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Research Article
Effects of Some Insecticides (Deltamethrin and Malathion) and Lemongrass Oil on Fruit Fly (*Drosophila melanogaster*)

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Abstract

Background and Objective: The continuous use of pesticides in the ecosystem is of great concern, as some of them are highly stable and impact non-target organisms. The effect was tested of different concentrations of insecticides such as (Deltamethrin and Malathion) and natural products, Including, lemongrass oil on Fruit Fly (*Drosophila melanogaster*), to calculate the concentration at which the highest mortality occurred and death half the number of individuals after 96 hrs, as well as calculating the half-lethal time for individuals. **Materials and Methods:** This study, which evaluated the toxicity of five different concentrations (0.75, 1.00, 1.25, 1.50 and 1.75 mg L^{-1}) of Malathion, (0.05, 0.10, 0.21, 0.53 and 1.48 mg L^{-1}) of Deltamethrin and lemongrass oil (0.25, 0.50, 0.75, 1.00 and 1.50 mg L^{-1}) on the insect of *Drosophila melanogaster* after 96 hrs of treatment. **Results:** From the results of this study, the concentration (LC_{50} = 2.938 mg L^{-1}) of Malathion leads to kills half of the individuals, compared to Deltamethrin a higher concentration (LC_{50} = 4.8673 mg L^{-1}) that leads to killing half of the individuals. While lemongrass oil the concentration (LC_{50} = 9.7478 mg L^{-1}) leads to kills half of individuals. Also, when used Deltamethrin it takes (LT_{50} = 660.277) hours to kill half of the individuals compared to Malathion, which takes approximately (LT_{50} = 321.862) hours to death half of the individuals. But lemongrass oil (LT_{50} = 819.745) hours to kill half of the individuals. **Conclusion:** In conclusion, the lemon plant and its components have excellent potential for being used in the control of *Drosophila melanogaster*, which had an effective role in biological control.

Key words: Concentrations, *Drosophila melanogaster*, insecticides, deltamethrin, malathion, lemongrass oil, longevity, mortality

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Becoming reducing economic loss due to pests using pesticides in agriculture imperative, to curtail economic costs become imperative. So, necessary to use bioindicators using living organisms becomes the method to be an inexpensive choice as this is a specific and easy to handle method. Moreover, pesticides could be accumulated by living organisms and thus helps to indicate environmental contamination by pesticides[1]. In recent years, pesticides play an important role as they are used to control pests and diseases[2]. But, the real problem, that the agricultural pollution caused by water contamination and other environmental substrates and the potentially detrimental effects of insecticide misuse on non-target organisms should never be underestimated[3]. Approximately 250,000-370,000 people around the world die from pesticide toxicity yearly[4]. Therefore, Interest is rising in reducing their effect, especially, after assessing their harmful properties for non-target species, the prolonged presence of toxic pesticide residues and also the destructive effects on natural habitats, many pesticides have been banned[5].

But, spraying insecticides (e.g., organophosphates and pyrethroids) has remained the most rapid and effective control method[6]. Amongst many strategies, pyrethroid insecticides are neurotoxic insecticides usually use for management and effectiveness of most agricultural pests toward young instars and adults[7]. Deltamethrin became one of the most popular pesticides, it is widely used in the prevention and control of agricultural pests and even human insect-borne diseases because of its high activity[8]. In modern agriculture, synthetic organophosphate pesticides are also widely used to control agricultural productivity. Besides, organophosphate is increasing use due to increased adaptation and resistance of pest different types in agriculture[9]. Including insecticide; Malathion is a wide-ranging insecticide in the organophosphate family and therefore is generally been using globally[10].

Nevertheless, for those responsible for pest control, pesticide resistance is an ongoing problem[11]. Therefore, because of the growing challenges associated with the production of insecticide resistance, off-target effects and environmental contamination, it has become increasingly important to develop new insecticides with safe and novel modes of action[12]. In recent years, biopesticides, some of these natural plant products and volatile host fruit compounds have been widely used in plant essential oils and many promising plant-derived substances have been identified as found in laboratory studies[13,14]. Among various species *Cymbopogon citratus* (DC.) Stapf (Poaceae), a species popularly known as "lemongrass", with medicinal properties and is widely used by people in many countries[15]. Specifically when studies have found that insects experience a variety of subtoxic and/or toxic xenobiotics through pesticides and plant defensive compounds in their diets[16].

In nutrition studies, the fruit fly has also been increasingly recognized as a model organism, in response to dietary factors the life span can be systematically calculated in *Drosophila*[17,18]. As both insects have homologous nicotinamide acetylcholine receptors and share highly conserved innate immune systems, *Drosophila melanogaster* is an appropriate organism to model the effects of pesticides on the innate immune system[19]. Furthermore, One of the most useful model systems for investigating the genetic determination of lifespan has been *Drosophila melanogaster*, both by identifying candidate ageing genes through classical genetic approaches and by characterizing the contribution of natural genetic variation to longevity phenotypes, artificial selection responses and natural selection responses[20]. To date, *D. melanogaster* has been a historically important device for investigating longevity's genetic basis and will continue to be of importance as new technologies allow genomic exploration into the biology of ageing, the usefulness of *D. melanogaster* is based on two resources: its powerful genetic instruments as a model system and a natural ecology that provides substantial genetic diversity through significant heterogeneity in the setting[20].

The first experiments studying the effects of environmental interventions on lifespan were carried out at the beginning of the 20th century using the fruit fly *D. melanogaster*[21]. The longevity of organisms is a quantitative attribute defined by both environmental and genetic components; in ageing studies, *D. melanogaster* is commonly used as a model organism. The relatively short life span of *Drosophila* is 60-90 days, which makes it especially attractive for life span studies[22]. In these studies, the ease with which uncertainty can be added can be demonstrated by the significant impacts on fly life caused by very minor changes in diet[23].

The variety and quantity of synthetic pesticides used per hectare are growing worldwide, along with an increase in the area around treated surfaces[24]. Important awareness gaps on environmental fate and unintended consequences of pesticides currently used, however, impede the understanding and mitigation of their global influence on ecological processes[25].

Therefore, we studied the importance of using non-targeted insects of which the most famous is the fruit fly (*Drosophila melanogaster*) in determining the toxicity of some insecticides used in agriculture to a large extent namely insecticides (Deltamethrin and Malathion) and compare by-product natural (lemongrass oil) when using sub-lethal concentrations of studying their effect on the mortality and longevity of insect.

MATERIALS AND METHODS

Study area: The study was carried out at the Department of Biology, Entomology Lab, University of Jeddah, Saudi Arabia, in October, 2020).

***Drosophila melanogaster* strains:** Samples of *Drosophila melanogaster* Meigen, 1930 (Diptera: Drosophilidae) were captured during 2020 at three sites from Southern Jeddah governorate. Samples were collected from adults by entomological nets in greenhouses with crops of Watermelon, during the morning continued to the afternoon on fields. Adult flies were preserved in cartons for preservation reared and transferred laboratory of the biology department of the University of Jeddah, Saudi Arabia.

Experimental materials: Groups of 10 insects have been placed in a 0.5 L beaker 0.3 L of mineral water and Drosophila food (Watermelon and yeast). Were covered by organza to avoid the escape of insects. For each combination of concentrations and classes of insecticides and lemongrass oil, four replicates of 10 insects each was used. Insects were only subjected to mineral water in the control group (0.00 mg L^{-1}). In a constant-temperature incubator at 25±1 °C.

Materials and chemicals used in this study

Deltamethrin (Flotron 2.5% EC): Chemical Flotron 2.5% EC Insecticide.

Chemical name: Deltamethrin, non-systemic pyrethroid insecticide in the form of a concentrated emulsifiable liquid (EC).

Chemical family and properties: Pyrethroid insecticide. Fast-acting affecting contact and through the stomach, used in the elimination of a wide range of insects, including worms and sucking insects, on a large number of crops protected and exposed as well as fruit trees and ornamental plants.

Malathion (Malafos 57% EC): Chemical Malafos 57% EC Insecticide.

Chemical name: Malathion; (O-O-Dimethyl phosphorodithioate of diethyl mercaptosuccinate).

Chemical family and property: Organophosphate Insecticide is an insecticide for the use of organophosphate in a variety of crops, including fruit, vegetables, nuts, palm trees, field and non-agricultural field crops.

Lemongrass oil: Procurement of lemongrass oil the essential oil of lemongrass (*Cymbopogon citratus*) pure lemongrass oil 100% from amazon[15].

Period of experiments

Study groups division: The research experiences were divided into four groups:

- Normally: a not-exposed (control group)
- Group exposed to different concentrations of Deltamethrin (Flotron 2.5% EC)
- Group exposed to different concentrations of Malathion (Malafos 57% EC)
- Group to exposed to different concentrations of lemongrass oil

Determination of the concentrations

Deltamethrin (Flotron 2.5% EC): Based on LC_{50} levels of pesticides, experiment with different concentrations of deltamethrin (0.05, 0.10, 0.21 and 0.53 mg L^{-1})[26] and (1.48 mg L^{-1})[27].

Malathion (Malafos 57% EC): Following the experiment, this experiment, industrial-grade malafos with 57% active ingredient at various concentrations (0.75, 1.00, 1.25, 1.50 and 1.75 mg L^{-1}).

Lemongrass oil: Was used different concentrations of lemongrass oil (0.25, 0.50, 0.75, 1.00 and 1.50 mg L^{-1})[28].

Study of the mortality, lethal concentration 50 (LC_{50}): Determination of the LC_{50} was carried out according to a previously described method[5]. Was assessed after 96 hrs of exposure and the individuals were considered dead when they remained motionless after repeated mechanical stimuli with a pipette tip[29].

Study of the longevity, lethal time 50 (LT_{50}): Determination of the lethal time 50 (LT_{50}), *D. melanogaster* was exposed for the concentration LC_{50}, through a period of varying length of time. The studied period lasted for Recorded through at 12, 24, 48, 72 and 96 hrs. The dead from *D. melanogaster* were removed immediately after death and their numbers registered[30].

Statistical analysis: Percentages of mortality were assessed for each treatment and corrected using Abbott's equation[31]. The lethal time 50 (LT_{50}) was calculated for each group at p = 0.05, LT_{50} was also determined by Probit analysis[32] Ldp line.

RESULTS

The results of the current study, which evaluated the toxicity of five different concentrations (0.75, 1.00, 1.25, 1.50 and 1.75 mg L^{-1}) of Malathion, (Malafos 57% EC) and (0.05, 0.10, 0.21, 0.53 and 1.48 mg L^{-1}) of Deltamethrin (Flotron 2.5% EC) and lemongrass oil (0.25, 0.50, 0.75, 1.00 and 1.50 mg L^{-1}) on the insect of *Drosophila melanogaster* after 96 hrs of treatment. To calculate the concentration at which the highest mortality occurred and death half the number of individuals after 96 hrs, as well as calculating the half-lethal time for individuals. In addition to the group that was not treated with any type of insecticide (control group (0.00 mg L^{-1}) and were fed naturally did not show any type of changes and continued to the end of the experiment and did not get any deaths. While groups exposed to insecticide have the following effects.

Mortality, lethal concentration (LC_{50})

Deltamethrin (Flotron 2.5% EC): The results of the current study evaluated the toxicity of five different concentrations of Deltamethrin (Flotron 2.5% EC) (0.05, 0.10, 0.21, 0.53 and 1.48 mg L^{-1}) on the insect of *D. melanogaster* after 96 hrs of treatment. The obtained results in Deltamethrin, the observed response rate was 10-35% at the concentration of 0.05 and 1.48 mg L^{-1} respectively, while the linear response rate was the lowest at the concentration of 0.05 mg L^{-1}, the highest percentage of 38.1793% at concentration 1.48 mg L^{-1}. The linear probity range ranged from 3.8432-4.6992 at the concentration of 0.05 and 1.48 mg L^{-1}, respectively, as shown in Table 1. The slope of the regression line (0.5818+/-0.1215). The Chi values of the data and their tabular values were calculated and the value of Chi (computed) (3.0399) and tabular (7.8) were found at freedom scores (n-2). As a strong relationship between the concentration and the death rate (r) Correlation coefficients were (0.9471), Table 1. The concentration LC_{25} = 0.3373 mg L^{-1} resulted in 25% death, whereas LC_{50} = 4.8673 mg L^{-1} in the death of 50%. The highest death rate and 99% death at a concentration (LC_{95} = 3269.365 mg L^{-1}). The regression line, which represents the relationship between the death ratios of the *D. melanogaster* and the concentrations of the Deltamethrin was plotted. From the Ldp line as shown in Fig. 1.

Malathion, (Malafos 57% EC): The findings of the current study measured the toxicity of five different Malathion (Malafos 57% EC) concentrations (0.75, 1.00, 1.25, 1.50 and 1.75 mg L^{-1}) after 96 hrs of treatment in *D. melanogaster* insects. The response rate observed for the results obtained in Malathion was 1-20% at a concentration of 0.75 and 1.75 mg L^{-1} respectively. Although the linear response rate was lowest at 0.75 mg L^{-1} concentration, the highest percentage at 1.75 mg L^{-1} concentration was 20.1948%. At a concentration of 0.75 and 1.75 mg L^{-1} respectively, the linear probity range ranged from 2.8007-41653, Table 2. Regression line slope (3.709+/-0.7749). The Chi values of the data and their tabular values were determined and the Chi (computed) (0.339) and tabular (7.8) values of the freedom scores were

Table 1: Mortality of an insect of the *Drosophila melanogaster* after 96 hrs of exposure to different concentrations of Deltamethrin (Flotron 2.5% EC)

Concentration	Concentration *10	Log (concentration *10)	Treated	Observed response (%)	Linear response (%)	Linear probit
0	0	0	100	0	0	0
0.05	5	0.699	100	10	12.3738	3.8432
0.1	10	1	100	15	16.3176	4.0183
0.21	21	1.3222	100	27	21.3555	4.2058
0.53	53	1.7243	100	30	28.7656	4.4397
1.48	148	2.1703	100	35	38.1793	4.6992
Slope		0.5818			+/-0.1215	
Chi		3.0399			Tabulated 7.8	
p		0.3855				
h		1.0133				
g		0.1676				
r		0.9471			Tabulated 0.878	

Chi-Square (Chiinv) (Chi), probability (p), harmonic mean (h), logarithmic (g), correlation coefficients (r)

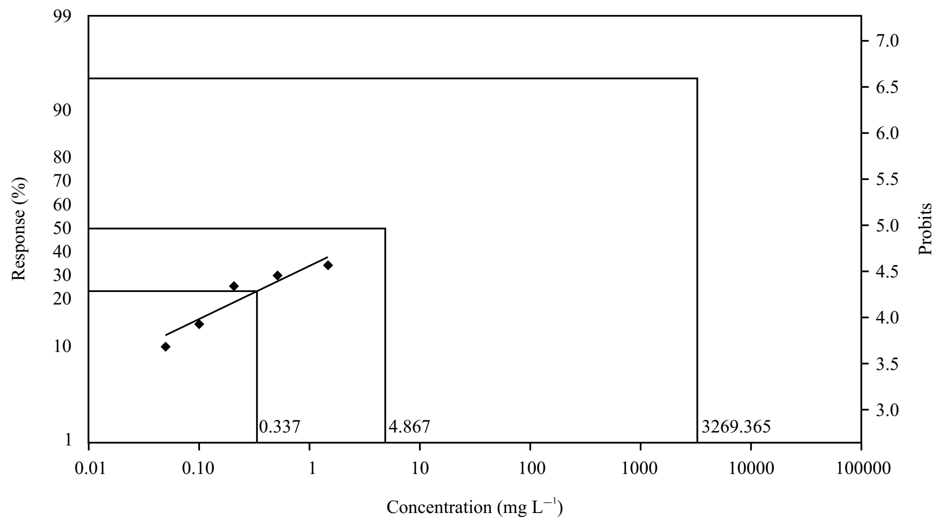

Fig. 1: Lethal concentration ($LC_{25,50,95}$) values are shown when *a Drosophila melanogaster* exposed 96 hrs after exposure to different concentrations of Deltamethrin (Flotron 2.5% EC)

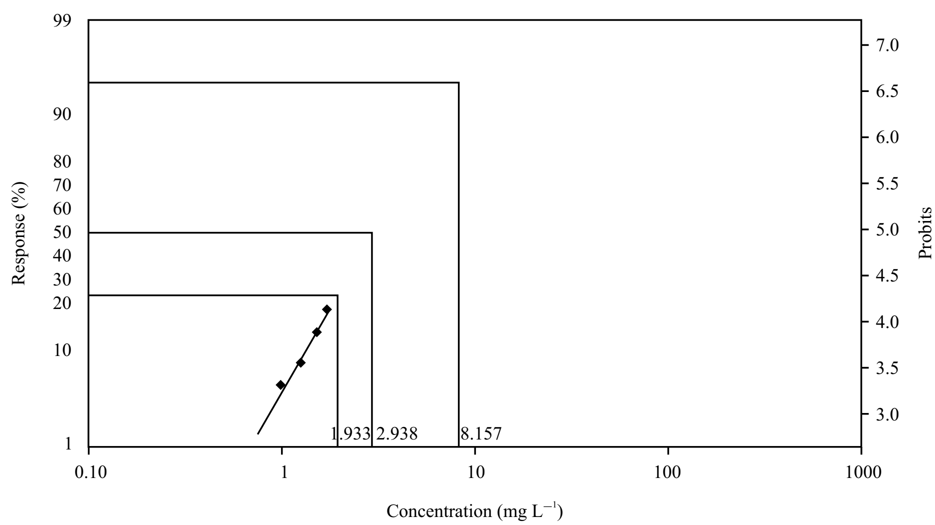

Fig. 2: Lethal concentration ($LC_{25,50,95}$) values are shown when a *Drosophila melanogaster* exposed 96 hrs after exposure to different concentrations of Malathion, (Malafos 57% EC)

found (n-2). Correlation coefficients were (0.992) as a clear correlation between concentration and death risk (r), Table 2. The LC_{25} = 1.9329 mg L^{-1} concentration resulted in a 25% death, while LC_{50} = 2.938 mg L^{-1} resulted in a 50% death. The highest death rate and a concentration of 99% death (LC_{95} = 8.1571 mg L^{-1}). A regression line was plotted, which reflects the relationship between the *D. melanogaster* death ratios and the Malathion concentrations. A figure, from the Ldp line, Fig. 2.

Lemongrass oil: The results of this study examined the effect after 96 hrs of treatment of five different concentrations of lemongrass oil (0.25, 0.50, 0.75, 1.00 and 1.50 mg L^{-1}) on *D. melanogaster* insects. And so, for mortality to be determined at (LC_{50}). The response rate observed for the results obtained in lemongrass oil was 3-17% at concentrations of 0.25 and 1.5 mg L^{-1} respectively, that although the linear response rate was the minimum at 0.25 mg L^{-1} concentration, the maximum value was 15.9527% at 1.5 mg L^{-1} concentration. At concentrations of 0.25 and 1.5 mg L^{-1}, the linear probity range ranged from 3.0495-4.0035, respectively, Table 3. The slope of the regression line (1.226+/-0.3480). The Chi values of the data and their tabular values were determined and the Chi (computed) (0.4345) and

Table 2: Mortality of an insect of the *Drosophila melanogaster* after 96 hrs of exposure to different concentrations of Malathion, (Malafos 57% EC)

Concentration	Concentration *10	Log (concentration *10)	Treated	Observed response (%)	Linear response (%)	Linear probit
0	0	0	100	0	0	0
0.75	7.5	0.8751	100	1	1.46588	2.8007
1	10	1	100	5	4.13856	3.264
1.25	12.5	1.0969	100	8	8.44261	3.6234
1.5	15	1.1761	100	14	13.944	3.9171
1.75	17.5	1.243	100	20	20.1948	4.1653
Slope			3.709			+/-0.7749
Chi			0.339			Tabulated 7.8
p			0.9525			
h			0.113			
g			0.1677			
r			0.992			Tabulated 0.878

Chi-Square (Chiinv) (Chi), probability (p), harmonic mean (h), logarithmic (g), correlation coefficients (r)

Table 3: Mortality of an insect of the *Drosophila melanogaster* after 96 hrs of exposure to different concentrations of lemongrass oil

Concentration	Concentration *10	Log (concentration *10)	Treated	Observed response (%)	Linear response (%)	Linear probit
0	0	0	100	0	0	0
0.25	2.5	0.3979	100	3	2.5967	3.0495
0.5	5	0.699	100	5	5.70488	3.4186
0.75	7.5	0.8751	100	9	8.61586	3.6345
1	10	1	100	10	11.2741	3.7876
1.5	15	1.1761	100	17	15.9527	4.0035
Slope			1.226			+/-0.3480
Chi			0.4345			Tabulated 7.8
p			0.933			
h			0.1448			
g			0.3095			
r			0.9849			Tabulated 0.878

Chi-Square (Chiinv) (Chi), probability (p), harmonic mean (h), logarithmic (g), correlation coefficients (r)

Table 4: Comparison of the LC_{50} mortality rate of the effect of Deltamethrin, Malathion and Lemongrass oil on the *Drosophila melanogaster* after 96 hrs of exposure

Line name	Lower limit	Upper limit	1	2	3	Index	RR	Slope	Slope +/-	LC_{25}	LC_{50}	LC_{90}
Malathion, (Malafos 57% EC)	2.323	5.038	*	*	*	100	1	3.709	0.775	1.933	2.938	6.51
Deltamethrin (Flotron 2.5% EC)	1.948	37.686	*	*	*	60.366	1.657	0.582	0.122	0.337	4.867	776.321
Lemongrass oil	3.913	220.662	*	*	*	30.14	3.318	1.226	0.348	2.746	9.748	108.213

Index compared with Malathion, (Malafos 57% EC), Resistance Ratio (RR) compared with Malathion, (Malafos 57% EC), Resistance Ratio (RR), Lethal concentration to kill 25% of the individuals (LC_{25}) (mg L^{-1}), Lethal concentration to kill 50% of the individuals (LC_{50}) (mg L^{-1}), Lethal concentration to kill 90% of the individuals (LC_{90}) (mg L^{-1})

tabular (7.8) values of the freedom scores were found (n-2). Correlation coefficients were (0.878) as a good correlation between concentration and death risk (r) Table 3. The concentration LC_{25} = 2.7462 mg L^{-1} resulted in 25% death, whereas LC_{50} = 9.7478 mg L^{-1} in the death of 50%. The highest death rate and 99% death at a concentration (LC_{95} = 214.0999 mg L^{-1}). The line of regression that reflects the relationship between the *D. melanogaster* death ratios and the concentrations of the Malathion was plotted. From the Ldp line, Fig. 3.

Comparison LC_{50}: Comparison of the effects of Deltamethrin (Flotron 2.5% EC), Malathion (Malafos 57% EC) and Lemongrass oil on the *D. melanogaster*. According to the mortality LC_{50}: The results of the current study show that Malathion, (Malafos 57% EC) has a stronger effect in the elimination and mortality of *D. melanogaster* where the LC_{50} reached 2.938 mg L^{-1} to kill half of the individuals after 96 hrs, compared to Deltamethrin (Flotron 2.5% EC), where the concentration of (2.938 mg L^{-1}) of Malathion leads to kills half of individuals compared to Deltamethrin a higher concentration of 4.867 mg L^{-1} that leads to killing half of the individuals. While lemongrass oil requires a higher concentration when at (9.748 mg L^{-1}) were to kill half of the individuals at 96 hours, Table 4, Fig. 4.

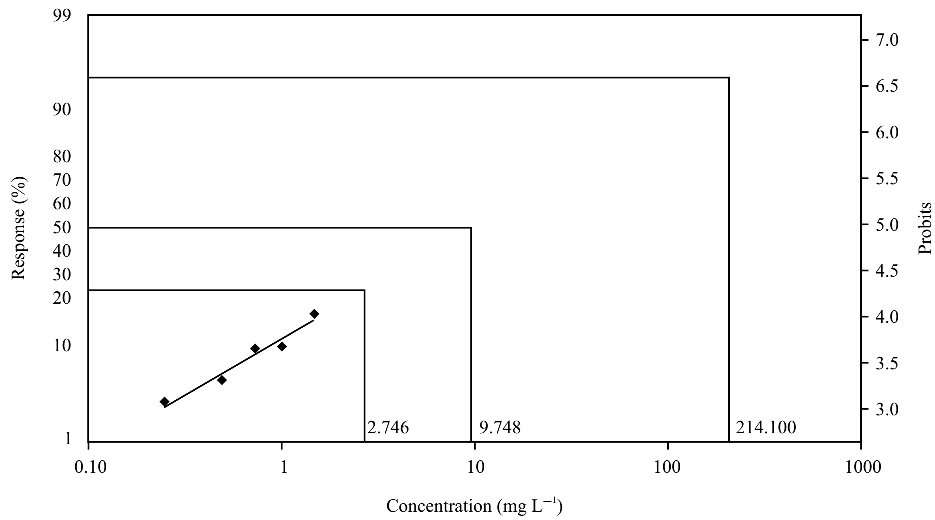

Fig. 3: Lethal concentration ($LC_{25,50,99}$) values are shown when a *Drosophila melanogaster* exposed 96 hrs after exposure to different concentrations of lemongrass oil

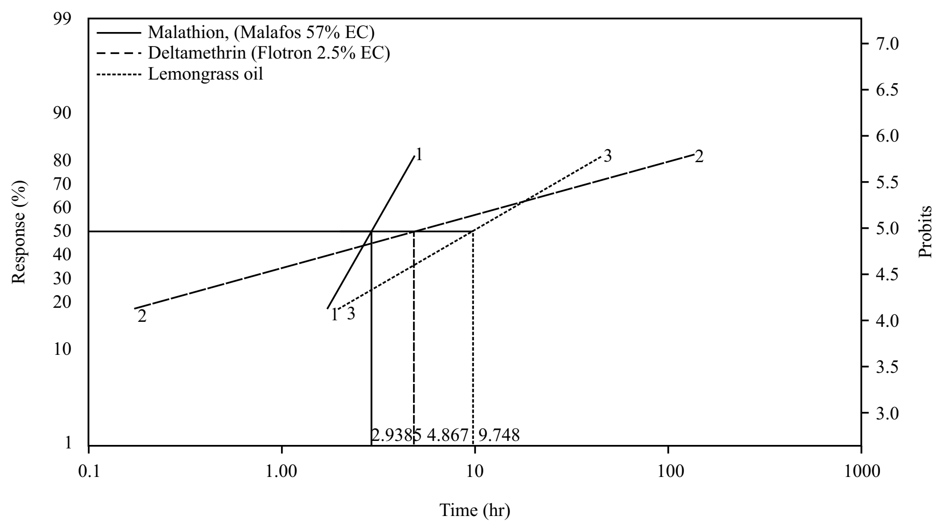

Fig. 4: Lethal concentration (LC_{50}) Comparison of the LC_{50} mortality rate of the effect of Deltamethrin, Malathion and Lemongrass oil on the *Drosophila melanogaster* after 96 hrs of exposure

Longevity, Lethal time (LT_{50}): The results of the current study, which evaluated the toxicity of Effects of some insecticides (Deltamethrin and Malathion) and lemongrass oil on Fruit Fly (*D. melanogaster*) in different concentrations. Where the Lethal half concentration (LC_{50}) was used Malathion, Deltamethrin and lemongrass oil after 12, 24, 48, 72 and 96 hrs of treatment. To calculate the time half-lethal time for individuals. The group that was not treated with any type of insecticide (control group (0.00 mg L^{-1}) and were fed naturally did not show any type of changes and continued to the end of the experiment and did not get any deaths. While groups exposed to insecticide have affected the following effects.

Deltamethrin (Flotron 2.5% EC): From the results of the current analysis, it is obvious that when half of the lethal concentration (LC_{50}) of Deltamethrin was used, half of the number of individuals (mortality) (50%) of *D. melanogaster* were exposed to this insecticide concentration (LC_{50} = 4.8673 mg L^{-1}) and its follow-up during periods (12, 24, 48, 72, 96 hrs) was killed. And then measure the lethal half-time LT_{50}, which for individuals has the highest death rate. The results obtained from Table 5 indicate that the response rate observed varied between 10 and 29% at 12 and 96 hrs, respectively. It is less valuable at 12 hrs and the maximum ratio is 25.7355% at 96 hrs. The linear response rate was

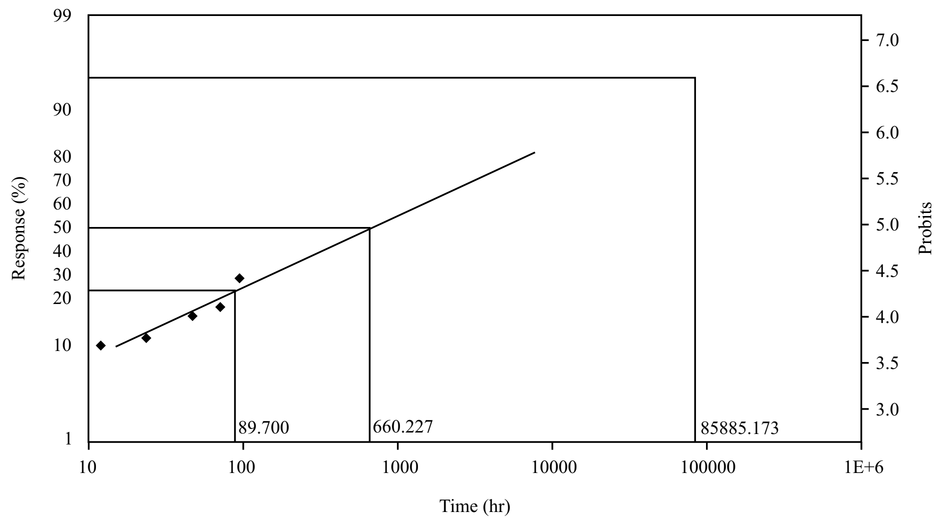

Fig. 5: Lethal time ($LT_{25,50,95}$) values when *Drosophila melanogaster* is exposed to LC50 concentration of Deltamethrin (Flotron 2.5% EC) after 96 hrs of exposure

Table 5: Percentage of Lethal Time (LT) of *Drosophila melanogaster* 96 hrs after exposure to the half-lethal concentration (LC_{50}) of Deltamethrin (Flotron 2.5% EC)

Time (hrs)	Log (Time * 1)	Treated	Observed response (%)	Linear response (%)	Linear probit
12	1.0792	100	10	8.79191	3.6458
24	1.3802	100	12	13.1388	3.88
48	1.6812	100	18	18.789	4.1142
72	1.8573	100	20	22.7005	4.2512
96	1.9823	100	29	25.7355	4.3485
Slope		0.778			+/-0.2156
Chi		1.3188			Tabulated 7.8
p		0.7247			
h		0.4396			
g		0.295			
r		0.9583			Tabulated 0.878

Chi-Square (Chiinv) (Chi), probability(p), harmonic mean (h), logarithmic (g), correlation coefficients (r)

8.79191%. In Table 5 during 12 and 96 hrs, respectively, the linear probity ranged from 3.6458-43485. The slope (0.778+/-0.2156) of the regression line was determined. Also measured were the Chi values of the data and their tabular value and the calculated Chi value (1.3188) and the scale (7.8) were found at the freedom ratings (n-2). The table also shows that the concentration and death rate correlation coefficients are closely related (0.9583), Table 5. From the results of the current analysis, it is obvious that the Lethal Period Confidence Limits ($LT_{25,50,95}$) on *D. melanogaster* was exposed to Deltamethrin LC_{50} concentration (Flotron 2.5% EC) after 96 hours of exposure and the LT time was estimated at 25, 50 and 95%) and the confidence limits were calculated Fig. 5.

Malathion, (Malafos 57% EC): Lethal Time (LT_{50}): In the current study, Lethal concentration (LC_{50}) was calculated from a Malathion which death half the number of individuals (mortality) (50%) of *D. melanogaster* after 96 hrs, ($LC_{50} = 2.938$ mg L^{-1}). It was exposed to this concentration of the insecticide and its follow-up during specific periods (12, 24, 48, 72, 96 hrs). And then calculate the lethal half-time LT_{50} which has the highest death rate for individuals. The results obtained from Table 6 show that the observed response rate ranged from 5-32% at 12 and 96 hrs, respectively. The linear response rate was 4.30916% at 12 hrs It is less valuable and the highest ratio is 26.3754% at 96 hrs. Linear probity ranged from 3.282-4.3682 between 12 and 96 hrs, respectively in Table 6. The slope of the regression line was calculated (1.2027+/-0.2447). The Chi values of the data and their tabular value were also calculated and the calculated Chi value (3.7689) and the scale (7.8) were found at freedom scores (n-2). The table also shows that there is a strong relationship between concentration and death rate Correlation coefficients (0.9487) and tabular scales (0.878), Table 6. It is evident from the results of the current study that the confidence limits of

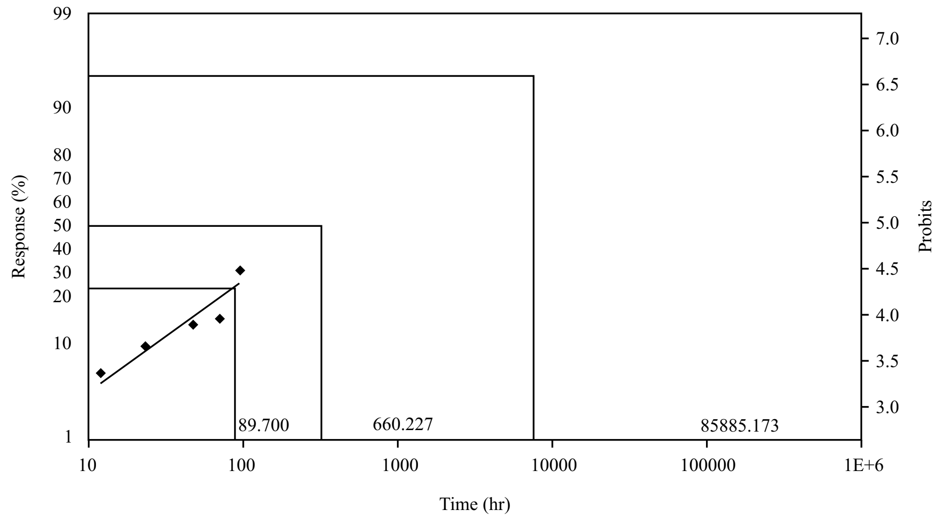

Fig. 6: Lethal time (LT $LT_{25,50,95}$) values when *Drosophila melanogaster* is exposed to LC_{50} concentration of Malathion, (Malafos 57% EC) after 96 hrs of exposure

Table 6: Percentage of Lethal Time (LT) of *Drosophila melanogaster* 96 hrs after exposure to the half-lethal concentration (LC_{50}) of Malathion, (Malafos 57% EC)

Time (hrs)	Log (Time * 1)	Treated	Observed response (%)	Linear response (%)	Linear probit
12	1.0792	100	5	4.30916	3.282
24	1.3802	100	9	8.76391	3.644
48	1.6812	100	15	16.0129	4.006
72	1.8573	100	16	21.7078	4.2178
96	1.9823	100	32	26.3754	4.3682
Slope		1.2027			+/-0.2447
Chi		3.7689			Tabulated 7.8
p		0.2875			
h		1.2563			
g		0.159			
r		0.9487			Tabulated 0.878

Chi-Square (Chiinv) (Chi), probability (p), harmonic mean (h), logarithmic(g), correlation coefficients (r)

the Lethal time values ($LT_{25,50,95}$) on the *D. melanogaster* are exposed to LC_{50} concentration of exposed to LC_{50} concentration of Malathion, (Malafos 57% EC) (LC_{50} = 2.938 mg L^{-1}) after 96 hrs of exposure and LT time was calculated at 25, 50 and 95%) and the confidence limits have, Fig. 6.

Lemongrass oil: In the current results, the lethal concentration (LC_{50}) of lemongrass oil was estimated to kill half the number of *D. melanogaster* individuals (mortality) (50%) after 96 hrs (LC_{50} = 9,7478 mg L^{-1}). It was exposed during unique periods (12, 24, 48, 72, 96) hrs to this concentration of lemongrass oil and its follow-up. And then measure the lethal half-time LT50, which for individuals has the highest death rate. The results obtained from Table 7 indicate that the response rate observed varied between 3 and 16% at 12 and 96 hrs, respectively. It is less valuable and the maximum ratio is 16.997% at 96 hrs, with a linear response rate of 3.00876% at 12 hrs. In Table 7 during the 12 and 96 hrs, the linear probity ranged from 3.1203-4.0457, respectively. There was a measure of the regression line slope (1.0246+/-0.2741). Also measured were the Chi values of the data and their tabular value and the calculated Chi value (0.4924) and the scale (7.8) were found at the liberty ratings (n-2). The table also shows that the concentration and death rate correlation coefficients are closely related (0.9878) and tabular scales (0.878) Table 7. The confidence limits of the LT_{50} value and LT time were calculated at 25,50 and 95%) and the confidence limits have, Fig. 7.

Comparison LT_{50}: The results of the current study show that the Malathion pesticide takes less time (321.862 hrs) to destroy and kill the *D. melanogaster* population by using the half-lethal concentration of it, according to longevity and the lethal half-time LT_{50}. Although Deltamethrin takes about 660,277 hrs to kill half of the individuals, compared to Lemongrass oil, which takes about 819,745 hrs to kill half of the individuals, it is considered to be the longest time possible to kill half of the individuals, Table 8, Fig. 8.

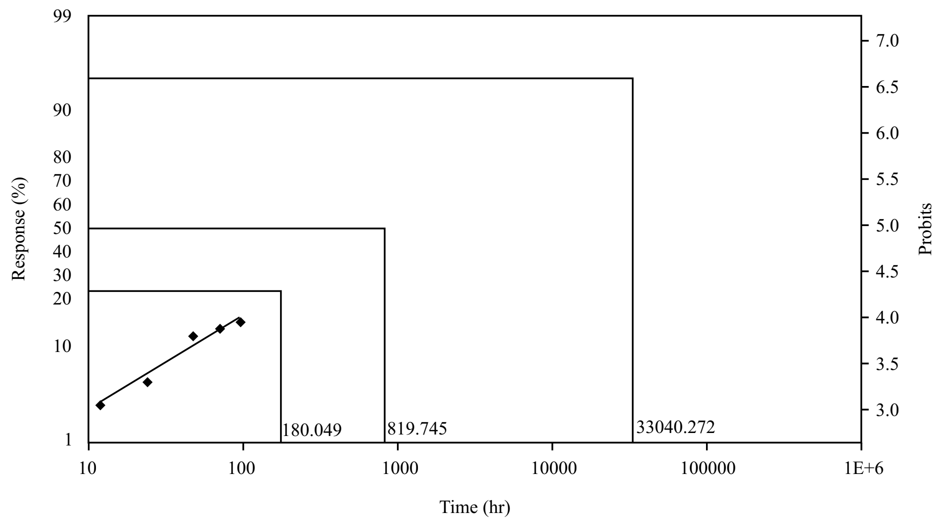

Fig. 7: Lethal time ($LT_{25,50,95}$) values when *Drosophila melanogaster* is exposed to LC_{50} concentration of lemongrass oil after 96 hrs of exposure

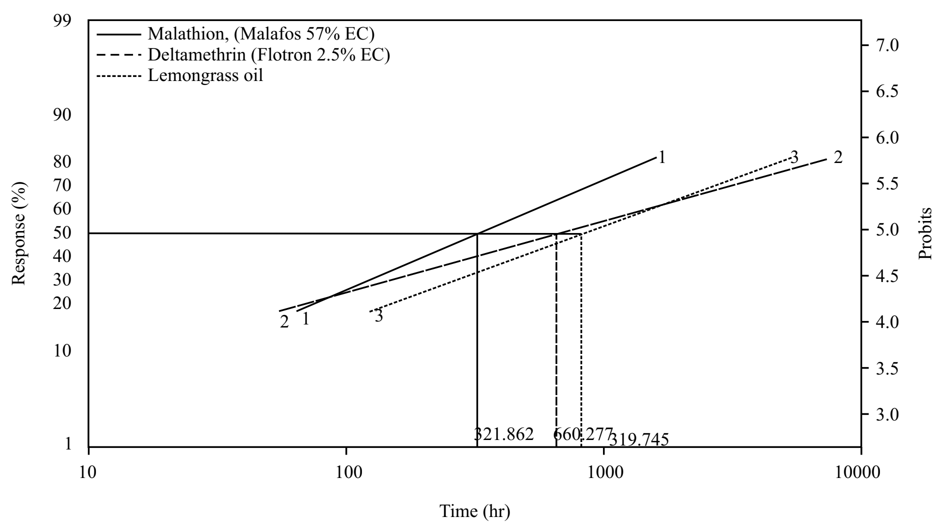

Fig. 8: Lethal concentration (LT_{50}) Comparison of the LC_{50} mortality rate of the effect of Deltamethrin, Malathion and Lemongrass oil on the *Drosophila melanogaster* after 96 hrs of exposure

Table 7: Percentage of Lethal Time (LT) of *Drosophila melanogaster* 96 hrs after exposure to the half-lethal concentration (LC_{50}) of lemongrass oil

Time (hrs)	Log (Time * 1)	Treated	Observed response (%)	Linear response (%)	Linear probit
12	1.0792	100	3	3.00876	3.1203
24	1.3802	100	5	5.81742	3.4288
48	1.6812	100	12	10.3404	3.7372
72	1.8573	100	14	13.9544	3.9176
96	1.9823	100	16	16.997	4.0457
Slope		1.0246			+/-0.2741
Chi		0.4924			Tabulated 7.8
p		0.9206			
h		0.1641			
g		0.2749			
r		0.9878			Tabulated 0.878

Chi-Square (Chiinv) (Chi), probability (p), harmonic mean (h), logarithmic (g), correlation coefficients (r)

Table 8: Comparison of the half-lethal time of (LT_{50}) for the effect of Deltamethrin (Flotron 2.5% EC), Malathion (Malafos 57% EC) and Lemongrass oil on the *Drosophila melanogaster* after 96 hrs of exposure

Line name	Lower limit	Upper limit	1	2	3	Index	RR	Slope	Slope +/-	LT_{25}	LT_{50}	LT_{90}
Malathion, (Malafos 57% EC)	180.904	1157.029	*	*	*	100	1	1.203	0.245	88.478	321.862	3743.66
Deltamethrin (Flotron 2.5% EC)	244.483	16779.57	*	*	*	48.747	2.051	0.778	0.216	89.7	660.277	29306.79
Lemongrass oil	302.206	18343.06	*	*	*	39.264	2.547	1.025	0.274	180.049	819.745	14604.12

Index compared with Malathion, (Malafos 57% EC), Resistance Ratio (RR) compared with Malathion, (Malafos 57% EC) Resistance Ratio (RR), Lethal time to kill 25% of the individuals (LC_{25}) (mg L^{-1}), Lethal time to kill 50% of the individuals(LC_{50}) (mg L^{-1}), Lethal time to kill 90% of the individuals (LC_{90}) 3 (mg L^{-1})

DISCUSSION

Insecticides owing to their variable effectiveness against crop pests and their possible effects on organisms, insecticide treatments are under investigation in the agroecosystems and can be indicators of the effect of the ecosystem. This study tested for effects of exposure to Deltamethrin and Malathion and natural products, including lemongrass oil on Fruit Fly (*D. melanogaster*) can prove an ideal model organism for pesticide risk assessment and toxicological classification, since it has striking similarities to different processes in the human body[33]. For some time, it becomes stands out as an ideal in vivo model organism for cytotoxicity evaluation, has attracted serious scholarly interest and acquired recognition in various fields of biological and medical science[33]. From the current study, it was found in the group that was not treated with any type of insecticide (control group) and were fed naturally did not show any type of changes and continued to the end of the experiment and did not get any deaths, this is similar to what was observed by Penn[34] when the ants were exposed to pesticides significantly suffered more intoxication and mortality from treated with fungicide plus imidacloprid compared to the control that had more effective normally functioning individuals than did those exposed to either of the treatments.

The present study was designed to determine the effect of survival and corrected mortality of adults of *D. melanogaster* after 96 hrs of exposure to insecticide differed insecticides. The results of this study showed that to Deltamethrin, the concentration LC_{25} = 0.3373 mg L^{-1} resulted in 25% death, whereas LC_{50} = 4.8673 mg L^{-1} in the death of 50%. The highest death rate and 99% death at a concentration (LC_{99} = 48486.39 mg L^{-1}). The regression line, which represents the relationship between the death ratios of the *D. melanogaster* and the concentrations of the Deltamethrin was plotted. Reference to previous research, the chemical composition of the active toxin, including the class of pesticides, the degree of exposure, the period of selection, the genetic variation of the target species and probably other biotic and abiotic factors, may also play a role in the development of resistance, most of the researchers have documented that insect susceptibility to insecticides is dependent upon dosage, exposure route and species[8-29]. From the current study, it was found Deltamethrin (Flotron 2.5% EC), the concentration of (4.867 mg L^{-1}) where leads to kills half of individuals, was of moderate toxicity. And in contrast, in a study, that by Gutiérrez *et al.*[29] the toxicity of deltamethrin (a type II pyrethroid insecticide stressor) and the swimming activity of *Buenoa tarsalis* and *Martarega bento* backswimmers have been measured. Bioassays of concentration-mortality and survival were performed with the insecticide, relative to controls without deltamethrin. For B, deltamethrin was 26 times more toxic.

They Gutiérrez *et al.*[29] found that deltamethrin survived approximately 80% of adult *B. Tarsalis* that were not exposed to deltamethrin during the three-day bioassays, while for adults exposed to the lowest concentration (0.5 ng a.i. L^{-1}), survival was approximately 70%. Survival rates of B. for treatments of 2.5 and 5 ng a.i. L^{-1}. *B. tarsalis* was roughly 50 and 40%, respectively. Deltamethrin concentrations greater than 50 ng a.i. L^{-1} resulted in 100% B mortality. Tarsal adults under 48 hrs at exposure times. In general, the median survival times of *B. tarsalis* and *M. bentoi* were lower when exposed to higher concentrations of deltamethrin than when exposed to lower concentrations. Because of the typical laboratory tests for deltamethrin using concentrations around 10 μg L^{-1} [35] and in aquatic environments, the concentrations of deltamethrin used in the present study are realistic. However, such conclusions should be analyzed with caution, based on deltamethrin toxicity. Research by Al-Fayyadh[36] showed that *D. melanogaster* Meigen, 1830 (Diptera, Drosophilidae) as a model organism was investigated using Spiromesifen (Oberon® 240 SC), a pesticide commonly used to manage pests such as mites and whiteflies. The compound was applied topically to freshly molten pupae at two concentrations (LC_{10}:21.45 and LC_{25}: 39.53 μg active ingredient/pupa) and tested for morphometric measurements of ovaries and surviving adult progeny. Results showed that spiromesifen inhibited ovary growth and development, reducing the number of oocytes, basal oocyte volume and ovarian weight at the maximum dose (LC_{25}).

On the other hand, we found in the current study, it was found Malathion, (Malafos 57% EC) has a stronger effect in the elimination and mortality of *D. melanogaster* where the LC_{50} reached 2.938 mg L^{-1} to kill half of the individuals after 96 hrs, compared to Deltamethrin (Flotron 2.5% EC), where the concentration of 2.938 mg L^{-1} of Malathion leads to kills half of individuals compared to Deltamethrin a higher concentration of 4.867 mg L^{-1} that leads to killing half of the individuals. This is consistent with the study conducted by Osman[30] when LC_{50} of Malafos 57 EC is calculated and the effects of acute malafos toxicity on behavioural and certain haematological parameters of *Oreochromis niloticus* freshwater fish are investigated, it has been found that malafos induces alterations in blood parameters. There is a substantial decrease in red (RBCs), haemoglobin (Hb) and hematocrit (Ht%) whereas White Blood Cells (WBCs) display an increase in their amount. A recent study by Aljedani *et al.*[37] that the use of insecticides affects the safety of the forager's honeybee workers, a result of that study has shown that the midgut cells affected by insecticides and clear effects depending on the insecticide used malathion was a clear effect on epithelial cells of midgut.

This study produced results that corroborate the lemongrass oil requires a higher concentration when at (9.748 mg L^{-1}) were to kill half of the individuals at 96 hrs, it is considered the least toxic. This is consistent with the study conducted by Eben *et al.*[13] when 17 volatile plant compounds from different chemical groups were examined for contact toxicity, feeding modification and oviposition repellence on *Drosophila suzukii* (Diptera: Drosophilidae), they were evaluated after 1, 4 and 24 hrs after contact with treated surfaces; Cinnamon oil and its components had the highest contact toxicity with an LC_{90} = 2-3%, whereas lemongrass oil, its main components, were less toxic (LC_{90} = 7-9%). The findings of the current study are consistent with those of Aiemsaard *et al.*[38] when they investigated the antibacterial activity of lemongrass, against subclinical mastitis bacterial isolates from dairy goats, the results of that study showed that lemongrass essential oil has the potential to be developed as an antibacterial agent or teat dip formula for the control of subclinical mastitis in goats.

It is interesting through the results of the current study, we can find that Malathion(Malafos 57% EC) was the most toxic, followed by Deltamethrin (Flotron 2.5% EC), while was Lemongrass oil the least toxic on the *D. melanogaster* according to the mortality LC_{50}.

The current study, which evaluated the toxicity of the effects of some insecticides (Deltamethrin and Malathion) and lemongrass oil on Fruit Fly (*D. melanogaster*) in different concentrations. Where the Lethal half concentration (LC_{50}) was used Malathion, Deltamethrin and lemongrass oil after 12, 24, 48, 72 and 96 hrs of treatment. To calculate the time half-lethal time for individuals. The group that was not treated with any type of insecticide (control group (0.00 mg L^{-1}) and were fed naturally did not show any type of changes and continued to the end of the experiment and did not get any deaths. From the current study, according to longevity and the lethal half time LT_{50}, the results of our study show that the Malathion pesticide needs less time (321.862 hrs) to eliminate and death of the *D. melanogaster* population when using the half-lethal concentration of it. Followed by Deltamethrin which takes approximately 660.277 hrs to kill half of the individuals.

And in a study by Blibech *et al.*[39] they the effect of deltamethrin on pupae of *Trichogramma oleae* (Voegele and Poitale), T. *cacoeciae* and *T. bourarachae* Pintureau and Babault persisted for 30 days following exposure. Moreover, showed Malbert-Colas *et al.*[40] that a given concentration of deltamethrin has different effects on the pest moth *Spodoptera littoralis*, when used low concentrations of it and two experimental concentrations led to very high mortality early in *S. littoralis* development (4th larval instar), but only to low mortality rates in adults.

The results of the current study show that Malathion can cause serious to a healthy status on *D. melanogaster*. This is consistent with the study conducted by reported a lower 96 hrs LC_{50} value (1.06 mg L^{-1}) for *O. niloticus*. Malathion was toxic to *Labeo rohita* (LC_{50} value 4.5 μg L^{-1})[41] and *C. gariepinus* (LC_{50} 8.22 mg L^{-1}) as recorded by Ahmad[42]. Malathion is used excessively to protect crops which eventually affect the aquatic ecosystem including fishes. Malathion gets oxidized to malaoxon by cytochrome p 450 enzymes and it is considered to be more toxic than the main compound[43]. Furthermore, the primary site of action of malathion is the central and peripheral nervous systems because they inhibit Acetylcholinesterase[44]. Nevertheless, resistance to insecticides can occur through various mechanisms, including target site insensitivity, decreased penetration and sequestration, as well as detoxification enzymes and transporters through phase changes I, II, or III[45-46].

Another important finding was that, when compared the effect of deltamethrin and Malathion on Fruit Fly (*D. melanogaster*) in different concentrations of theirs, we found the Lemongrass oil takes approximately 819.745 hrs to kill half of the individuals, it is considered the longest period required to kill half of the individuals, but it was the least toxic. This agrees on whit the study by Aiemsaard *et al.*[38] when they study effected of Lemongrass essential oil at concentrations of 0.75-1.5% v/v on bacteria reduced survival of it's in the time-kill assay by 99.90-99.99% within 30 min. In a study by they found the concentration of essential oil and contact time was increased, the antibacterial effect also increased. This is consistent with the report of Chamdit and Siripermpool[47], who studied the effect of lemongrass and clove essential oils against *S. aureus* ATCC43300. And therefore, lemongrass is effective for eliminating many pests even if it takes some time.

Many studies have reported that the age of the insects may be affected by many factors, a study conducted by Pearl[48] it was found that *Drosophila*, kept at lower temperatures, lived longer. Since the metabolic rate in poikilotherms is dictated by the ambient temperature, suggested that organisms have a genetically predetermined amount of energy to expend over a lifetime and that the lifespan will therefore be determined by the rate of their expenditure. *D. melanogaster* 's laboratory lifetime, on the other hand, is on the order of eight weeks and is extremely resistant to manipulations such as induced mutations or artificial selection regimes. Long-lived strains can demonstrate twice the lifespan of short-lived strains[20]. However, even with the use of short-lived model organisms for relatively rapid lifespan studies, this is likely to be partially due to the difficulty of physiology involved in deciding the length of life, but perhaps also partly due to technical difficulties in experimental design hampering a consistent direction of development[49].

Data on the intake of foods rich in fruits and vegetables show that diets are a significant determinant of health and disease prevention[50]. The traditional Asian and Mediterranean diets are abundant in vegetables and fruits[51]. In the safe production of agricultural products, food safety must be preserved from pests as well as pesticide residues, so the best solution is to go towards using natural products that have proven effective in eliminating pests and at the same time environmentally friendly.

CONCLUSION

From the current study, it can be concluded that natural products can be used to control insect pests and should be the use of synthetic chemicals is limited due to environmental concerns. So, in the present study, an effect was tested of different concentrations of insecticides such as (Deltamethrin and Malathion) and natural products, Including, lemongrass oil on Fruit Fly (*D. melanogaster*). From the results of this study, when calculating the concentration LC_{50} after 96 hrs, at which the highest mortality occurred at Malathion more than Deltamethrin. While, when calculating the half-lethal time for individuals LT_{50}, Deltamethrin took less time to eliminate a Fruit Fly comparing with Malathion. Lemongrass oil has proven effective in eliminating Fruit Fly had an effective role in biological control. A further study in the future with more focus on using natural products to combat insect pests is therefore suggested.

SIGNIFICANCE STATEMENT

This study discovers that lemongrass oil and its components that can be beneficial for eliminating *Drosophila melanogaster*, can be considered an environmentally friendly pesticide. This study will help the researcher to uncover the critical areas of efforts that are placed into the hunt for alternative substances relevant to the insect's pest control that many researchers were not able to explore. Thus, could be useful in the development of more effective natural compounds as alternatives to synthetic pesticides.

REFERENCES

1. Saha, A., R.K. Ghosh, P.K. Jesna and P.P. Choudhury, 2021. Bioindicators of Pesticide Contaminations. In: Sustainable Agriculture Reviews 48: Pesticide Occurrence, Analysis and Remediation Vol. 2 Analysis. Inamuddin, M.I. Ahamed and E. Lichtfouse (Eds.)., Springer International Publishing, New York, pp: 185–231,.
2. Bass, L. and K. Alston, 2018. Black masculine caring and the dilemma faced by black male leaders. J. Sch. Leadersh., 28: 772-787.
3. de Oliveira Marques, P.R.B., G.S. Nunes, T.C.R. dos Santos, S. Andreescu and J.L. Marty, 2004. Comparative investigation between acetylcholinesterase obtained from commercial sources and genetically modified *Drosophila melanogaster*. Biosens. Bioelectron., 20: 825-832.
4. Dawson, A.H., M. Eddleston, L. Senarathna, F. Mohamed and I. Gawarammana *et al*., 2010. Acute human lethal toxicity of agricultural pesticides: A prospective cohort study. PLoS med., Vol. 7. 10.1371/journal.pmed.1000357.
5. Korkmaz, V., A. Güngördü and M. Ozmen, 2018. Comparative evaluation of toxicological effects and recovery patterns in zebrafish (*Danio rerio*) after exposure to phosalone-based and cypermethrin-based pesticides. Ecotoxicol. Environ. Saf., 160: 265-272.
6. Borsuah, J.F., T.L. Messer, D.D. Snow, S.D. Comfort and A.R. Mittelstet, 2020. Literature review: Global neonicotinoid insecticide occurrence in aquatic environments. Water, 12: 1-17.
7. Aylward, L.L., C.R. Kirman, R. Schoeny, C.J. Portier and S.M. Hays, 2013. Evaluation of biomonitoring data from the CDC national exposure report in a risk assessment context: Perspectives across chemicals. Environ. Health Perspect., 121: 287-294.

8. Li, S., X. Zheng, X. Zhang, H. Yu and B. Han *et al*., 2021. Exploring the liver fibrosis induced by deltamethrin exposure in quails and elucidating the protective mechanism of resveratrol. Ecotoxicol. Environ. Saf., Vol. 207. 10.1016/j.ecoenv.2020.111501.
9. Jaiswal, D.K., R. Krishna, S. Singh, T. Belwal, J.P. Verma and J. Yadav, 2020. Toxicity of Organophosphate Pesticide on Soil Microorganism: Risk Assessments Strategies. In: Emerging Trends in Plant Pathology, Singh, K.P., S. Jahagirdar and B.K. Sarma (Eds.)., Springer, Singapore, pp: 257-295.
10. Hamed, H.S., 2015. Impact of a short-term malathion exposure of Nile tilapia, (*Oreochromisniloticus*): The protective role of selenium. Inter. J. Environ. Monitor. Anal., 3: 30-37.
11. Whalon, M.E., D. Mota-Sanchez and R.M. Hollingworth, 2008. Global Pesticide Resistance in Arthropods. CABI, England, Pages: 208.
12. Audsley, N. and R.E. Down, 2015. G protein coupled receptors as targets for next generation pesticides. Insect Biochem. Mol. Biol., 67: 27-37.
13. Eben, A., F. Sporer, H. Vogt, P. Wetterauer and M. Wink, 2020. Search for alternative control strategies of drosophila Suzukii (Diptera: Drosophilidae): Laboratory assays using volatile natural plant compounds. Insects, 11: 1-18.
14. Nenaah, G.E., 2014. Chemical composition, insecticidal and repellence activities of essential oils of three *Achillea* species against the Khapra beetle (Coleoptera: Dermestidae). J. Pest Sci., 87: 273-283.
15. Sousa, S.M., P.S. Silva and L.F. Viccini, 2010. Cytogenotoxicity of cymbopogon citratus (DC) Stapf (lemon grass) aqueous extracts in vegetal test systems. An. Acad. Bras. Ciênc., 82: 305-311.
16. Abdu-Allah, G.A.M., K.M. Seong, O. Mittapalli, J.A. Ojo and W. Sun *et al*., 2020. Dietary antioxidants impact DDT resistance in *Drosophila melanogaster*. PLoS ONE, Vol. 15. 10.1371/journal.pone.0237986.
17. Piegholdt, S., G. Rimbach and A.E. Wagner, 2016. The phytoestrogen prunetin affects body composition and improves fitness and lifespan in male *Drosophila melanogaster*. FASEB J., 30: 948-958.
18. Wagner, A.E., S. Piegholdt, D. Rabe, N. Baenas and A. Schloesser *et al*., 2015. Epigallocatechin gallate affects glucose metabolism and increases fitness and lifespan in *Drosophila melanogaster*. Oncotarget, 6: 30568-30578.
19. Di Prisco, G., V. Cavaliere, D. Annoscia, P. Varricchio and E. Caprio *et al*., 2013. Neonicotinoid clothianidin adversely affects insect immunity and promotes replication of a viral pathogen in honey bees. Proc. Natl. Acad. Sci. U.S.A., 110: 18466-18471.
20. Paaby, A.B. and P.S. Schmidt, 2009. Dissecting the genetics of longevity in *Drosophila melanogaster*. Fly, 3: 29-38.
21. Moretti, C.H., T.A. Schiffer, M.F. Montenegro, F.J. Larsen and V. Tsarouhas *et al*., 2020. Dietary nitrite extends lifespan and prevents age-related locomotor decline in the fruit fly. Free Radical Biol. Med., 160: 860-870.
22. Grandison, R.C., R. Wong, T.M. Bass, L. Partridge and M.D.W. Piper, 2009. Effect of a standardised dietary restriction protocol on multiple laboratory strains of *Drosophila melanogaster*. PLoS ONE, Vol. 4. 10.1371/journal.pone.0004067.
23. Bass, T.M., R.C. Grandison, R. Wong, P. Martinez, L. Partridge and M.D.W. Piper, 2007. Optimization of dietary restriction protocols in *Drosophila*. J. Gerontol. Ser. A Biol. Sci. Med. Sci., 62: 1071-1081.
24. DiBartolomeis, M., S. Kegley, P. Mineau, R. Radford and K. Klein, 2019. An assessment of acute insecticide toxicity loading (AITL) of chemical pesticides used on agricultural land in the United States. PLoS ONE, 14: 1-27.
25. Pelosi, C., C. Bertrand, G. Daniele, M. Coeurdassier and P. Benoit *et al*., 2021. Residues of currently used pesticides in soils and earthworms: A silent threat? Agric. Ecosyst. Environ., Vol. 305. 10.1016/j.agee.2020.107167.
26. Gharaei, A., M. Karimi, J. Mirdar, M. Miri and C. Faggio, 2020. Population growth of *Brachionus calyciflorus* affected by deltamethrin and imidacloprid insecticides. Iran. J. Fish. Sci., 19: 588-601.
27. Chakraborty, D., T. Madhumathi and S.V.S. Gopalaswamy, 2020. Toxicity evaluation of Spinosad against Malathion and deltamethrin resistant population of rusty grain beetle, *Cryptolestes ferrugenius* (Stephens) in Andhra Pradesh, India. J. Entomol. Zool. Stud., 8: 141-144.
28. Noori, A.M., M. Abdul and A. Lateef, 2020. *In vitro* multiplication of citrus lemon with different 6-benzylaminopurine (BA) concentrations. Plant Arch., 20: 6966-6968.
29. Gutiérrez, Y., H.V.V. Tomé, R.N.C. Guedes and E.E. Oliveira, 2017. Deltamethrin toxicity and impaired swimming behavior of two backswimmer species. Environ. Toxicol. Chem., 36: 1235-1242.
30. Osman, H.A., 2018. Effect of malafos (57 EC) acute toxicity on fresh water fish *Oreochromis niloticus*. J. Aquat. Sci. Mar. Biol., 1: 26-30.
31. Abbott, W.S., 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol., 18: 265-267.
32. Russell, R.M., J.L. Robertson and N.E. Savin, 1977. POLO: A new computer program for probit analysis. Bull. Entomol. Soc. Am., 23: 209-213.
33. Demir, E., 2020. Drosophila as a model for assessing nanopesticide toxicity. Nanotoxicology, 14: 1271-1279.
34. Penn, H.J., 2016. Effects of landscape, intraguild interactions, and a neonicotinoid on natural enemy and pest interactions in soybeans. Theses Dissertations-Entomol., 10.13023/ETD.2016.441.

35. Amin, K.A. and K.S. Hashem, 2012. Deltamethrin-induced oxidative stress and biochemical changes in tissues and blood of catfish (*Clarias gariepinus*): Antioxidant defense and role of alpha-tocopherol. BMC Vet. Res., Vol. 8 10.1186/1746-6148-8-45.
36. Al-Fayyadh, M.J., 2020. Diagnostic of pepper fruit fly *Atherigona orientalis* (Schiner) (Insecta: Diptera: Muscidae) on greenhouse crops from thi-qar province (South of Iraq). Plant Arch., 20: 2537-2538.
37. Aljedani, D.M., M.H. Shiboob and R.M. Almehmadi, 2017. Effects of Insecticides on the Midgut of the Foragers honeybee worker *Apis mellifera*. JKAU: Met. Environ. Arid Land Agric. Sci., 27: 59-66.
38. Aiemsaard, J., C. Jarassaeng and E. Thongkham, 2021. The effect of some essential oils against subclinical mastitis bacteria isolated from dairy goats. Chiang Mai Univ. J. Nat. Sci., 20: 1-10.
39. Blibech, I., M. Ksantini, T. Jardak and M. Bouaziz, 2015. Effect of insecticides on *Trichogramma* parasitoids used in biological control against *Prays oleae* insect pest. Adv. Chem. Eng. Sci., 5: 362-372.
40. Malbert-Colas, A., T. Drozdz, M. Massot, T. Bagni and T. Chertemps *et al*., 2020. Effects of low concentrations of deltamethrin are dependent on developmental stages and sexes in the pest moth *Spodoptera littoralis*. Environ. Sci. Pollut. Res., 27: 41893-41901.
41. Patil, V.K. and M. David, 2010. Behavioral and morphological endpoints: As an early response to sublethal malathion intoxication in the freshwater fish, *Labeo rohita*. Drug Chem. Toxicol., 33: 160-165.
42. Ahmad, Z., 2012. Toxicity bioassay and effects of sub-lethal exposure of malathion on biochemical composition and haematological parameters of *Clarias gariepinus*. Afr. J. Biotechnol., 11: 8578-8585.
43. Bonilla, E., F. Hernández, L. Cortés, M. Mendoza and J. Mejía *et al*., 2008. Effects of the insecticides malathion and diazinon on the early oogenesis in mice *in vitro*. Environ. Toxicol., 23: 240-245.
44. Prapamontol, T., S. Hongsibsong, W. Naksen, T. Kerdnoi and S. Kawichai *et al*., 2020. Multiple pesticide residues found in vegetables and fruits from rural and urban markets in upper northern Thailand. Chiang Mai Univ. J. Nat. Sci., 20: 1-25.
45. Strycharz, J.P., A. Lao, H. Li, X. Qiu and S.H. Lee *et al*., 2013. Resistance in the highly DDT-resistant 91-R strain of *Drosophila melanogaster* involves decreased penetration, increased metabolism, and direct excretion. Pestic. Biochem. Physiol., 107: 207-217.
46. Daborn, P., S. Boundy, J. Yen, B. Pittendrigh and R. Ffrench-Constant, 2001. DDT resistance in *Drosophila correlates* with Cyp6g1 over-expression and confers cross-resistance to the neonicotinoid imidacloprid. Mol. Gen. Genomics, 266: 556-563.
47. Chamdit, S. and P. Siripermpool, 2012. Antimicrobial effect of clove and lemongrass oils against planktonic cells and biofilms of *Staphylococcus aureus*. Mahidol Univ. J. Pharm. Sci., 39: 28-36.
48. Pearl, R., 1921. The biology of death-VI. Experimental studies on the duration of life. Sci. Mon., 13: 144-164.
49. Piper, M.D.W. and L. Partridge, 2007. Dietary restriction in *Drosophila*: Delayed aging or experimental artefact? PLoS Genet., Vol. 3. 10.1371/journal.pgen.0030057.
50. Pallauf, K., N. Duckstein and G. Rimbach, 2017. A literature review of flavonoids and lifespan in model organisms. Proc. Nutr. Soc., 76: 145-162.
51. Pallauf, K., K. Giller, P. Huebbe and G. Rimbach, 2013. Nutrition and healthy ageing: Calorie restriction or polyphenol-rich “MediterrAsian” diet? Oxid. Med. Cell. Longevity, Vol. 2013. 10.1155/2013/707421.