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Comparative Effects of Certain Plant Oils, Plant Powders and Insect Growth Regulators Against *Sitophilus oryzae* (Linnaeus) and *Triboluim castanium* (Herbst) Adults Using Two Methods of Application

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ABSTRACT

World wide storage of grains is a vitality measure for facing the catastrophes and crises. Through storage the grains are susceptible to infest by many of primary and secondary stored product insects. Heavily application of synthetic chemical insecticides led to environmental pollution, resistance development and contribution in destroying human health. The present study was conducted to evaluate three biomaterial groups, plant oils, castor (*Ricinus communis*) , garlic (*Allium sativum*) and sesame oil (*Sesamum idicum*), plant powder, rice hull, maize and cotton stems as well as insect growth regulators, agron (flufenoxuron), alsystin (triflumuron) and match (lufenuron) using two methods of application, common mixing technique and modified mixing of feeding medium (layer method) against *Sitophilus oryzae* (Linnaeus) and *Triboluim castanium* (Herbst) adults. The residual activity of the tested materials also was studied. Based on LC_{50}, IGRs had the strongest effect followed by plant oils and plant powders. For IGRs alsystin was the premier while garlic oil and rice hull achieved the best activity for plant oils and plant powders, respectively. Results also showed that the three tested groups caused obviously inhibition on progeny with the all tested concentrations, especially at concentration of 10 and 15 ml/kg for plant oils, 10 and 15 g/kg for plant powders and 10 and 15 mg/kg for insect growth regulators that completely prevented any emergence of adults with both insects, *Sitophilus oryzae* and *Triboluim castanium.* Moreover, results cleared that the modified manner (layer technique) protected wheat grain for five months posttreatment. In addition, the down position was the most effective on the tested parameters. In the long run the present study suggests the application layer manner technique which minimizes the direct contamination of grains and rationalized the use of chemical insecticides in stored product insect control. Furthermore the oils or powders may replace the IGRs as alternatives

Keywords: modified manner, IGR, plant oils, plant powder. *Sitophilus oryzae*, *Rhzopetha dominica*, infestation.

INTRODUCTION

Wheat is one of the most important cereal crops in many countries of the world. It is main diet for Egyptian populations. The rice weevil, *Sitophilus oryzae*(L) and red flour beetle, *Triboluim castanium*(Herbst) are two of the most widespread and destructive insect pests of stored cereals (Park *et al.,* 2003, Demitry *et al.,* 2007). Control of these insects around the world primarily depends upon application of chemical insecticides. But their repeated use has led to residual toxicity, environmental pollution, undesirable effects on food and human health (Dubey *et al.,* 2007, Kumar *et al.,* 2007). These serious problems have highlighted the need for the development of selective insect control alternatives to insecticides. Natural compounds from plants could be efficient alternatives to chemical insecticides because of their low toxicity to mammals, fast degradability properties and regional availability (Rajendran and Sriranjini, 2008). Many plant essential oils were investigated for their insecticidal activity such as repellents, anti-feedants, oviposition deterrent and insect growth regulators (Prakash and Rao 1997, Isman 2000). Essential oils are more compatible components than synthetic pesticides (Isman and Machial 2006). Additionally, there are various mineral substance from plant origin which can be added to control stored grain insects such as ashes. The addition of ashes to cereals grains is wide spread in African countries. Oven ash of cotton stem is used to protect stored grain from insects (El-lakwah *et. al,* 1996). Insect growth regulators (IGR_S) are widely used in pest control as alternatives to chemical insecticides where they have low mammalian toxicity, high specify , rapid degradation in the environment, effective at killing all immature stages of insect pests (Moser *et al.,* 1992) Thus the objectives of this study were to evaluate the toxic effect of plant oils, castor (*Ricinus commuois*), garlic (*Allium sativum*) and sesame (*Sesamum idicum*), plant powders, cotton stem, maize stem and rice hull and insect growth regulators, agron, alsystin and match against *Sitophilus oryzae* and *Triboluim castanium* adults and to evaluate modified manner (layer manner) as new method of mixing with feeding medium. The effect on progeny and life cycles in addition to the residual effect of the tested materials, was also evaluated.

MATERIALS AND METHODS

Insect culture :

Cultures of rice weevil, *Sitophilus oryzae*(L) and red flour beetle, *Triboluim castanium* (Herbst) adults used in this study were reared free of insecticidal contamination at 28 $\pm$ 2^{o}C, 70 $\pm$ 5% R.H. at the laboratory of Stored Product Pests Research Department, Plant Protection Research Institute, Sakha Agriculture Research Station. Correct grains of wheat for *S. oryzae* and crushed wheat grains for *T. castanium* were used. Newly emerged adults (1-7 days old) were randomly chosen for the next bioassay experiments.

Materials :

1-Plant materials used :

Plant oils :

Essential oils used in this study were purchased from the local market.

Castor oil: (*Ricinus communis*). Fam. : Euphorbiaceae
Garlic oil : (*Allium sativum*). Fam. : Lilliceae
Sesame oil : (*Sesamum idicum*). Fam. : Pedaliaceae

Plant powders :

Plant powders used in this study were cotton stem, maize stem and rice hull collected from Farm and

Agricultural land do not priorly treated with any pesticides in Kafr El-Sheikh Governorate in May 2014. The collected materials were placed in a polyethylene bag to prevent loss of moisture during transportation on the laboratory.

Procedure of the powder preparation :

Cotton stem, maize stem and rice hull were washed with distilled water and dried at room temperature to remove moisture, then placed in paper envelop and oven- dried at 55 ^{o}C for 24 hr.(Abuye *et al.*, 2003) . The dried stems were ground into powder using pestle and mortar and sieved through 300 mesh sieve. The stem powders were used as experimental materials at three concentrations, 5, 10 and 15 g /kg grain.

2- Insect growth regulators (IGR'S):

Three insect growth regulators are used during the present study namely, flufenoxuron (Agron 10% EC) produced by American Cyanamide Co., triflumuron (Alsystin 48% SC) produced by Bayer Crop Science and lufenuron (Match 5 % EC) obtained from Syngenta Agro Co.

Methods :

Bioassay of the tested compounds :

1-Mixing with medium :

Common method (complete admixing) :

a-For toxicity experiments : The concentrations of the tested materials were determined according to a preliminary laboratory assessment. 5, 10, 15 ml of each plant oil, 5, 10, 15 g of each plant powder and 5, 10, 15 mg active ingredient of each insect growth regulator were mixed with one kilogram of grain wheat for each and placed in appropriate glass jars. The jars were shaken by hand to mix the grains with the tested materials. The jars of insect growth regulators were left a convenient time until the solvent evaporated. 20 g sample of wheat grains treated by the previous concentrations were placed in small glass jars (11.5 by 6 cm diameter). Each concentration was replicated three time. The jars which left without any tested materials were served as control. Twenty unsexed newly emerged adults of *Sitophilus oryzae* and *Triboluim castanium* (1-7 days old) were transferred to each jar and then covered with nylon cloth and kept under laboratory conditions. Mortality counts were recorded after 2, 3 and 5 days. All results were corrected according to Abbot's formula (1925). Median lethal concentration (LC_{50}) and their confidence limits (95% CL) were calculated based on Finney' analysis (Finney, 1971) using Pc-Probit software program.

b-For effect on progeny and life cycle : The same experiment mentioned above for toxicity was conducted and continued until the emergence and mean number of emerged adults and life cycle were estimated.

Modified method of mixing with medium (layer method) :

a- Two layers method :

According to the above mentioned experiment (toxicity experiment) of common mixing there is no any adults emerged of F_1 with concentration of 10 ml/kg, 10 g/kg and 10 mg/kg, of plant oils, plant powders and IGR'S, respectively. So this concentration was used in the modified method (layer manner). In this experiment, plant oils, plant powders and IGR'S were used separately. 40g of wheat grains was divided into two layers, each of 20g. One layer was treated with the tested materials and placed on upper or bottom position of the jar. Each jar was replicated three times. The jars which contain only untreated wheat served as control. Randomly 10 pairs of unsexed adults of *S. oryzae* (1-7 days old) were transferred to each jar, then the jars were covered with nylon cloth. Mortality count were recorded after 2days. The same experiment was conducted and left under laboratory conditions to estimate F_1 progeny.

b- Three layers method :

In this experiment, 60g of wheat grains were divided into three groups each 20g. Each jar contains three layers, the upper or bottom layer was 20g of wheat treated with castor oil, garlic oil or IGR, flufenoxuron, while the middle layer contained untreated wheat grain. Each jar was replicated three times. The jars served as control contained wheat grains without any tested materials. Ten pairs of unsexed adults of *Sitophilus oryzae* were randomly chosen and transferred to each jar. The jars were covered with nylon cloth, and kept under laboratory conditions. Mortality counts were recorded after 2 days. The same mentioned experiment was repeated to estimated F_1 progeny.

Statistical analysis:

The obtained data were statistically analyzed, utilizing a computer software package, and differences between means were tested using the method of multiple range test outlined by Duncan (1955).

RESULTS

Mixing with medium

Common method :

Insecticidal activity

Plant oils:

Mixing with feeding medium was used as a bioassay technique, data obtained in (Table 1) showed that all tested oils had a bioactivity effect on the two tested insects. Five days exposure period was the effective with the lowest level of concentration against the two tested adult insects, where the LC_{50} values were 3.61, 5.83 and 6.00 and 7.68, 8.04 and 11.65 ml/kg grains for garlic, castor and sesame oils against *S. oryzae* and *T. castanium*, respectively. In this experiment the exposure period was the main factor to induce effect since the LC_{50}'s decreased with the increasing of exposure time from 15.58 to 3.61, 22.86 to 5.33 and from 28.43 to 6.00 ml/kg for *S. oryzae* and from 40.45 to 7.68, 44.53 to 8.04 and from 46.55 to 11.65 ml/kg grains for *T.castanuim* after 2, 3 and 5 days with garlic, castor and sesame oil, respectively. In addition that garlic oil had the strongest effect. In contrast, the sesame oil was the lowest agent. Based on the LC_{50}'s values of the tested materials, *T. castanium* was more tolerant than *S. oryzae*.

Table 1. LC_{50} values of plant oils against *S. oryzae* and *T. castanium* adults after indicated periods post treatment

oil	Exposure period (days)	*S. oryzae* LC_{50} ml/kg	Confidence limits Lower	upper	Slope value	*T. castanium* LC_{50} ml/kg	Confidence limits lower	upper	Slope value
Garlic	2	15.58	12.40	24.99	1.10	40.45	33.44	45.55	1.08
	3	7.41	6.16	8.57	2.39	23.52	15.76	97.46	1.31
	5	3.61	2.18	4.67	2.36	7.68	6.12	9.22	1.55
Castor	2	22.86	21.76	23.96	1.75	44.53	35.82	51.27	2.70
	3	8.32	5.94	10.79	2.45	28.26	20.63	65.26	2.97
	5	5.83	1.93	9.98	3.90	8.04	6.14	9.91	1.63
Sesame	2	28.43	27.08	29.59	1.75	46.55	43.37	48.62	1.78
	3	13.00	10.80	15.21	2.21	37.56	23.76	177.13	2.45
	5	6.00	2.01	7.98	2.99	11.65	10.30	13.61	2.86

b- Plant powders :

Similarly, data in Table 2 indicated that the three tested powders achieved a better effect against the two tested insects and the effect increased with the increasing of exposure period. Results cleared that *T. castanium* was the more tolerant insect with LC_{50} ranged from 22.23 to 83.84 g/ kg grain in comparison with that of *S. oryzae* which ranged from 14.61 to 65.81 g/kg. Also, the results showed that the rice hull was the most effective powder followed by maize stem then cotton stem against the two tested insects and *T. castanium* was more tolerant than *S. oryzae.* For example, LC_{50} at two days posttreatment was 32.7, 43.00 and 65.81 g/kg for *S. oryzae* compared to 59.66, 68.06 and 83.84 g/kg for *T. castanium* at the same period of exposure.

Table 2. LC_{50} values of plant powder against *S. oryzae* and *T. castanium* adults after indicated periods post treatment

powder	Exposure period (days)	*S. oryzae* LC_{50} g/kg	Confidence limits Lower	upper	Slope value	*T. castanium* LC_{50} g/kg	Confidence limits lower	upper	Slope value
Rice hull	2	32.70	22.26	105.93	2.73	59.66	57.50	61.67	2.69
	3	26.77	19.77	55.84	2.64	35.07	30.02	45.29	3.26
	5	14.61	11.62	17.70	3.09	22.23	17.18	38.79	2.37
Cotton stem	2	65.81	62.12	75.61	1.38	83.84	82.12	85.61	2.10
	3	28.66	18.25	67.33	1.82	51.15	50.29	55.30	2.10
	5	29.47	28.43	30.59	1.05	39.71	9.99	55.04	1.40
Maize stem	2	43.00	25.26	57.67	2.41	68.06	66.60	70.60	2.02
	3	33.06	30.20	67.33	2.16	37.05	29.36	58.72	2.44
	5	19.77	14.83	39.96	1.71	35.23	21.64	180.11	1.66

c- Insect growth regulators:

Similar effect was observed for the tested growth regulators the two insects, and *S. oryzae* was more susceptible than *T. castanium* (Table 3). The data showed that triflumuron had the highest activity followed by flufenoxuron and later match with LC_{50}s of 22.33 and 48.80, 23.07 and 50.52 and 38.66 and 51.92 mg/kg at the second day of exposure against *S. oryzae* and *T. castanium*, respectively.

Table 3. LC_{50} values of Insect growth regulators against *S. oryzae* and *T. castanium* adults after indicated periods post treatment

Growth regulator	Exposure period (days)	*S. oryzae* LC_{50} mg/kg	Confidence limits Lower	upper	Slope value	*T. castanium* LC_{50} mg/kg	Confidence limits lower	upper	Slope value
flufenoxuron	2	23.07	20.04	28.57	3.30	50.52	22.07	147.94	3.32
	3	19.90	16.78	23.08	3.11	28.30	20.63	47.08	2.97
	5	8.51	7.57	9.48	3.26	17.52	15.02	22.76	3.35
triflumuron	2	22.33	16.81	29.45	2.47	48.80	47.51	50.06	1.28
	3	14.59	12.55	18.84	2.68	23.28	27.08	29.47	1.20
	5	3.07	2.08	4.06	0.99	17.16	13.10	33.05	1.57
lufenuron	2	38.66	37.51	39.81	3.15	51.92	36.92	63.26	3.18
	3	28.29	27.08	29.47	1.20	28.30	17.63	49.47	2.27
	5	5.18	2.49	6.87	1.37	22.67	16.68	47.89	1.88

Effect on the progeny and life cycle :

In order to evaluate the effect of plant oils, plant powders and IGRs, on biology of *S. oryzae* and *T. castanium*, two ordinary parameters, mean emerged adults and the long of life cycle of tested insects were used. The obtained data in Tables 4-6 obviously showed the undesirable influence of materials investigated on the tested parameters.

Table 4. Effect of plant oils on progeny and life cycle of *S. oryzae* and *T. castanium*

oil	Conc. ml/kg	*S. oryzae* Mean adults emerged	Reduction %	Life cycle (day)	Life cycle increasing rate [a]	*T. castanium* Mean adults emerged	Reduction %	Life cycle (day)	Life cycle increasing rate [a]
	5	40.3 b	77.50 c			45.0 b	76.90 c		
Castor	10	0	100	40	1.21	0	100	40	1.25
	15	0	100			0	100		
	5	26.0 c	85.30 b			33.6 c	83.00 b		
Garlic	10	0	100	45	1.36	0	100	52	1.62
	15	0	100			0	100		
	5	22.0 d	87.82 a			28.33 d	85.67 a		
Sesame	10	0	100	51	1.55	0	100	50	1.56
	15	0	100			0	100		
Control		180.7 a		33		197.7 a		32	

Means followed by the same letter are not significantly different at the 5% level by Duncan Multiple Range Test(1955)
[a] Life cycle increasing rate = Life cycle in treatment / Life cycle in control

a-Effect of plant oils:

Results obtained showed that the concentration of 5 ml/kg significantly depressed the mean number of emerged adults and elongated the life cycle of both of the studied insects. In this regarding, sesame oil had the greatest impact followed by garlic and castor oils with percent reduction of 87.82, 85.30 and 77.50 % and life cycle of 51, 45 and 40 day, respectively for *S. oryzae*. For *T. castanium*, sesame oil followed by garlic and castor oils had percent reduction of 85.67, 83.00 and 76.90 % and life cycle of 50, 52, and 40 day, respectively. Data cleared that life cycle of *T. castanium* more drastically affected than that of *S. oryzae*. In addition, the life cycle increasing rate ranged between 1.21 to 1.55 and 1.25 to 1.62 time of that of control for *S. oryzae* and *T. castanium*, respectively. The rate of concentration of 10 and 15 ml/kg completely prevented any emerged adults after 60 day of treatment with both insects.

a-Effect of Plant powders:

Also, the tested powders significantly increased the percent of reduction from 65.32 to 76.20 % for *S. oryzae* and from 68.47 to 76.06 % for *T. castanium* compared to control compared to control. Moreover, the powders increased the life cycle of *S. oryzae* from 35 to 38 day and from 35 to 40 days for *T. castanium* compared to control of 33 and 32 days of both insects, respectively. In this regarding rice hull was the premier with the two tested insects (Table 5).

Table 5. Effect of plant powders on the progeny and life cycle of *S. oryzae* and *T. castanium*

powder	Conc. g/kg	*S. oryzae* Mean adults emerged	Reduction %	Life cycle (day)	Life cycle increasing rate [a]	*T. castanium* Mean adults emerged	Reduction %	Life cycle (day)	Life cycle increasing rate [a]
	5	43.0 d	76.20 a			48.33 d	76.06 a		
Rice hull	10	0	100	38	1.15	0	100	40	1.25
	15	0	100			0	100		
	5	62.67 b	65.32 c			56.66 c	71.34 b		
Cotton stem	10	0	100	35	1.06	0	100	35	1.09
	15	0	100			0	100		
	5	60.0 c	66.80 b			62.33 b	68.47 c		
Maize stem	10	0	100	35	1.06	0	100	35	1.09
	15	0	100			0	100		
Control		180.7 a		33		197.7 a		32	

Means followed by the same letter are not significantly different at the 5% level
[a] Life cycle increasing rate = Life cycle in treatment / Life cycle in control

b-Effect of Insect growth regulators (IGRs) :

Data in Table 6 summarized the effect o IGRs on progeny of tested insects. Triflumuron had the greatest effect on the two tested insects at 5 mg/kg where the percent of reduction reached to 80.82 and 82.30 % for *S. oryzae* and *T. castanium*, respectively based on untreated control. Also life cycle reached to 45 days for both insects with increasing rate of 1.36 and 1.41 for *S. oryzae* and *T. castanium,* respectively. The two concentrations 10 and 15 mg/kg completely prevented any emerged adults with the tested insects.

2- Modified mixing method (Layer manner) :

To minimize the probable disadvantages which result in direct mixing of the tested materials to grain and users, the present study suggested using modified mixing technique (layer method). Two experiments were done using 10ml/kg for oils and 10 mg/kg for growth regulator (which gave 100% progeny reduction). For two layers, each toxicant was admixed at the two different positions in upper or down while, the other layer was permanently wheat grain only. For three layers, the upper or down layer of grain was mixed with any tested toxicant while the middle layer was served as untreated control. Adults of *S. oryzae* were exposed to aforemention technique and the % mortality was estimated after 48 hr. of treatment while the effect on progeny continue for 5 months to study the residual effect of tested materials.

a-Two layers manner:

Results summarized in (Table 7) showed that garlic oil had the greatest impact either in upper or down position followed by castor oil and later IGR, flufenoxuron with mortality values of 91.6, 95.0, 76.0, 91.6 and 62.6 and 67.0 in upper and down position, respectively. With the exception of flufenoxuron, after two months the all tested materials completely prevented any emerged adults till 150 days post treatment.

Table 6. Effect of Insect growth regulators on the progeny and life cycle of *S. oryzae* and *T. castanium*

		S. oryzae				***T. castanium***			
Growth regulator	**Conc. mg/kg**	**Mean adults emerged**	**Reduction %**	**Life cycle (day)**	**Life cycle increasing rate [a]**	**Mean adults emerged**	**Reduction %**	**Life cycle (day)**	**Life cycle increasing rate [a]**
	5	45.30 [c]	74.70 [b]			45.6 [c]	76.90 [b]		
flufenoxuron	10	0	100	40	1.21	0	100	45	1.41
	15	0	100			0	100		
	5	34.67 [d]	80.82 [a]			35.0 [d]	82.30 [a]		
triflumuron	10	0	100	45	1.36	0	100	45	1.41
	15	0	100			0	100		
	5	45.00 [b]	74.33 c			52.00 [b]	73.73 [c]		
lufenuron	10	0	100	40	1.21	0	100	40	1.25
	15	0	100			0	100		
Control		180.70 [a]		33		197.70 [a]		32	

Means followed by the same letter are not significantly different at the 5% level [a] Life cycle increasing rate = Life cycle in treatment / Life cycle in control

Table 7. Mortality and inhibition of *S. oryzae* progeny production on wheat grain with two layer manner

layer	**treatment**	**%Mortality**	**Progeny 1 month**	**2 month**	**3 month**	**4 month**	**5 month**
upper	Castor						
down	untreated	76.0 [b]	0	0	0	0	0
upper	untreated	91.6 [a]					
down	Castor		0	0	0	0	0
upper	Garlic	91.6 [a]	0	0	0	0	0
down	untreated						
upper	untreated	95.0 [a]	0	0	0	0	0
down	Garlic						
upper	flufenoxuron	62.6 [c]	0	20.6	0	0	0
down	untreated						
upper	untreated		0	0	0	0	0
down	flufenoxuron	67.0 [c]					
control				180.6			

Means followed by the same letter are not significantly different at the 5% level

b- Three layers manner:

Based on the values of mortality (Table 8), the garlic oil is the main agent for increasing the insecticidal activity of the first and third groups compared to the second group which have not garlic oil and caused the lowest mortality. Also results manifested that the three groups completely prevented the emergence of *S. oryzae* for 150 days posttreatment.

Table 8. Mortality and inhibition of *S. oryzae* of progeny production on wheat grain with three layer manner

layer treatment			**%Mortality**	**Progeny 1 month**	**2 month**	**3 month**	**4 month**	**5 month**
Group	upper	Garlic	94.3 [a]	0	0	0	0	0
1	meddle	untreated						
	down	Castor						
	upper	Castor	96.3 [a]	0	0	0	0	0
	meddle	untreated						
	down	Garlic						
Group	upper	Castor	90.3 [b]	0	0	0	0	0
2	meddle	untreated						
	down	flufenoxuron						
	upper	flufenoxuron	90.3 [b]	0	0	0	0	0
	meddle	untreated						
	down	Castor						
Group	upper	Garlic	90.3 [b]	0	0	0	0	0
3	meddle	untreated						
	down	flufenoxuron						
	upper	flufenoxuron	94.3 [a]	0	0	0	0	0
	meddle	untreated						
	down	Garlic						
control					180.7			

Means followed by the same letter are not significantly different at the 5% level

Results in Table 8 included three binary groups, the first group which had the highest effect contained (garlic+castor) and (castor+garlic) with % mortality of 94.3 and 96.3. The second group had the least effect comprised (castor+flufenoxuron) and (flufenoxuron +castor) achieving % mortality of 90.3 and 90.3. The third group enclosed (flufenoxuron +garlic) and (garlic+flufenoxuron) had intermediated % mortality values of 90.3 and 94.3.

DISCUSSION

This study was designed to evaluate the efficacy of three classes, plant oils (garlic, castor and sesame), plant powders (rice hull, cotton stem and maize stem) and insect growth regulators (flufenoxuron, triflumuron and lufenuron) as a bioactive agents on mortality, progeny and life cycle of the two tested insects, *S. oryzae* and *T. castanium* adults as well as their residual activity using two mixing technique, the first was the common method and the second was the layer manner (a new technique). Both tested methods had moderately effects on the tested parameters. Based on the LC_{50} values, the three growth regulators had the strongest efficiency followed by oils and powders. Also, the obtained results revealed that layer manner completely prevented the emergence for five months posttreatment and that oils or powders could replace the insect growth regulators. Oils and powders have advantages exceed that of insect growth regulators. Plant oils are mixtures of hydrocarbons with diversity of functional groups, they cause death of insects by inhibiting aceylcholinesterase activity in the nervous system (Houghton *et. al,* 2006). Moreover, essential oils possess acute contact and fumigant toxicity to insects (Liu and Ho 1999; Sahaf *et. al*, 2008; Abdelgaleil *et.al,* 2009), repellent activity (Wang *et. al,* 2006; Nerio *et. al,* 2009; Nerio *et. al,* 2010), antifeedant activity (Huang *et. al,* 1997&2000) as well as development and growth inhibitory activity (Tomova *et. al*, 2005; Waliwitiya *et. al*, 2008). Furthermore, essential oils negatively affect progeny production, oviposition, longevity of adults, egg hatch rate and mating behavior (Ho *et.al,* 1997; Huang *et. al*, 1997, Rajapakse and Emden1997). The growth inhibitory or insecticidal effect of plant powders may attribute to one or more of such properties as stomach poisoning effect where insects feed on admixed grains and pickup lethal doses of treatment particles and these particles might reduce insect movement and also cause death through occlusion of their spiracles, thereby preventing respiration via trachea (Shaheen and Khaliq, 2005). While IGRs have several advantages over neurotoxic insecticides. They affect development at an early stage and therefore can slow down population build up. They can be used in minute amounts and pose no residue problems. They are reported to be non-toxic to mammals and produce no tratogenic or mutagenic effects in warm-blooded animals even with high concentrations (Antognini, 1972). Subsequently, the advantages of plant powders and oils as stored product protectants exceed that of insect growth regulators where plant materials have many modes of action if compared with that of growth regulator.

These results are in agreement with that of Khanzada *et al.,*(2015) they observed that plant edible oil affected the developmental stages of red flour beetle, *T. castanium* exposed to wheat grain treated with mustard oil (*Brassica campestris*), coconut oil (*Coeus nucifera*), sesame oil (*Sesamum indicum*) and roket seed oil (*Eurca sativa*). Ali *et al.,*(2014) reported that both garlic (*Allium sativum*) and turmeric (*Curcma longa*) acetone medicinal plant extracts reduced the larval, pupal and adult emergence of *T. castanium*. Saleem *et al.,* (2014) investigated the insecticidal activity of essential oils of four locally grown plants, *Datura stramanium*, *Eucalyptus camaldulensis, Mornga oleifera* and *Nigella sativum* against three major insect pests, *T. castanium*, *Trogoderma granarium* and *Cryptolests ferugineus* under laboratory condition at concentration of 5, 10, 15 and 20 ul/L. All the tested essential oils significantly increased the mortality rate at all levels of concentrations and exposure periods. In the same context, botanicals oils from higher plants have been found suitable after investigating their fumigant insecticidal properties by many scientists (Isman, 2006, 2008; Rajendran and Sriranjini, 2008; Sagheer *et al*., 2013). Bilal *et at*., (2015) claimed that the citrus oils extracted from seed citrus of rough lemon (*Citrus jambhiri*), freutrall early (*Citrus reticulate*), kinnow (*Citrus reticulate var_kinnow*) and red blood orange (*Citrus sinensis*) had insecticidal activity on both adults and grubs of *T. castanium*.

Results of the present study are in accordance with previous studies which conducted to evaluate different plant oils against stored insect pests. Tapondjou *et al.,* (2005) evaluate essential oils from *Cupressus sempervirens* and *Eucalyptus salinga* against *Sitophilus zeamais* and *T. castanium* and showed significant mortality on the tested insects.. Also the present results are quite inline to those of Shaaya *et al.,* (1991) and Ho *et al.,* (1996) who reported that essential oil of garlic has insecticide effect to *T. castanium.*

Many essential oils have been reported for their capacity to delay adult emergence and fertility (Marimutu *et al.,* 1997; Chaubey, 2007a, 2007b). Chaubey, (2011) showed that dried fruits of *Cuminum cyminum* and *Piper nigrum* caused reduction in oviposition potential, inhibition of development of larvae to pupae and pupae to adults and increase in development period of the *T. castanium.*

Azadirachtin (AZ), a *Tetranortriterpenoid limonoid* from the Indian neem tree (*Azadrirachta indica* A. Juss) is the active ingredient found in commercial insect growth regulators as Align and Margoson-O (Wells *et al.,* 1993). Neem or AZ based IGR_S are very selective ecdysone antagonists and has a broad spectrum of activity against agricultural, stored product and house-hold pests (Awad *et al.,* 1998). Abo Arab *et al.,* (2013) studied the effect of the biocide, ivomic and the insect growth regulator, cascade on the toxicity and emergence of *Trogoderma granarium*. They found that the biocide ivmoic had the strongest effect for toxicity and reduction of offspring compared to the insect growth regulator, cascade. Also they found that the down position of treated layer was the most effective compared to the other two layers (middle and surface). Tessema *et. al,* (2015) found that leaf powders of neem and basil were effective in reducing the damage inflicted by bruchid compared to the control.

In the long run the current study suggests the use of plant materials (oils and powders) as alternatives to insect growth regulators tested to protect the wheat grain and also the use of layer manner to replace the common technique of mixing with feeding medium. Finally, the variation between the tested materials may ascribe to the dissimilarity of the chemical components of each material.

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التأثيرات المقارنة لزيوت ومساحيق نباتية ومنظمات نمو حشرية ضد حشرتي سوسة الأرز وخنفساء الدقيق الصدئية باستخدام طريقتين من طرق التقييم الحيوي

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يعتبر تخزين الحبوب ذات أهمية كبيرة عالمياً وذلك لمواجهة الكوارث والأزمات وفي أثناء التخزين تتعرض الحبوب للإصابة بالعديد من حشرات المنتجات المخزونة والتي منها حشرات تصيب الحبوب السليمة (حشرات أولية) مثل سوسة الأرز ومنها حشرات تصيب منتجات الحبوب (حشرات ثانوية) مثل خنافس الدقيق . وقد أدي الاستخدام الكثيف للمبيدات الحشرية المصنعة في مكافحة هذه الآفات إلى العديد من المشاكل مثل تلوث البيئة والسمية المتراكمة وتطور صفة مقاومة الحشرات للمبيدات بالإضافة إلى التأثيرات الضارة لصحة الإنسان . وفي هذه الدراسة تم تقييم فعالية ثلاث مجموعات حيوية . المجموعة الأولى وهي الزيوت النباتية وتشمل كل من زيت الثوم وزيت الخروع وزيت السمسم والمجموعة الثانية المساحيق النباتية وتشمل مسحوق قشرة الأرز ومسحوق ساق القطن ومسحوق ساق الذرة بالإضافة إلى المجموعة الثالثة وهي منظمات النمو الحشرية وتشمل السيستون والأجرون والماتش ضد حشرتي سوسة الأرز وخنفساء الدقيق وذلك باستخدام طريقتين الأولى بطريقة الخلط العادية مع البيئة والثانية بطريقة الخلط المعدلة (طريقة الطبقات) .وبناء على التركيزات المميتة قد أظهرت النتائج أن منظمات النمو الحشرية كانت أقوى تأثيرا على الحشرات المختبرة يليها الزيوت النباتية يليها المساحيق النباتية. بالنسبة لمنظمات النمو كان منظم النمو السيستين الأقوى بينما كان زيت الثوم ومسحوق قشرة الأرز الأكثر تأثيراً بالنسبة للزيت النباتية والمساحيق النباتية على التوالي. أظهرت النتائج أن المجاميع المختبرة أدت إلى خفض واضح في أعداد الذرية الناتجة مع كل التركيزات المختبرة خصوصاً تركيزي ١٠ و ١٥ملليلتر للزيوت النباتية و ١٠ و ١٥ جرام للمساحيق النباتية و ١٠ و ١٥ ملليجرام لمنظمات النمو الحشرية والتي أدت إلى المنع الكامل لخروج الذرية لكلا الحشرتين تحت الدراسة (سوسة الأرز وخنفساء الدقيق الصدئية). أظهرت النتائج بوضوح أن أسلوب الخلط المعدل (طريقة الطبقات) أدت إلى حماية الحبوب المعاملة لمدة خمسة شهور بالإضافة إلى ذلك وجد أن الطبقة السفلى المعاملة كانت هي الأشد تأثيراً على كل القياسات المختبرة. في نهاية المطاف فإن الدراسة الحالية تقترح تطبيق الطريقة المعدلة للخلط (الطبقات) حيث أن هذا الأسلوب يؤدي إلى خفض التلوث المباشر للحبوب وكذا ترشيد استخدام المبيدات الكيماوية في مكافحة حشرات المواد المخزونة. بالإضافة إلى ما سبق فإن الزيوت أو المساحيق النباتية يمكن أن تستخدم كبدائل لمنظمات النمو.