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Toxicological Effects of five Insecticides on Cabbage Aphid, *Brevicoryne brassicae* (L.) (Homoptera: Aphididae) and its Parasitoid *Aphelinus sp.* (Hymenoptera:Aphelinidae)

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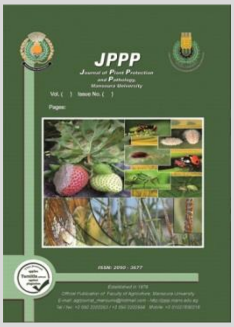
Ali, A. M. and Marwa F. K. Aly*

Department of plant protection -faculty of agriculture - Minia university - Egypt



ABSTRACT

Cabbage aphid, *Brevicoryne brassicae* (L.) is an important agricultural insect pest that attacks many vegetable crops all over the world. Herein, the study was conducted to evaluate the efficacy of five insecticides, acetameprid 20% SP (neonicotinoid), abamactin 1.8% EC (avermectin), indoxicarb 15% EC (oxadiazine), chlorpyrifos methyl 50%EC (organophosphate) and lambda cyhalothrin 5% EC (pyrethroid) against cabbage aphids *Brevicoryne brassicae* (L.) and its parasitoid *Aphelinus* sp. under laboratory conditions. Mortality percentages for both cabbage aphid and parasitoid were determined after 24, 48 and 72-h after treatment. Result revealed that acetamiprid was the greatest toxic insecticide against cabbage aphid followed by abamectin and indoxacarb after 24 and 48-h of treatment. Otherwise, lambda cyhalothrin followed by chlorpyrifos methyl was the lowest toxicity on cabbage aphid after 24 and 48-h from treatment. In contrast, toxicological results for parasitoid suggested that acetamiprid had less toxicity followed by abamectin and indoxacarb after 24 and 48-h of treatment. whereas, lambda cyhalothrin followed by chlorpyrifos methyl demonstrated great toxicity on the parasitoid after 24 and 48-h of treatment. In addition, safety factor for each treatment was determined, and results revealed that greater safety factor was recorded for acetamiprid, abamectin and indoxacarb than chlorpyrifos methyl and lambda cyhalothrin. Thus, these results suggest that acetamiprid can be included in the Integrated Pest Management (IPM) Program against cabbage aphid with safe side and minimum harmful effect on its parasitoid.

Keywords: Toxicity, *Brevicoryne brassicae*, pesticides, parasitoid

INTRODUCTION

The cabbage aphid, *Brevicoryne brassicae* (L.) is considered one of the most serious and cosmopolitan pests of cabbage in the world (Moharramipour *et al*., 2003). In Egypt, *B. brassicae* is a major insect pest on cruciferous plants especially on cabbage and cauliflower (Saleh 2004 and 2014). Cabbage aphids feed on the underside of the leaves and on the center of the cabbage head and they prefer feeding on young leaves and flowers and often go deep into the heads of brussels sprouts and cabbage (Natwick 2009; Hines & Hutchison, 2013). Adults and nymphs feeding cause direct damage like leaves yellowing, curling, wilting, and stunting of plants, resulting in plant deformation (Ali & Zedan, 2015). In this interim, it causes indirect damage by honeydew through cornicles which stick to leaves and causes sooty mold to develop, which ultimately renders photosynthesis death and decay of leaf (Griffin & Williamson, 2012) or by transmission of viruses (Lashkari *et al*., 2007). In addition, it is a vector of 20 virus diseases in a large range of plants including important viruses like cauliflower and turnip mosaic viruses (Ellis *et al*., 1998). Interestingly, cabbage aphid has a great reproduction capacity and may have up to forty-five generations per year (Ali & Zedan, 2015).

Parasitoids have often been shown to be more sensitive to synthetic insecticides than their hosts. In order to integrate the use of biological control with pesticide applications, synthetic pesticides should be selected for minimal impact on biological control agents. For that reason, determination of the compatibility of pesticides with biological control requires information on their direct and indirect toxicity to beneficial species, the pest's economic threshold, and the timing of applications (Stark *et al*., 2007). In this regards, many of the conventional insecticides in current use are broad-spectrum neurotoxins that affect both target and non-target species and, as a result, may disrupt biological control processes (Talebi *et al*., 2008).

To reduce damages caused by insect pests, various synthetic insecticides are applied at different stages of growth of the plant. These synthetic insecticides have some impacted toxicological and environmental consequences which include toxic residue in food, soil, water, adverse effects on non-target insects, and other beneficial organisms as well as the development of resistant strain of insects. Thus, it is necessary to evaluate the effects of insecticides on the natural enemies i.e. parasitoids, as well as on pest itself in order to have a better understanding of the effect of the chemicals on the biological components of the system.

Natural enemies are recognized as essential pest control agents on the long run (Banken & Stark, 1998). These organisms are important in the dynamics of communities of arthropods. Natural control agents interact with their hosts in a cyclical homeostasis between their populations (Rodríguez, 1980). Parasitoids are different from predators in that the first spend most of their life inside their hosts, and thus are subjected to the same factors of mortality (Ives & Settle, 1996).

* **Corresponding author.**
E-mail address: dr.mero_83@yahoo.com
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Although biological control is desirable, some pests having high reproductive rate and mobility as aphids, which are very difficult to control only by biocontrol agents and may require selective insecticides acting together with biological control (Stark & Rangus, 1994). Integrated pest management (IPM) depends on natural enemies, which can be complemented with selective insecticides when necessary (Metcalf, 1982).

Continuous usage of broad-spectrum insecticides to control cabbage aphid results in its resurgence, secondary pest outbreaks, and development of insecticide resistance in cabbage aphid (Dimetry & Merei, 1992; Kakahel *et al*., 1998). This is due to destruction of natural enemies. Therefore, the objective of this study is to determine the toxicity of five insecticides (acetamiprid, abamectin, indoxicarb, chlorpyrifos and lambda cyhalothrin) on cabbage aphid, *B. brassica* and its parasitoid *Aphelinus sp.* In this study, toxicological studies were conducted for figuring out insecticides that express high degree of toxicity against aphid and in the same time have low toxicity to its parasitoid.

MATERIALS AND METHODS

1.Aphid culture

Apterous virginoparous aphids *B. brassicae* were collected from infested cabbage leaves (aged 120 days) in the agricultural research farm, Department of Plant Protection, Faculty of Agriculture, Minia University, Egypt. Samples were transferred to the laboratory and kept in wooden cages covered with muslin. Twenty aphid nymphs were placed on new cabbage leaves in one cage and were followed until reproduction. The cabbage leaves were changed every day with fresh ones.

2.Parasitoid culture

Once the signs of parasitism occurred in this cage, infested leaves with parasitized nymphs were transferred to the other cages to establish parasitoid cage. In those cages, parasitized aphids were checked daily for mummies. Aphid mummies were collected and placed in test tubes sealed with water-moistened cotton plugs and they were left under laboratory conditions (25±1 oC, 60±5 % RH) until adult emergence. Ten parasitoid females and 10 males were released into cages containing cabbage leaves infested with healthy cabbage aphids. Mummies formed in this culture were collected using small brush and placed in aerated-transparent cylinders until emergence.

3.Insecticides

Five insecticides acetamiprid 20% SP (neonicotinoid), abamactin 1.8% EC (avermectin), indoxicarb 15% EC (oxadiazine), chlorpyrifos methyl 50% EC (organophosphate) and lambda cyhalothrin 5% EC (pyrethroid) were used to evaluate their toxicity on cabbage aphid and its parasitoid *Aphelinus sp.* Insecticides were purchased from Kafr El Zayat Company to conduct the current experiments.

4.Laboratory assessment of insecticides

The experiment was conducted in the laboratory of Plant Protection Department, Faculty of Agriculture, Minia University. The toxicity of five pesticides was evaluated against cabbage aphid and parasitoid *Aphelinus sp*. Five concentrations (5, 15, 25, 50 and 100 µg/ml) were used for each tested insecticide. Cabbage leaf discs were dipped on the different insecticide concentrations for one min., then left to dry for 20 min. under laboratory conditions on a filter paper. Cabbage leaves were immersed in water as a control. Newly ten apterous virginoparous aphid adults were exposed to dipped cabbage leaf discs at different insecticide concentrations inside petri-dishes having a muslin-covered opening to permit aeration and the cover was sealed on the edge by parafilm to prevent escaping of aphids. Three replicates were used for each concentration.

On the other side, toxicity of selected insecticides were tested against parasitoid *Aphelinus sp*. Parasitoid aphid nymphs were exposed to treated cabbage as described above for aphids. Mortality percentages for both cabbage aphid and parasitoid were determined after 24, 48 and 72-h of after treatment. Where the mortality of the parasitoid was recorded according to the direct effect of the used insecticides on the parasitoid not to the mortality of aphids. Percentage of mortality was corrected by using the formula of Abbott, (1925). The safety factor was calculated according to this formula:

Safety factor= LC_{50} for parasitoid/LC_{50} for pest×100

5.Statistical analyses

Data were subjected to Probit analysis (Finney 1971). Data were analyzed using SPSS (Windows 9.0. SPSS, Chicago, IL.) computer program to estimate LC_{50} values, slope and standard error, intercept and its standard error, Pearson goodness of fit Chi-square (X^2), expected mortality and its residual, 95% confidence limits (CL) for effective level of concentrations, and the heterogeneity factor in calculation of the confidence limits. For the experiment of insecticides toxicity to the cabbage aphid, the design was Completely Randomized Design (CRD) with each Petri-dish representing a replicate.

RESULTS AND DISCUSSION

The toxicity of selected pesticides were evaluated on cabbage aphid *B. brassicae* and its parasitoid *Aphelinus sp*. as well as Probit data were estimated (Table 1, 2 and Fig.1, 2). The results revealed that X^2 values were insignificant for all tested pesticides after 24, 48 and 72-h of exposure.

Probit data after 24 and 48-h of *B. brassicae* showed that acetamiprid and abamectin significantly resulted in high toxicity compared with chlorpyrifos methyl and lambda cyhalothrin, which expressed significantly low toxicity, while indoxacarb showed intermediate effect among the tested pesticides.

Data recorded after 24-h presented that lambda cyhalothrin were significantly the least toxic pesticide with highest LC_{50} value (58.88 µg/ ml), followed by chlorpyrifos methyl (LC_{50} = 51.29 µg/ ml). The lowest LC_{50} value 22.38 µg/ ml was observed when acetamiprid was applied. According to the data the tested pesticides can be divided to three groups; group 1; which includes, acetamiprid and abamectin the high toxicity pesticides; group 2; which includes chlorpyrifos methyl and lambda cyhalothrin that group significantly showed highest LC_{50} values that reflecting lowest toxicity compared with other groups; the third group includes only indoxacarb which comes in the middle between the two groups in respect to its toxicity against *B. brassicae.* The data after 48-h was showed the same manner as 24-h except that the two pesticides in group 2 chlorpyrifos methyl and lambda cyhalothrin significantly varied in their toxicity, where lambda cyhalothrin significantly showed the lowest toxicity against *B. brassicae* compared with all other tested pesticides. Total mortality was occurred after 72-h for all treatments except chlorpyrifos methyl and lambda cyhalothrin with moderate toxic (22.91 and 27.54 µg/ ml, respectively). In contrast, no significant differences were found between both treatments.

Furthermore, safety factor for each pesticide was determined after 24 and 48-h of treatment on both *B. brassicae* and the parasitoid *Aphelinus sp*. However, the highest safety factors were recorded for acetamiprid, abamectin and indoxacarb after 24 and 48-h which exceeded 100% and ranged between 104.69- 346.83 µg/ ml.

Table 1. Toxicity of five insecticides with different mode of actions on cabbage aphid, *B. brassicae* after 24, 48 and 72 hrs exposure.*

Insecticides	Hours after exposure							
	24-h			48-h			72-h	
	χ^2	LC_{50} (µg/ ml)	Safety factor	χ^2	LC_{50} (µg/ ml)	Safety factor	χ^2	LC_{50} (µg/ ml)
Acetamiprid	1.79	22.38 a	208.98	0.82	12.30 a	346.83	-	-
Abamectin	1.41	25.70 a	144.55	0.62	14.13 a	213.66	-	-
Indoxacarb	0.89	32.36 ab	104.69	0.60	16.59 ab	128.87	-	-
Chlorpyrifos methyl	1.35	51.29 c	47.87	1.32	38.90 c	13.19	0.81	22.91 a
Lambdacyholothrin	0.44	58.88 c	33.87	1.02	53.70 d	8.13	1.09	27.54 a

***LC_{50} values having different letters are significantly different. (-) means no living cabbage aphid after 72 hrs after acetamiprid, abamectin and indoxacarb treatments.**

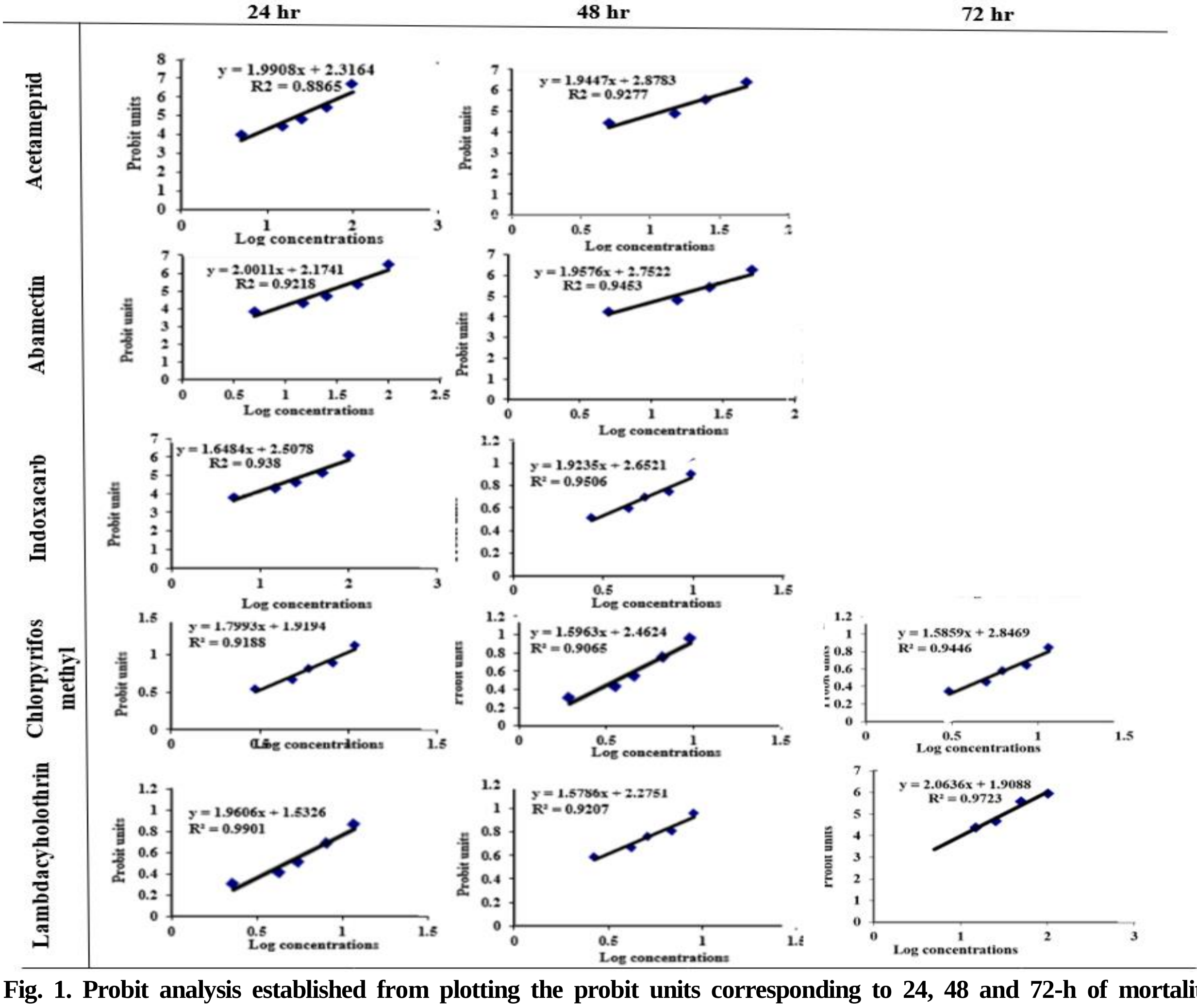

Fig. 1. Probit analysis established from plotting the probit units corresponding to 24, 48 and 72-h of mortality percentages of *Brevicoryne brassica* versus concentration logarithms of tested chemicals.

While, chlorpyrifos methyl and lambda cyhalothrin showed a lower safety factor for both 24 and 48-h ranged between 8.13-47.87 µg/ ml.

On the other hand, toxicity of the same treatments was also studied on the parasitoid *Aphelinus sp* (Table 2 and Fig. 2). The 24, 48 and 72-h LC_{50} for acetamiprid significantly showed lowest toxicity to the parasitoid compared to other treatments and ranged between 32.36-46.77 µg/ ml. Also, abamectin and indoxacarb significantly exhibited a moderate toxicity after 24, 48 and 72-h compared to other treatments ranged between 16.22-37.15 µg/ ml. However, both chlorpyrifos methyl and lambda cyhalothrin had significantly the greatest toxicity after 24 and 48-h ranged between 4.37-24.55 µg/ ml. Chlorpyrifos methyl and lambda cyhalothrin were expressed total mortality of *Aphelinus sp.* 72-h after treatment.

Acetamiprid is one of the most recently introduced classes of insecticides and have become the most widely used insecticides worldwide in different field. Acetamiprid is neonicotinoid which consider a neurotoxic insecticide, systemic pesticide, in that once applied, it translocated to all parts of plants (Bacci *et al*., 2007). the high toxicity of Acetamiprid against sucking pests has been confirmed in various studies. Ashwthanarayana and Gouda (2006) reported that acetamiprid 20% SP at 40 and 30 g a.i/ha, followed by acetamiprid 20% SP at 20 g ai/ha were the most effective in reducing the sucking pest's population with maximum okra fruit yield. Another study by Begum *et al*. (2016) was evaluated the efficacy of newer insecticides as foliar application against various pests and the author reported that acetamiprid 20% SP showed better results as 81% reduction of aphids. Another study on aphids, *Liphaphis erysimi* and *Myzus persicae*, using acetamiprid 20% SP pesticide was confirmed the high efficacy of acetamiprid on both aphids (Si Shengyun *et al*., 2005). Moreover, it is also supported by Muhammad *et al*. (2002) who reported that Confidor (imidacloprid) belongs to same chemical group of acetamiprid with same mode action shown a better result against cabbage aphid, *Brevicoryne brassicae* (L.). The efficacy of acetamiprid as neurotoxic insecticide was also confirmed on midge in cauliflower plants (Mao chen *et al*., 2007), and in laboratory against *Myzus persicae* (Omkar Gavkare *et al*. 2013).

Table 2. Probit data (LC-P line data) established from plotting the probit units corresponding to 24, 48 and 72-h mortality percentages of *Aphelinus sp.* versus concentration logarithms of tested insecticides.

Insecticides	Hours after exposure								
	24-h			48-h			72-h		
	χ^2	LC_{50} (µg/ ml)	Safety factor	χ^2	LC_{50} (µg/ ml)	Safety factor	χ^2	LC_{50} (µg/ ml)	Safety factor
Acetameprid	0.89	46.77A	208.98	0.88	42.66A	346.83	1.14	32.36A	-
Abamectin	0.90	37.15B	144.55	1.18	30.19B	213.66	1.12	23.99B	-
Indoxacarb	0.98	33.88B	104.69	0.96	21.38B	128.87	0.86	16.22B	
Chlorpyrifos methyl	1.71	24.55C	47.87	0.13	5.13C	13.19	-	-	-
Lambdacyholothrin	2.39	19.94C	33.87	0.11	4.37C	8.13	-	-	-

LC_{50} values having different letters are significantly different. (-) means no living parasitoids after 72 hrs after acetamiprid, abamectin and indoxacarb treatments

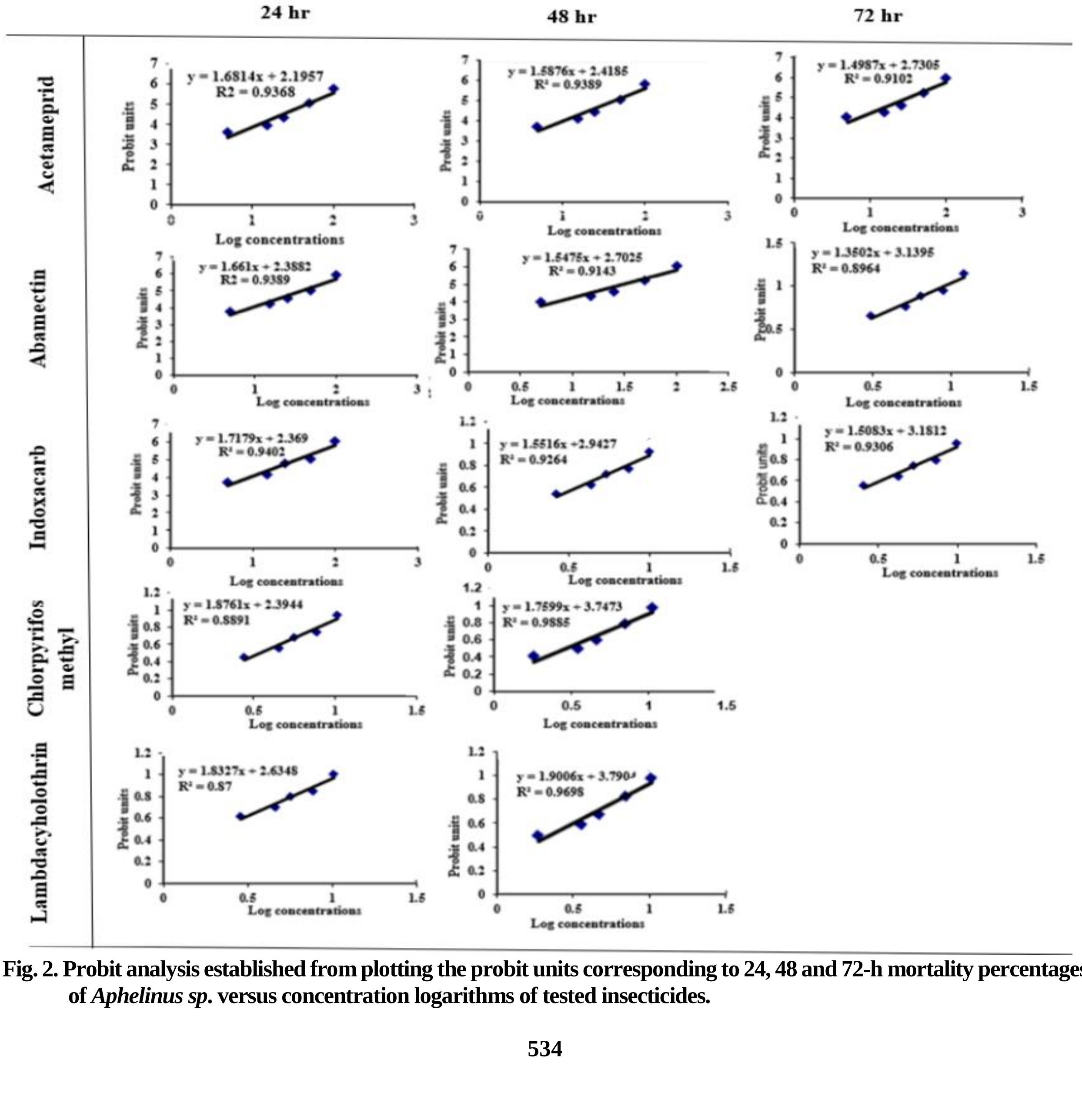

Fig. 2. Probit analysis established from plotting the probit units corresponding to 24, 48 and 72-h mortality percentages of *Aphelinus sp.* versus concentration logarithms of tested insecticides.

However, abamectin acts on insects by interfering with neural and neuromuscular transmission. It acts on a specific type of synapse located only within the brain and is protected by the blood-brain barrier (Hayes & Laws 1990). It showed high toxicity against aphids in many studies. Sun *et al.* (2013) reported very low LC_{50} (value was 1.690 µg/ml) of abamectin against aphids on honeysuckle.

Basically, indoxacarb (DPX-JW062) is an oxadiazine insecticide useful in killing a wide variety of insect pests. It blocks the insect voltage-gated sodium channel by the n-decarbome thoxyllated metabolite (Wing *et al*., 2000; Shono *et al*., 2004). Indoxacarb is a new insecticide had a high efficiency in controlling certain important sucking insects such as leafhopper species and aphids (Wing *et al*., 2000; Zuo *et al*., 2016).

The toxicity of chlorpyrifos and lambdacyhalothrin against predators was reported by Abdelrahman (2007). He studied the side effect of chlorpyrifos, profenofos, gamma-cyhalothrin, lambda-cyhalothrin, esfenvalerate and deltamethrin on cotton against the beneficial arthropods, *Coccinella undecimpunctata*; *Scymnus sp*.; *Chrysoperla carnea*; *Paederus alfierii*; *Orius spp*. and many species of true spiders, and found that lambda-cyhalothrin, esfenvalerate and deltamethrin treatments were associated with the greatest reduction in the population of the predators. Also, he mentioned that the highest reduction in mean number of predators was achieved in lambdacyhalothrin, esfenvalerate, deltamethrin and chlorpyrifos treatments in the previous treatments reduction percent ranged from 41 to 65 %. It could be concluded that acetamiprid and abamectin recommended as alternative insecticides for the management of cabbage aphid, *Brevicoryne brassicae* (L.) under Minia condition with low toxicity on its parasitoid *Aphelinus sp*.

CONCLUSION

Based on our experiment for evaluating the toxicological effect of tested insecticides on cabbage aphid, *Brevicoryne brassicae* (L.) and its parasitoid *Aphelinus* sp., it could be concluded that acetamiprid may be included in the Integrated Pest Management (IPM) Program for suppression cabbage aphid with safe side and minimum harmful effect on natural enemies.

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التأثيرات التوكسولوجية (السامة) لخمسة مبيدات علي حشرة من الكرنب وطفيليها افيلينس

علي مصطفي علي و مروه فاروق كامل علي*
قسم وقاية النبات - كلية الزراعة - جامعة المنيا

من الكرنب من اهم الافات الحشرية الزراعية التي تهاجم العديد من محاصيل الخضروات علي مستوي العالم. هنا اجريت هذه الدراسة لتقييم كفاءة خمسة مبيدات، acetameprid 20% SP, abamactin 1.8% EC, indoxicarb 15% EC, chlorpyrifos methyl 50%EC and lambda cyhalothrin 5% EC. ضد حشرة من الكرنب وطفيلها افيلينس تحت الظروف المعملية. تم تحديد النسب المئوية للموت لكل من حشرتي المن والطفيل بعد 24، 48 و 72 ساعة بعد المعاملة. قد اظهرت النتائج المعملية acetamiprid كان اكثر المبيدات سمية علي حشرة من الكرنب يتبعه abamectin و indoxacarb بعد 24 و 48 ساعة من المعاملة. من ناحية اخري ، lambda cyhalothrin يتبعه chlorpyrifos methyl اظهرا اقل سمية علي من الكرنب بعد 24 و 48 ساعة من المعاملة. علي النقيض، اظهرت نتائج الطفيل ان acetamiprid قليل السمية يتبعه abamectin و indoxacarb بعد 24 و 48 ساعة من المعاملة. بينما اشار lambda cyhalothrin يتبعه chlorpyrifos methyl سمية كبيرة علي الطفيل بعد 24 و 48 ساعة من المعاملة. بالاضافة الي ذلك، تم تقدير معامل الامان لكل معاملة (مبيد) وقد اظهرت النتائج ان اعلي معامل امان تم تسجيله acetamiprid, abamectin و indoxacarb مقارنة ب chlorpyrifos methyl وlambda cyhalothrin . ومن هنا فأن النتائج تقترح ان المبيد acetamiprid يمكن استخدامه بشكل امن ضد من الكرنب وبأقل تأثير علي طفيله في برنامج المكافحة المتكاملة.