest Science. 82, (2) :171–177.

Jood, S., A. C. Kapoor, and R. Singh (1996). Evaluation of some plant products against Trogoderma granarium everts in sorghum and their effects on nutritional composition and organoleptic characteristics. Journal of Stored Products Research. 32, (4) :345–352.

Khater, H. F., M. Y. Ramadan, and R. S. El-Madawy (2009). Lousicidal, ovicidal and repellent efficacy of some essential oils against lice and flies infesting water buffaloes in Egypt. Veterinary Parasitology. 164, (2–4) :257–266.

Korunic, Z., V. Rozman, D. Hamel, A. Liska, and others (2012). Long term effectiveness of several grain protectants on wheat. IOBC-WPRS Bulletin 81, :7–16.

Phillips, T. W., and J. E. Throne (2010). Biorational Approaches to Managing Stored-Product Insects. Annual Review of Entomology. 55, (1) :375–397.

Pimpão, C. T., A. R. Zampronio, and H. C. Silva de Assis (2007). Effects of deltamethrin on hematological parameters and enzymatic activity in *Ancistrus multispinis* (Pisces, Teleostei). Pesticide Biochemistry and Physiology. 88, (2) :122–127.

Plata-Rueda, A., G. D. S. Rolim, C. F. Wilcken, J. C. Zanuncio, J. E. Serrão(2020). Acute toxicity and sublethal effects of lemongrass essential oil and their components against the granary weevil, *Sitophilus granarius*. Insects 11, (6) :379.

Ramadan, N. M. E. (2016). Methods of storage and their effect on seed of some filed crops. [Ph D. Thesis]: Mansoura Univ., Egypt.

Rengasamy, S., and B. S. Parmar (1989). Dissipation of isomalathion on solid pesticide carriers, container surfaces, and leaves and some degradation products of isomalathion on carriers. Journal of Agricultural and Food Chemistry. 37, (2) :430–433.

Seadh, S. E., M. A. Attia, M. A. Badawi, and S. N. H. Rojbaiany (2014). Response of chemical constituents of wheat grains to treatment with some chemical insecticides, pp. 202–218 in El-Mansoura, Egypt.

Snedecor, G. W., and W. G. Cochran (1980). Statistical Methods. Iowa State University Press, Iowa, USA., PP :507.

Soe, T. N., A. Ngampongsai, and W. Sittichaya (2020). Bioactivity of some plant essential oils for seed treatment against pulse beetle, Callosobruchus maculatus (F.) (Coleoptera: Bruchidae) on mung bean. Bulgarian Journal of Agricultural Science. 26, (1) :7.

Sriti Eljazi, J., O. Bachrouch, N. Salem, K. Msaada, J. Aouini (2017). Chemical composition and insecticidal activity of essential oil from coriander fruit against *Tribolium castaenum*, *Sitophilus oryzae*, and *Lasioderma serricorne*. International journal of food properties 20, (sup3) : 2833–2845.

Storey, C. L., D. B. Sauer, and D. Walker (1984). Present use of pest management practices in wheat, corn, and oats stored on the farm. Journal of Economic Entomology. 77, (3) :784–788.

Tadesse, M. (2020). Post-Harvest Loss of Stored Grain, Its Causes and Reduction Strategies. Food Science and Quality Management. 96, :26–35.

Taylor, R. W. D. (1994). Methyl bromide—Is there any future for this noteworthy fumigant? Journal of Stored Products Research. 30, (4) :253–260.

WHO (2020). The WHO recommended classification of pesticides by hazard and guidelines to classification 2019. World Health Organization.

Winks, R. G. (1984). The toxicity of phosphine to adults of *Tribolium castaneum* (Herbst): Time as a dosage factor. Journal of Stored Products Research. 20, (1) :45–56.

استخدام زيت حشيشة الليمون لتحسين فعالية تخزين حبوب القمح المعالج بالفوسفين

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تحت الظروف البيئية لشونة برج العرب ، محافظة الإسكندرية ، مصر، تم إجراء تجربة تخزين من ٣٠ مايو ٢٠٢٠ إلى ٢٦ فبراير ٢٠٢١ لدراسة تأثير المعاملة ببعض المركبات الكيميائية (المبيدات الحشرية) مثل الدلتامثرين بتركيز في ١ و ٢ جزء في المليون، الملاثيون بتركيز ١٠ و ١٥ جزء في المليون والفوسفين بمعدل ٣ و ٥ أقراص/م^{٣} والمركبات الطبيعية (زيوت نباتية) مثل زيت القرنفل والكزبرة والليمون بتركيز ١٠ و ١٥٪ لكل منهم على كفاءة تخزين القمح بعد ٩ أشهر من وقت الحصاد. نفذت الدراسة في تجربة عاملية بتصميم القطاعات كاملة العشوائية الكاملة (RCBD) في ثلاث مكررات. أوضحت النتائج المتحصل عليها أن أقل نسبة إصابة للحشرات ونسبة فقدان وزن للحبوب وأكبر عدد من الحشرات الميتة / عينة نتجت عن معاملة حبوب القمح بالفوسفين بمعدل ٥ أقراص/م^{٣}. سجلت معاملة حبوب القمح بزيت حشيشة الليمون بنسبة ١٥٪ أقل نسبة إصابة بالحشرات وأقل نسبة فقدان وزن للحبوب وأعلى عدد من الحشرات الميتة / عينة. أوصت هذه الدراسة بمعاملة عينات حبوب القمح بالفوسفين بمعدل ٥ أقراص/م^{٣} بجانب زيت حشيشة الليمون بنسبة ١٥٪ لتحسين كفاءة التخزين تحت الظروف البيئية بمنطقة برج العرب بمحافظة الإسكندرية ، مصر.