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Research Article

Assessment of Effectiveness of the Imidacloprid and Azadirachtin on the Black Watermelon Bug

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Abstract

Background and Objective: Watermelon is grown for food and as summer water source for both humans and animals. It is considered a multi-purpose crop that has many economic benefits but is susceptible to several insect pests. Specifically, the black watermelon bug *Coridius viduatus*, a very harmful agricultural pest. The objective of this study was to determine the effects of Imidacloprid and Azadirachtin on the black watermelon bug *Coridius viduatus*, specifically assessing the acute toxicity, mortality and sublethal effects while determining the lethal concentration (LC_{50}) and lethal time (LT_{50}). **Materials and Methods:** Study the effect of Imidacloprid and Azadirachtin at varying concentrations (0, 0.2, 1, 5, 6 ppb). During specific time intervals (1,3,6,10,12,24 h) the number of dead the number of dead individuals was calculated, thus calculating the death rate. Results were compiled to calculate the lethal concentration of individuals (LC_{50}) and then calculate the lethal halftime (LT_{50}). As was followed up during specific time periods (1, 3, 6, 10, 12, 24 h). **Results:** This study showed that Imidacloprid had a stronger effect in the elimination and mortality of black bugs *Coridius viduatus* compared to Azadirachtin, where the concentration of 1.658 ppb of Imidacloprid leads to 50% mortality compared to the Azadirachtin dosage of 3.085 ppb. Also, the Imidacloprid pesticide needs less time in the elimination and death of the black bug population when using the half-lethal concentration. It takes 14.779 h to achieve 50% mortality, compared to Azadirachtin, which takes approximately 28.3 h to achieve 50% mortality. **Conclusion:** The results concluded that the Imidacloprid was very toxic against the black bugs, in terms of both mortality and longevity. A botanical insecticide group such as Azadirachtin is environmentally friendly and is effective for controlling the insect.

Key words: Black watermelon bug, concentrations, insecticides, longevity, mortality, toxicity

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

INTRODUCTION

Demand for food has been increasing; a more comprehensive understanding of the impact of landscapes on sustainable agriculture production is required to meet the continual increase in human demand. This includes how chemical are used but also how cultivated and surrounding landscapes are managed to maximize ecosystem services. Watermelon *Citrulus lanatus* (Thuab.) is considered as the second most-produced vegetable, with regards to production quantity, with 89.1 million t produced in 2010 and a total worldwide production area[1,2] of 3.2 million ha. It was reported that the genetic origin of the watermelon is Africa but the exact geographical origin and domestication process of the crop is not clear. One possible genetic center is in the Kalahari Desert region where various wild forms of the species can still be found but it has also been suggested that the origin is in the Sahel Region in Northern Africa[3]. Watermelon has been grown in Africa and the Middle East for thousands of years. Throughout history, watermelon was distributed throughout the world as trade and knowledge[4].

There are several insects causing damage on important watermelon crop species, one of which is the black watermelon bug (*Coridius viduatus*) Fabricicus (F.) (Heteroptera: Dinidoridae). The genus, *Coridius*, including this species[5]. Afterward, this species was represented in *Aspongopus* genus by Stal[6] but current research classifies this species under *Coridius* genus[7]. The black watermelon bug (*Cordius viduatus*) is one of the most destructive pests threatening the watermelon and is widely distributed in the Near East and Africa. It is present in almost all of Africa, the Arabian Peninsula, Egypt and Turkey. Optimum temperature and humidity, adequate rainfall and good vegetation cover create suitable conditions for the insect survival[1,8-10] female black watermelon bug deposits approximately 287-295 eggs, sometimes up to 741 eggs, over a 150 day period. Eggs are laid individually or in clusters or rows on the main stems or lower parts of leaves, of the host plants[8]. Also, the insect has the ability to paste eggs together so that they can be lifted as one long stick of eggs[1,8,9]. Oviposition period was long (64 days), which may be due to the long rainy season and good climatic conditions that influence the fecundity and which resulted in the increase in the number of eggs and spontaneous population increases. Nevertheless, hatchability, nymphal mortality, predators, parasites, pathogens and the climate are the important factors influencing population density and should be considered in the strategy of the pest management[1]. A survey of arthropods associated with cucurbit crops during 2011 and 2012 at the New Valley in Egypt found the existence of 28 insect species belonging to 25 genera under 20 families of 9 orders. The important piercing-sucking arthropod pests were the black melon bug, *Coridius viduatus* F. on the melon[1,11]. Previous studies showed that *C. viduatus* is considered to be the most important piercing-sucking arthropod pest in cucurbit plants, causing very serious yield losses if no chemical control is applied[11].

Imidacloprid is a synthetic chemical insecticide widely used for controlling insect pests. In turfgrass and ornamental settings, Imidacloprid has been shown to effectively control adelgids, aphids, lace bugs, leafminers, mealybugs, scales, thrips, whiteflies, elm leaf beetles, leafhoppers and Japanese beetles[12]. This insecticide is used less often because of its highly negative effect on non-target organismss[13] but such organophosphates also have poor environmental and toxicological profiles. The unique mode of action of Imidacloprid, the degree of systemic and contact activity, a variety of application methods, low application rates, extended residual control, resilient binding to soil organic matter and good environmental and toxicological profiles result in this being one of the most widely used agents for chemical control[14]. Several previous studies have documented that insect susceptibility to neonicotinoids is dependent upon dosage, exposure route and species. Exposure to neonicotinoids may kill insects outright or may cause altered behaviors via sublethal effects[15,16].

The problems caused by organo synthetic insecticides on the environment and non-target organisms[17,18] has stimulated the use of natural products as an alternative pest control strategy, mainly in developing countries[19]. In general, these natural products have a lower environmental persistence and therefore, are considered environmentally and toxicologically safer than several of the currently used organo synthetic pesticides[19]. In addition to lethal effects[20], natural products, such as botanical insecticides, might have repellent effects, inhibit oviposition and change the feeding and hormonal systems of several arthropod pests[21].

These characteristics made the use of these biopesticides attractive for pest management. Plant-based insecticides such as Neem (i.e., Azadirachtin) have a range of commercial formulations that exhibit good efficacy against more than 400 insect species[22]. In fact, many scientific studies and have shown that Neem are a successful model in the natural control of many agricultural pests. The possibility of using nontoxic deterrents and repellents as crop protectants and the concept of using insect antifeedants such as Azadirachtin on a large number of pest species is intuitively attractive[23]. The remarkable bioactivity of Azadirachtin from the Indian Neem tree (*Azadirachta indica*) led to the search for natural insecticides that can be used in the natural control of many agricultural pests. Botanical insecticides can be obtained from seeds of the Indian Neem tree, *Azadirachta indica*[24]. Neem oil could be effective against insects and mites and is useful in the management of phytopathogens. Neem seeds contain more than a dozen Azadirachtin analogs but the major form is Azadirachtin and the remaining minor analogs likely contribute little to the overall efficacy of the extract. The role of these other natural substances has been controversial but most evidence points to Azadirachtin as the most important active ingredient[21]. However, the authorization to use these products remains controversial worldwide and although the activity of these botanical insecticides on agricultural pests is well established, their effects on other organisms need to be studied more comprehensively[25].

Due to the economic benefits of watermelon and the effects of the exposure to several insect pests, specifically, the black watermelon bug *Coridius viduatus* (F.), it is from very harmful agricultural pests. So, in this study the exposure of some insecticides on this insect was determined and the acute toxicity and sublethal effects of some insecticides was assessed including Imidacloprid and Azadirachtin, which that is of the most used insecticides in agriculture and determine the effect of the use of different concentrations and periods different from it. Also, the concentration of lethal concentration (LC_{50}) and lethal time (LT_{50}) was studied.

MATERIALS AND METHODS

Study samples: This study considered an insect *Coridius viduatus* (F.) (Heteroptera:Dinidoridae) as a harmful pest of the melon plant because it feeds on the juice of the cell, affecting its productivity. It is a light black insect with medium size, the mouth is a piercing pipette which is used to absorb the cellular juice from the leaves of the plant. Its front wings are semi-sheath and the membrane background is used for flight (Fig. 1).

Insecticide used in the study: Firstly, Imidacloprid insecticide; Trade name: Imidaclorin, soluble insecticide active ingredient: Imidacloprid (20% SL), the general name of pesticide: Imidacloprid 20 SL, chemical group: Neonicotinoid, based on available information, is a pesticide that works by contact. Second: Azadirachtin insecticide: trade name: Amen, which is a pesticide of plant origin, chemical group: From the botanical insecticide group. Insecticide: An insecticide of plant origin in the form of an Emulsifying Center (EC). Active ingredient: Azadirachtin 1% (EC). The properties of the insecticide: A selective insecticide, it is effective on all larval stages and pupae, they reduce crop damage by repelling and deterring feeding of all stages of insects. It is a pesticide commonly used in the control of agricultural pests (Fig. 2).

Fig. 1: A black watermelon bug *(Coridius viduatus* (F.)) (12MP-10X)

Concentrations used: Different concentrations (0, 0.2, 1, 5, 6) were used as parts per billion (ppb)[14].

Procedures of the experiment: The study samples were collected in the summer of 2018 (July) from farms located south of Jeddah (21°15'00.7"N 39°17'27.0"E) that are famous for the cultivation of watermelon. Samples were collected and transported directly to the laboratory. Laboratory experiments were carried out under the influence of the laboratory where the temperature was 25±5°C and the humidity was 65±10% relative humidity.

The samples were placed at a rate of 15 insects in a container. They were supplied with watermelon leaves for feeding and a small container with water. The container was covered with a piece of gauze to help it ventilate and prevent the insects from escaping. The insecticides of Imidacloprid and Azadirachtin were applied in five groups per insecticide (dosages of 0, 0.2, 1, 5, 6 ppb), with each group placed in a separate container and to calculate the mortality of individuals.

Divisions study groups

First: Imidacloprid insecticide:

- Treatment group with Imidacloprid with a concentration of 0 ppb (control group)
- Imidacloprid treatment group with a concentration of 0.2 ppb
- A treatment group with Imidacloprid with a concentration of 1 ppb
- Treatment group with Imidacloprid pesticide with a concentration of 5 ppb
- Treatment group with Imidacloprid pesticide with a concentration of 6 ppb

Fig. 2(a-d): (a) Imidacloprid insecticide, (b) Azadirachtin insecticide and (c, d) Insect black watermelon bug in the experimental bowl

Second: Azadirachtin insecticide:

- Azadirachtin treatment group with a concentration of 0 ppb (control group)
- Azadirachtin treatment group with a concentration of 0.2 ppb
- Azadirachtin treatment group with a concentration of 1 ppb
- Azadirachtin treatment group with a concentration of 5 ppb
- Azadirachtin treatment group with a concentration of 6 ppb

Statistical analysis: Percentage of mortalities and longevity of black watermelon bug was corrected for control mortalities using Abbott's formula[26] and the LC_{50} value was determined after 12 h using[27,28]. The lethal halftime, LT_{50} was determined using LC_{50} concentration. Statistical analysis was conducted by a program (Ldp line). Also, the confidence limits of the LC_{50} and LT_{50} value were calculated as described by Litchfield and Wilcoxon[29].

RESULTS

The results of the current study, which evaluated the toxicity of four different concentrations (0, 0.2, 1, 5, 6 ppb) of Imidacloprid and Azadirachtin insecticides on the black watermelon bug after 24 h of treatment. The lethal concentration of individuals (LC_{50}) is the concentration that caused in the death of half of the individuals after 24 h. The lethal halftime (LT_{50}) was defined as the time at which the highest death rate for individuals is achieved when exposed to the LC_{50} dosage, with observations conducted at 1, 3, 6, 10, 12 and 24 h. The group that was not treated with any type of insecticide (control group, 0 ppb) was fed naturally and did not show any type of changes nor was any deaths observed in the control group. Groups exposed to insecticide have the following effects.

Imidacloprid: Mortality at a lethal concentration (LC_{50}): Of the obtained results in Imidacloprid, observed response rate was 20-99.9% at the concentration of 0.2 and 6 ppb, respectively, while the linear response rate was the lowest at the concentration of 0.2 ppb, the highest percentage of 89.58% at the concentration 6 ppb. The linear probity range ranged from 4.0515-6.2585 at the concentration of 0.2 and 6 ppb, respectively (Table 1). The slope of the regression line was (1.494±0.1438). The Chi and tabular values were calculated and the value of Chi (computed) (7.1868) and tabulated (6) were found at degrees of freedom (n-2). A strong relationship between the concentration and the death rate (r) was observed, with correlation coefficients of 0.9196 (Table 2). The concentration LC_{25} = 0.305 ppb resulted in 25% death, whereas LC_{50} = 0.8627 ppb in the death of 50%. Based upon these statistics, 99% death is at a concentration of LC_{99} = 31.1137 ppb. The regression line, which represents the relationship between the death ratios of the black watermelon bug and the concentrations of the Imidacloprid were plotted. From the Ldp line, the value of the concentration that kills 50% of the LC_{50} was determined. It was 0.8627 ppb as in Table 3.

Lethal time (LT_{50}): In the current study, lethal concentration (LC_{50}) was calculated from an Imidacloprid at which there was 50% mortality of the black watermelon bug after 24 h (LC_{50} = 0.8627 ppb) (Table 3). It was exposed to this concentration of the insecticide and the death rate was evaluated at times 1, 3, 6, 10, 12, 24 h. The lethal half time, LT_{50} was calculated as the time at the highest death rate. The results obtained from Table 4 showed that the observed response rate ranged from 13.33-86.66% at 1 and 24 h, respectively. The linear response rate was 4.59612% at 1 h it is less valuable and the highest ratio its 61.9343% at 24 h. Linear probity ranged from 3.3124-5.3038 between 1 and 24 h, respectively (Table 4). The slope of the regression line was calculated (0.1531±1.4428). The Chi and tabular values were also calculated and the calculated Chi-value (60.8037) and the scale (9.5). The table shows a strong relationship between the concentration and the death rate (r) was observed, with a correlation coefficient of 0.795 and tabular scale value of 0.811 (Table 5). The confidence limits of the LT_{50} value were calculated according to the Litchfield and Wilcoxon[29] methods for statistical analysis and LT time was calculated at confidence intervals of 25, 75, 90, 95 and 99% (Table 6).

Table 1: Median lethal concentration (LC_{50}) of Imidacloprid on black watermelon bug and risk assessment after 24 h of exposure

Con.	Con. *10	Log (Con.*10)	Treated	Observed response (%)	Linear response (%)	Linear probit
0.2	2	0.301	100	20	17.1479	4.0515
1	10	1	100	46.67	53.8183	5.0958
5	50	1.699	100	93.33	87.2827	6.1401
6	60	1.7782	100	99.9	89.58	6.2585

Table 2: Statistics from the analysis of the capacities of the black watermelon bug that treated by different concentrations of Imidacloprid

Parameters	Concentration	Statistics
Slope	1.494	±0.1438
Chi	7.1868	Tabulated 6
p	0.0275	
	3.5934	
g	0.6165	
r	0.9196	Tabulated 0.95

r: Death rate

Table 3: Lethal Concentration (LC) values of Imidacloprid after exposure of black watermelon bug to different concentrations of it

LC	Con. (ppb)
25	0.305
50	0.8627
75	2.4396
90	6.2185
95	10.8857
99	31.1137

Table 4: Lethal Time (LT) of Imidacloprid after exposure to lethal concentration (LC_{50}) on the black watermelon bug

Time	Time*1	Log (Time*1)	Treated	Observed response (%)	Linear response (%)	Linear probit
1	1	0	100	13.33	4.59612	3.3124
3	3	0.4771	100	13.33	15.8866	4.0008
6	6	0.7782	100	20	28.6119	4.4352
10	10	1	100	26.66	40.3298	4.7552
12	12	1.0792	100	33.33	44.8094	4.8695
24	24	1.3802	100	86.66	61.9343	5.3038

Table 5: Statistics from the analysis of the capacities of the black watermelon bug that treated with Imidacloprid at a lethal time

Parameters	Concentration	LT_{50}
Slope	1.4428	±0.1531
Chi	60.8037	Tabulated 9.5
p	0	
h	15.2009	
g	1.3197	
r	0.795	Tabulated 0.811

r: Death rate

Azadirachtin: Mortality at a lethal concentration (LC_{50}): When these insects were exposed to Azadirachtin, the

Table 6: Lethal Time (LT) values of Imidacloprid after exposure of black watermelon bug to different concentrations of it

LT	Time (h)
25	5.037
50	14.7794
75	43.3647
90	114.2627
95	204.0327
99	605.2896

Table 7: Median lethal concentration (LC_{50}) of Azadirachtin on black watermelon bug and risk assessment after 24 h of exposure

Con.	Con. *10	Log (Con.*10)	Treated	Observed response (%)	Linear response (%)	Linear probit
0.2	2	0.301	100	6.66	8.50202	3.6272
1	10	1	100	33.33	28.5982	4.4348
5	50	1.699	100	53.33	59.5775	5.2424
6	60	1.7782	100	66.66	63.0751	5.3339

Table 8: Statistics from the analysis of the capacities of the black watermelon bug that treated by different concentrations of Azadirachtin

Parameters	Concentration	LC_{50}
Slope	1.1554	±0.1292
Chi	3.7105	Tabulated 6
p	0.1564	
h	1.8553	
g	0.0481	
r	0.9845	Tabulated 0.95

r: Death rate

Table 9: Lethal concentration (LC) values of Azadirachtin after exposure of black watermelon bug to different concentrations of it

LC	Con. (ppb)
25	0.8043
50	3.0846
75	11.8301
90	39.6684
95	81.8254
99	318.165

observed response rate was 6.66-66.66% at the concentration of 0.2 and 6 ppb, respectively, while the linear response rate was the lowest in concentration 0.2 ppb, with the highest concentration at 6 ppb. Linear probity ranged between 3.6272-5.3339 at the concentration of 0.2 and 6 ppb, respectively (Table 7). The slope of the regression line was determined as 0.1292±1.1554. The Chi-values of the data (Chi) calculated to (3.7105) and the tabular value of (6) was calculated at the degrees of freedom (n-2). There was a strong correlation between the concentration and the death rate (r), with a correlation coefficient of (0.95) (Table 8). The concentration of $LC_{25} = 0.8043$ ppb was found to result in 25% death, while $LC_{50} = 3.0846$ ppb lead to 50% death of and the 99% death rate would occur at a concentration of $LC_{99} = 318.165$ ppb. The regression line, which represents the relationship between the death rates of the black bug and the concentrations of Azadirachtin was drawn. From the Ldp line, the value of the concentration that death 50% of the LC_{50} was determined. It was 3.0846 ppb as in Table 9.

Table 10: Lethal Time (LT) of Azadirachtin after exposure to lethal concentration (LC_{50}) on the black watermelon bug

Time	Time*1	Log (Time*1)	Treated	Observed response (%)	Linear response (%)	Linear probit
1	1	0	100	6.66	3.39077	3.17
3	3	0.4771	100	13.33	10.9622	3.7714
6	6	0.7782	100	13.33	19.7947	4.151
10	10	1	100	20	28.4534	4.4305
12	12	1.0792	100	26.66	31.9312	4.5304
24	24	1.3802	100	60	46.4047	4.9098

Table 11: Statistics from the analysis of the capacities of the black watermelon bug that treated with Azadirachtin at a lethal time

Parameters	Concentration	LT_{50}
Slope	1.2605	±0.1625
Chi	18.8264	Tabulated 9.5
P	0.0009	
h	4.7066	
g	0.6031	
r	0.892	Tabulated 0.811

r: Death rate

Table 12: Lethal Time (LT) values of Azadirachtin after exposure of black watermelon bug to different concentrations of it

LT	Time (h)
25	8.2542
50	28.2999
75	97.028
90	294.1287
95	571.1629
99	1983.106

Lethal Time (LT_{50}): A sample of black bugs was exposed to the LC_{50} concentration of Azadirachtin, LC_{50} (3.0846 ppb). Follow-up measurements were conducted at 1, 3, 6, 10, 12, 24 h after exposure to determine the fatal half time LT_{50}. The results in Table 10 showed that the observed response rate ranged from 6.66-60% at 1 and 24 h, respectively. The linear response rate was less than 3.39077% at 1 h and the highest rate of 46.4047% at 24 h. Linear probity ranged from 3.17-4.9098 between 1 and 24 h, respectively in Table 10. The slope of the regression line (0.1625±1.2605) was calculated. The Chi and tabular values were also calculated and the value of Chi (calculated 18.8264) and the scale (9.5) was found at the degrees of freedom (n-2) (Table 11). The confidence limits of the LT_{50} value were calculated according to the Litchfield and Wilcoxon 29 methods of statistical analysis and the LT time ratio was calculated for confidence intervals of 25, 75, 90, 95 and 99% (Table 12).

Table 13: Comparison of the LC_{50} mortality rate of the effect of Imidacloprid and Azadirachtin on the black watermelon bug after 24 h of exposure

Line name	LC_{50}	Lower limit	Upper limit	1	2	Index	RR	Slope	Slope (±)	LC_{90}
Imidacloprid	1.658	1.297	2.104	*		100	1	1.333	0.127	15.182
Azadirachtin	3.085	2.355	4.194		*	53.744	1.861	1.155	0.129	39.668

Index compared with Imidacloprid, Resistance Ratio (RR) compared with Imidacloprid

Table 14: Comparison of the half-lethal time of (LT_{50}) for the effect of Imidacloprid and Azadirachtin on the black watermelon bug after 24 h of exposure

Line name	LT_{50}	Index	RR	Slope	Slope (±)	LT_{90}
Imidacloprid	14.779	100	1	1.443	0.153	114.263
Azadirachtin	28.3	52.223	1.915	1.26	0.163	294.129

Index compared with Imidacloprid, Resistance Ratio (RR) compared with Imidacloprid

Comparison of the effects of Imidacloprid and Azadirachtin on the black bug

According to the mortality LC_{50}: The results of the current study showed that Imidacloprid (LC_{50} of 1.658 ppb) has a stronger effect in the elimination and mortality of black bugs compared to Azadirachtin (LC_{50} of 3.085 ppb) based upon a lower dosage that leads to 50% mortality (Table 13).

According to longevity and the lethal half time LT_{50}: The results of the current study showed that the Imidacloprid pesticide needs less time in the elimination and death of the black bug population when using the half-lethal concentration. At the LC_{50} dosage, it takes 14.779 h to kill half of the individuals using Imidacloprid compared to 28.3 h using Azadirachtin (Table 14).

DISCUSSION

Insecticide treatments are under scrutiny because of their variable efficacy against crop pests and for their potential impacts on organisms in agroecosystems. In this study, the group that was not treated with any type of insecticide (control group) and were fed naturally did not show any changes, continued to the end of the experiment and no deaths were observed[30].

In the obtained results for black watermelon bug exposure to Imidacloprid, the concentration $LC_{25} = 0.305$ ppb resulted in 25% death, whereas $LC_{50} = 0.8627$ ppb in the death of 50%. The 99% death concentration was calculated as $LC_{99} = 31.1137$ ppb. Majority of researchers have documented that insect susceptibility to neonicotinoids is dependent upon dosage, exposure route and species. Exposure to neonicotinoids may kill insects outright or may cause altered behaviors via sublethal effects[15,16]. From the current study, Imidacloprid had an observed response rate of 20% at a concentration of 0.2 ppb. This low concentration caused a high rate of mortality, consistent with prior results that observed impaired mobility in ants treated with low dosages of Imidacloprid and fungicide treated seeds[31]. A study by Dilling[14] revealed that the differences between soil drenched and soil injection Imidacloprid concentrations and respective effect on non-target canopy insects may represent a threshold of tolerance; however, the correlation between Imidacloprid concentration and LC_{50} of non-target insects is not known and the LC_{50} of Imidacloprid on hemlock wooly adelgid is loosely correlated with existing estimates varying from 120-300 ppb. This is an area in need of future research. Additionally, species-level interaction differences with Imidacloprid were seen in how ant species' abundances responded to seed dressing with this neonicotinoid. Although, some species were not affected, pitfall trap captures of others increased or decreased with the addition of Imidacloprid to the system. However, some insects such as aphids were not negatively impacted by the Imidacloprid seed dressing despite aphids being among the targeted pests of this insecticide[30]. This study showed when a black watermelon bug is exposed to an LC_{50} concentration of Imidacloprid, the lethal time calculated as $LT_{50} = 14.7794$ h and LT99 = 605.2896 h. The sublethal effects from Imidacloprid might impact in other ways such as their ability to reproduce, longevity or aggression of a colony[31]. One potential cause is that the mechanism of neuro-toxic insecticides, such as Imidacloprid, was related to its nicotinic acetylcholine receptor affinity[15].

On the one hand, when the black watermelon bug was exposed to Azadirachtin the concentration of found to result in 25% death was $LC_{25} = 0.8043$ ppb, while 50% death was $LC_{50} = 3.0846$ and a calculated 99% death rate concentration was $LC_{99} = 318.165$ ppb. Measurements of death rate made at the LC_{50} dosage at multiple times following treatment during time periods set to determine the time at 50% mortality, LT_{50} determined as $LT_{50} = 28.2999$ h. These results were in agreement with Omar and El-Kholy[32] who found that the reduction in the population size of *Coccinella undecimpunctata* ranged between 12.7 and 14.2% when azadirachtins (Neemazal 5% EC) was applied against *Thrips tabaci* (Lind.) on onion crop. Meanwhile, Abdel-Aziz *et al.*[33]

found that the highest effect of Neem oil (Neemix) on the population of cereal aphids was observed 3 days after application. The residual effect extended for about 21 days post application with medium selective effect against total numbers of natural enemies after 3 days and good selective after 21 days. Rembold and Czoppelt[34] studied the effects of Azadirachtin on honey bee larvae (Third instar larvae) by topical application. Larvae were fed with a royal jelly and yeast mixture and reared in the incubator. The lowest dose causing observable effects was 0.25 µ larva. Also, Naumann and Isman[35] used an emulsifiable concentrate with an undiluted Azadirachtin content of 46000 mg kg^{-1}. Oral application of increasing doses of Azadirachtin on first and fourth instar larvae resulted in larval ejection by nurse bees in a dose-dependent manner. The LD_{50} for both instars was 37 and 61 µg g^{-1} b.wt.

On the other hand, Neem seed oil was tested at concentrations of 5.0, 2.5, 1.2, 0.6 and 0.3% for oviposition deterrence, by Raguraman and Singh[36] feeding deterrence, toxicity, sterility and insect growth regulator effects against *Trichogramma chilonis* Ishii. Neem seed oil at 0.3% deterred oviposition (parasitization) by the parasitoid. Neem seed oil also deterred feeding at or above a 1.2% concentration, seed oil at 5% concentration caused <50% mortality to both males and females. In contact toxicity tests, females were affected, while males did not seem to be affected. In view of the sensitivity of the parasitoid adults to oviposition deterrent and (mild) toxic effects of Neem seed oil, it is suggested that for the inundative release of the parasitoid *T. chilonis* pretreatment of the crop with Neem extracts should be avoided. Other research[37] concluded that the effect of Neemix (Azadirachtin) pesticide against the adult and nymph stages of *Bemisia tabaci* and its natural enemies inhibiting cucumber plants during summer. The tested compound was more effective against the adult stage of the whitefly than the nymph stage, during the summer season. The initial mortality rates were 93.10 and 73.80%, respectively. The high effects 93.10 and 75.63% against the adult and nymph stages were recorded after one day and 11 days of application, respectively. Neem seeds typically contain 0.2-0.6% Azadirachtin by weight, so solvent partitions or other chemical processes are required to concentrate this active ingredient to a range of 10-50% in the technical grade materials used to produce commercial products[21].

Azadirachtin had two significant impacts on insects. At the physiological level, Azadirachtin hinders the union and arrival of shedding hormones (ecdysteroids) prompting inadequate ecdysis in immature insects. In adult female insects, a similar mechanism of action leads to sterility. In addition, Azadirachtin is a strong antifeedant to numerous insects. The discovery of Neem by western science is credited to Heinrich Schmutterer, who saw that swarming desert beetles in Sudan defoliated all neighborhood greenery with the exception of some nearby Neem trees. Without a doubt, Azadirachtin was first disconnected due to its effective antifeedant action in the desert beetle and this substance remains the most powerful insect antifeedant found to-date. On the other hand, Azadirachtin has defied total synthesis to this point. Advanced in the Unified States by Robert Larson (with assistance from the U.S. Department of Agriculture), Neem rapidly became the modern paradigm for the development of botanical insecticides[21,38].

In this study, the concentration LC_{50} = 1.658 ppb of Imidacloprid leads to 50% mortality, compared to Azadirachtin at a higher concentration of LC_{50} = 3.085 ppb. Also, it takes LT_{50} = 14.779 h to reach 50% mortality, compared to Azadirachtin which takes approximately LT_{50} = 28.3 h to reach 50% mortality. This is consistent with the study conducted by Aljedani[39] where Imidacloprid and Azadirachtin at concentrations of 0.5 and 7.5 ppm on the honeybee were treated. Treatment was found most effective at 0.5 ppm, the lethal time LT_{50} = 10.348 and 47.535 h in Imidacloprid and Azadirachtin, respectively. Whereas at 7.5 ppm, the LT_{50} = 2.714 and 8.687 h in Imidacloprid and Azadirachtin, respectively. The control group showed the longest age of the honey bee workers having an LT_{50} = 1749.421 h.

CONCLUSION

The present study concluded that the Imidacloprid had a stronger effect on the elimination and mortality of the black watermelon bug (*Coridius viduatus*) compared to Azadirachtin. Also, the Imidacloprid pesticide needs less time in the elimination and death of the black bug population when using the half-lethal concentration. Finally, the study concludes that the Imidacloprid was very toxic against the black bugs, in terms of both mortality and longevity. In addition, the botanical insecticide group such as Azadirachtin had a moderate toxic effect on the population density of the black bug compared to the Imidacloprid.

SIGNIFICANCE STATEMENT

The present investigation has proven the different concentrations of Imidacloprid that produce toxic effects on the black watermelon bug. The natural-origin insecticides (Azadirachtin) has also been shown as effective. Therefore, this study helps to advance the fight against this insect by using natural-origin insecticides that are considered as environmentally friendly. This can lead to the rational use of the insecticides, which reduces the cost of control and reduces environmental pollution. The motivation in assessing effects of insecticides on a black bug is that they are a common pest in cucurbits crops. Furthermore, this insect will attract the attention of scientists in the future due to its utilization as food in the human diet in some countries.

REFERENCES

1. Alla, M.I.A., E.E. Mohammed and A.M.A. Hammad, 2015. Biology and fecundity of the melon bug *Aspongopus viduatus* (Fabricius), in the laboratory. Int. J. Sci. Environ. Technol., 4: 414-423.
2. FAOSTAT., 2010. Food and agriculture organization of the United Nations. Food and Organization Statistics Division, http://faostat.fao.org/.
3. Wasylikowa, K. and M. van der Veen, 2004. An archaeobotanical contribution to the history of watermelon, *Citrullus lanatus* (Thunb.) Matsum. & Nakai (syn. *C. vulgaris* Schrad.). Vegetation History Archaeobot., 13: 213-217.
4. Wehner, T.C., 2008. Watermelon. In: Vegetables I: Asteraceae, Brassicaceae, Chenopodiaceae and Cucurbitaceae. Prohens, J. and F. Nuez (Eds.). Springer Science Business Media, New York, pp: 381-418.
5. Illiger, J.C.W., 1807. Fauna etruscasistens insectaquae in provinciis florentina et pisanapraesertimcollegit petrus rossius. Iterumedita et Annotatisperpetuisaucta, Helmstadii Fleckeisen, 2: 511.
6. Stal, C., 1867. Bidragtill hemipteren as systematic. Ofv Vet. Akad Forth., 24: 501-532.
7. Tarla, S., H. Yetisir and G. Tarla, 2013. Black watermelon bug, *Coridius viduatus* (F.) (Heteroptera: Dinidoridae) in hatay region of Turkey. J. Basic Applied Sci., 9: 31-35.
8. Schmutterer, H., 1969. Pests of Crops in Northeast and Central Africa with Particular Reference to the Sudan. G. Fischer, Stuttgart Portland, USA., Pages: 296.
9. Adra, A.I., 2005. Biological, ecological and morphological studies on the melon bug, *Cordius viduatus* (Fabricus) (Hemplera, Dinideridae) on watermelon in North Kordofan state. M.Sc. Thesis, University of Kordofan, Sudan.
10. Salih, M.H.M.M., 2008. Studies on the biology, morphology and host range of the melon bug *Coridius viduatus* (Fabricius) (Hemiptera, Dinidoridae) in the northern state. M.Sc. Thesis, University of Khartoum, Sudan
11. Gameel, S.M.M., 2013. Species composition of piercing-sucking arthropod pests and associated natural enemies inhabiting cucurbit fields at the new valley in Egypt. Egypt. Acad. J. Biol. Sci., 6: 73-79.
12. Dotson, J.A., 1994. Merit product information manual. Bayer Corp, Kansas City, MO.
13. Cowles, R.S. and C.A.S.J. Cheah, 2002. Foliar sprays for control of hemlock woolly adelgid. Arthropod Manage. Tests, Vol. 27. 10.1093/amt/27.1.G48.
14. Dilling, C.I., 2007. Impact of imidacloprid and horticultural oil on non-target phytophagous and transient canopy insects associated with eastern hemlock, *Tsuga canadensis* (L.) Carriere, in the Southern Appalachians. Master's Thesis, University of Tennessee, Tennessee.
15. Galvanho, J.P., M.P. Carrera, D.D.O. Moreira, M. Erthal Junior, C.P. Silva and R.I. Samuels, 2013. Imidacloprid inhibits behavioral defences of the leaf-cutting ant *Acromyrmex subterraneus subterraneus* (Hymenoptera: Formicidae). J. Insect Behav., 26: 1-13.
16. Barbieri, R.F., P.J. Lester, A.S. Miller and K.G. Ryan, 2013. A neurotoxic pesticide changes the outcome of aggressive interactions between native and invasive ants. Proc. Royal Soc. London B: Biol. Sci., Vol. 280. 10.1098/rspb.2013.2157.
17. Biondi, A., V. Mommaerts, G. Smagghe, E. Vinuela, L. Zappala and N. Desneux, 2012. The non-target impact of spinosyns on beneficial arthropods. Pest Manage. Sci., 68: 1523-1536.
18. Decourtye, A., M. Henry and N. Desneux, 2013. Overhaul pesticide testing on bees. Nature, 497: 293-294.
19. Duke, S.O., C.L. Cantrell, K.M. Meepagala, D.E. Wedge, N. Tabanca and K.K. Schrader, 2010. Natural toxins for use in pest management. Toxins, 2: 1943-1962.
20. Hsu, W.S., J.H. Yen and Y.S. Wang, 2013. Formulas of components of citronella oil against mosquitoes (*Aedes aegypti*). J. Environ. Sci. Health Part B, 48: 1014-1019.
21. Isman, M.B., 2006. Botanical insecticides, deterrents and repellents in modern agriculture and an increasingly regulated world. Annu. Rev. Entomol., 51: 45-66.
22. Ntalli, N.G. and U. Menkissoglu-Spiroudi, 2011. Pesticides of Botanical Origin: A Promising Tool in Plant Protection. In: Pesticides-Formulations, Effects, Fate, Stoytcheva, M. (Ed.). InTech, USA., ISBN: 9789533075327.
23. Immaraju, J.A., 1998. The commercial use of azadirachtin and its integration into viable pest control programmes. Pesticide Sci., 54: 285-289.
24. Schmutterer, H., 2002. The Neem Tree. Neem Found, Mumbai.
25. Xavier, V.M., M.C. Picanco, M. Chediak, P.A.S. Junior, R.S. Ramos and J.C. Martins, 2015. Acute toxicity and sublethal effects of botanical insecticides to honey bees. J. Insect Sci., Vol. 15. 10.1093/jisesa/iev110.
26. Abbott, W.S., 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol., 18: 265-267.
27. Finney, D.J., 1971. Probit Analysis. 3rd Edn., Cambridge University Press, Cambridge, London.
28. Bakr, E., 2007. LdP line. http://embakr.tripod.com/ldpline/index.htm

29. Litchfield, Jr. J.T. and F. Wilcoxon, 1949. A simplified method of evaluating dose-effect experiments. J. Pharmacol. Exp. Ther., 96: 99-113.
30. Penn, H.J., 2016. Effects of landscape, intraguild interactions and a neonicotinoid on natural enemy and pest interactions in soybeans. Ph.D. Theses, University of Kentucky, Kentucky.
31. Thiel, S. and H.R. Kohler, 2016. A sublethal imidacloprid concentration alters foraging and competition behaviour of ants. Ecotoxicology, 25: 814-823.
32. Omar, B.A. and M.I. El-Kholy, 2001. Comparative bio-efficacy of certain traditional and non-traditional insecticides against thrips infesting onion. Mansoura Univ. J. Agric. Sci. (Egypt), 23: 73-81.
33. Abdel-Aziz, M.A., A.A. Abdel-Alim, N.A. Abdel-Aziz and G.A. Morsi, 2002. Susceptibility of different wheat varieties to infestation to cereal aphids with reference to safe control approach. Proceedings of the 2nd International Conference of Plant Protection Research Institute (ICPPRI'02), Cairo, Egypt, pp: 21-24.
34. Rembold, H. and C. Czoppelt, 1981. Pruefung pflanzlicher insektenwachstumshemmer aus azadirachta indica im aufzuchttest von bienenlarven (*Apis mellifica*, Hym., Apidae). Mitteilungen der Deutschen Gesellschaft fuer Allgemeine und Angewandte Entomologie.
35. Naumann, K. and M.B. Isman, 1996. Toxicity of a neem (*Azadirachta indica* A. Juss) insecticide to larval honey bees. Am. Bee J., 7: 518-520.
36. Raguraman, S. and R.P. Singh, 1999. Biological effects of neem (*Azadirachta indica*) seed oil on an egg parasitoid, *Trichogramma chilonis*. J. Econ. Entomol., 92: 1274-1280.
37. Gameel, S.M.M., 2013. The side effect of some pesticide alternatives on the population densities of the natural enemies of two piercing-sucking insect pests at the new valley province, Egypt. Egypt. Acad. J. Biol. Sci., 5: 1-6.
38. National Research Council, 1992. Neem: A Tree for Solving Global Problems. National Academy Press, Washington, DC Pages: 141.
39. Aljedani, D.M., 2017. Detection of toxicity and effects of some insecticides to local honey bee race (*Apis mellifera jemenatica*). J. Am. Sci., 13: 19-31.