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Toxicity and field persistence of thiamethoxam and dinotefuran against cabbage aphid, *Brevicoryne brassica* L. (Homoptera: Aphididae) under laboratory and field conditions

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Abstract

Cabbage aphid, *Brevicoryne brassica* L. is one of the most destructive and economically important insect pests of canola (*Brassica napus* L.) worldwide including Egypt. Few information is available on the effect of neonicotinoid insecticides (thiamethoxam and dinotefuran) against cabbage aphid on canola fields in Egypt, particularly in Assiut Governorate. Thus, this study was carried out to evaluate the toxicity and field persistence of thiamethoxam and dinotefuran against cabbage aphid under laboratory and field conditions. Under laboratory condition, thiamethoxam was showed high toxic effect against adult field strain of cabbage aphid with LC_{50} values, 84.10, 6.60 and 3.21 mg/L after 24, 48 and 72 hrs post treatment, respectively. In addition, dinotefuran also exhibited toxic effect against this pest but less than thiamethoxam where the LC_{50} values were 300.50, 43.85 and 6.74 mgL^{-1}, respectively after the periods of exposure. Based on the relative potency values, thiamethoxam was more effective than dinotefuran with 3.6, 6.6 and 2.1 fold after the periods of exposure. Under field condition, both thiamethoxam and dinotefuran exhibited efficiency against cabbage aphid population on canola plants after one, three, seven, fifteen and twenty-one days of treatments but thiamethoxam was more efficient than dinotefuran. Cabbage aphid reduction percent were 62.07, 89.80, 96.02, 96.59 and 94.55% for thiamethoxam and 8.58, 65.63, 86.77, 93.92 and 71.18% for dinotefuran after periods of exposure. The obtained data from this study indicated that thiamethoxam have a high toxicity effect against cabbage aphid under laboratory and field conditions. Based on our results, we suggest using thiamethoxam for cabbage aphid control in canola fields in Assiut Governorate, however more trails are needed about which in other Egyptian Governorates.

Key words: *Brevicoryne brassica*, neonicotinoid insecticides, canola

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Introduction

Canola or rapeseed (*Brassica napus* L., Brassicaceae) is one of the promising oil crops all over the world. In Egypt, canola cultivation is recommended for increasing the total oil production to bridge the gap between production and consumption of the edible oil, which reached 87% and yet did not cover the total needs of local consumption (El-Hadidi et al., 2007; Sayed and Teilep, 2013). Aphids are the most important insect pest of a 43 insect species have been recorded attacking canola crops and causing a poor growth and low yield (Khan et al., 2013). There are three major aphid species that can attack canola; cabbage aphid, *Brevicoryne brassicae* L., the turnip aphid, *Lipaphis erysimi* Kalt and the green peach aphid, *Myzus persicae* Sulzer (Homoptera: Aphididae) (Rehman et al., 1987; Arif et al., 2012). Cabbage aphid is the common and the most serious aphid species in several countries, including Egypt (Sayed & Teilep, 2013). It reduced canola grain yields by 9 to 77% and oil content up to 11% (Ellis &Farrell, 1995; Butin & Raymer, 1994; Ellis et al., 1996). The common approach for controlling aphids on canola is the chemical insecticides. Nowadays, neonicotinoid insecticides such as thiamethoxam and dinotefuran represent the most effective chemical class for the control of homopteran pests, such as aphids (Elbert et al., 1991; Abd-Ella, 2014; Gaber et al., 2015).

Thiamethoxam is launched by Syngenta in 1998 and represented the second-generation of neonicotinoid compounds and also considered as the second biggest neonicotinoid in terms of sales where it registered for 115 crops including canola in at least 64 (Elbert et al., 2008). It has a similar mode of action of nicotine that interferes with the nicotinic acetylcholine receptors in the insect's nervous system (Maiensfisch et al., 2001). Dinotefuran is developed and lunched in 2002 by Mitsui Chemicals, Inc., in Japan and represents the third generation of neonicotinoid group for use against sucking pests. It acts through contact and ingestion which results in a cessation of feeding and ultimately death. In Egypt, thiamethoxam and dinotefuran were registered to control aphids and white fly in many crops (Anonymous, 2014). Many researchers have reported the effectiveness of acetamaprid, thiamethoxam and imidacloprid against *B. brassicae* under laboratory and field conditions worldwide (Buntin and Raymer, 1994; Kumar & Dikshit, 2001; Schroeder et al., 2001; Khattak et al., 2002; Sarwar et al., 2003; Abdu-Allah, 2012; Amer et al., 2010; Arif et al., 2012). No literature reports the efficacy of thiamethoxam and dinotefuran against *B. brassicae* in canola fields in Assiut Governorate. Thus, this research was carried out to evaluate the effectiveness of thiamethoxam and dinotefuran against cabbage aphid, *B. brassicae* under laboratory and field conditions.

Materials and methods

Insects: Field populations of cabbage aphid were collected from canola fields of Assiut UniversityExperimental Farm (Assiut, Egypt) during 2014/2015 season.

Insecticides: Commercial formulations of two neonicotinoid insecticides thiamethoxam (Actara 25% WP; Syngenta Crop Protection, Switzerland) and dinotefuran (Oshin 20% SG; Syngenta Crop Protection, Switzerland) were used in this study.

Laboratory bioassay: The leaf-dip bioassay method corresponded to that described by Moores et al. (1996); Mokbel & Mohamed (2009) was used to treat the pest. The experiments were conducted in the laboratory of Plant Protection Department, Faculty of Agriculture, Assiut University during 2014. Series of different concentrations (800, 400, 200, 100, 50, 25, 12.50 and 6.26 (only thiamethoxam) mg (a.i.) L^{-1}) of each insecticide were freshly prepared in water. The leaf discs were cut from canola leaves collected from untreated fields, then washed, dried and dipped for 30 second in each concentration. After dipping, discs allowed to dry at ambient temperature for 30 min. For control treatment, leaf discs immersed in water. Each dried treated leaf disc was placed in an individual plastic Petri dishes (5 cm diameter) containing moistened filter paper. Ten apterous adult cabbage aphids, approximately of same size, were transferred to the treated leaf discs surface by a camel hair brush. Each treatment concentration was replicated four times. The bioassay were reserved at 25 ± 2 °C temperature 60% ± 5 RH% and 12:12 (light : dark) photoperiod. Mortality was recorded after 24, 48 and 72 hrs after exposure to the tested concentrations. Percentage of mortality was corrected using the formula of Abbott (1925), and the LC_{50} values, slopes and fiducial limits were estimated by probit analysis using SPSS software according to Finney (1971).

Field evaluation: Field experiment was carried out on canola field at Assiut University Experimental Farm, Assiut, Egypt during 2014/2015 season. The experimental field was design in a randomized complete block with four replications, each was 3×3.5 m. Canola variety, Pactol, was planted on October 13, 2014. The recommended agricultural processes were followed. The labeled field rate of thiamethoxam (40 g/100 L water) and dinotefuran (50 g/100 L water) were sprayed using a single-nozzed knapsack sprayer (200 L water/ feddan). Aphid numbers were recorded from the top 10 cm of the central inflorescence of 10 plants / replicate before spray and at 1, 3, 7, 15 and 21 days after treatment (DAT) in control and insecticides treatments. Percent population reduction was calculated according to the Henderson and Tilton's equations (1955).

Results

Laboratory bioassay: Toxicity effect of thiamethoxam and dinotefuran against cabbage aphid field strain collected from canola fields was determined in the laboratory using a leaf-dip bioassay. Data in Table (1) showed that thiamethoxam showed a high toxicity against adult field strain of cabbage aphid with LC_{50} values 84.10, 6.60 and 3.21 mgL^{-1} after 24, 48 and 72 hrs of exposure, respectively. However, dinotefuran also exhibited toxicity effect against this pest but less than thiamethoxam with LC_{50} values 300.50, 43.85 and 6.74 mgL^{-1}, respectively.

According to the relative potency values, thiamethoxam was more effective than dinotefuran with 3.6, 6.6 and 2.1 fold after the periods of exposure. Generally, laboratory bioassay results indicated that the LC_{50} values of thiamethoxam and dinotefuran against field strains of cabbage aphid were dramatically decreased with the periods of exposure increased and the LC_{50} values of thiamethoxam were lower than LC_{50} values of dinotefuran so thiamethoxam was more toxic on cabbage aphid field strain than dinotefuran.

Table 1: Toxicity of thiamethoxam and dinotefuran against adults of field strain of cabbage aphid, *B. brassicae* after 24, 48 and 72 hrs of exposure using leaf-dip bioassay technique.

Insecticides	24 hrs of exposure		48 hrs of exposure		72 hrs of exposure		Relative potency[b]		
	LC_{50} (mgL^{-1}) (95% CL)[a]	Slope ± (SE)	LC_{50} (mgL^{-1}) (95% CL)	Slope ± (SE)	LC_{50} (mgL^{-1}) (95% CL)	Slope ± (SE)	24 h	48 h	72 h
Thiamethoxam	84.1 ± 7.57 (58.5-122.8)	1.3 ± 0.10	6.6 ± 2.82 (3.6-10.4)	0.73 ± 0.15	3.21 ± 1.11 (1.4-5.8)	0.70 ± 0.09	1	1	1
Dinotefuran	300.5 ± 48.03 (204.9-506.3)	1.42 ± 0.12	43.85 ± 15.29 (22.6-67.6)	0.64 ± 0.05	6.739 ± 3.14 (0.007-25)	0.71 ± 0.22	3.6	6.6	2.1

[a]LC_{50} and 95% confidence limits (CLs) are given in mg (a.i) L^{-1} .
[b]Relative potency is calculated as LC_{50} of the tested insecticide/LC_{50} of the most effective insecticide.

Field evaluation: Under field condition, both thiamethoxam and dinotefuran exhibited efficiency against cabbage aphid populations on canola plants and they caused reduction in the cabbage aphid populations after 1, 3, 7, 15 and 21 days of treatments but thiamethoxam was more efficient than dinotefuran (Table 2). Furthermore, cabbage aphid reduction percent were 62.07, 89.80, 96.02, 96.59 and 94.55% for thiamethoxam and 8.58, 65.63, 86.77, 93.92 and 71.18% for dinotefuran after the periods of exposure. These results indicated that thiamethoxam and dinotefuran exhibited a high efficiency against cabbage aphids. Thiamethoxam was more effective than dinotefuran after period of exposure.

Table 2: Effect of thiamethoxam and dinotefuran against cabbage aphid, *B. brassicae* populations on canola plants at 1, 3, 7, 15 and 21 DAT under field conditions.

Insecticides	% reduction of cabbage aphid population					
	Labeled field rate	1 DAT	3 DAT	7 DAT	15 DAT	21 DAT
Thiamethoxam	40 g/100 L	62.07	89.80	96.02	96.59	94.55
Dinotefuran	50 g/100 L	8.58	65.63	86.77	93.92	71.18

Discussion

In the present study, efficiency of two neonicotinoid insecticides (thiamethoxam and dinotefuran) against the cabbage aphid field stains was tested under laboratory and field conditions in Assiut Governorate. Under laboratory condition, LC_{50} values showed that both tested insecticides exhibited efficiency against cabbage aphid field strains and relative potency values indicated that thiamethoxam was more effective than dinotefuran (Table 1). Similar results were obtained by Abd-Ella (2014) who indicated that thiamethoxam showed a high efficiency against cowpea aphid *Aphis craccivora* Koch under laboratory condition compared to dinotefuran.

Results of field trials presented in Table (2) proved that the labaled field rates of thiamethoxam and dinotefuran display toxicity against cabbage aphid populations on canola fields and thiamethoxam was more effective than dinotefuran. Thus they were effective tools to control this pest in canola fields in Assiut governorate. In agreed with our results, Abd-Ella (2014) where he reported that thiamethoxam followed by dinotefuran registered the highest significant reduction percent on cowpea aphids in faba bean at 1, 7, 15 and 21 days after treatments. Gaber et al. (2015) found that the foliar application of neonicotinoid insecticides thiamethoxam and dinotefuran caused a high significant reduction in cotton aphid population in cotton fields and thiamethoxam was more effective than dinotefuran. Moreover, thiamethoxam have shown a great potential against different aphid species such as pomegranate aphid, *Aphis punicae* P. (Rouhani et al., 2013), *A. craccivora* Koch (Abdu-Allah, 2012), *B. brassicae* L. (Schroeder et al., 2001), *M. persicae* and *M. nicotianae* (Nauen & Elbert, 1997).

The difference in toxicity between thiamethoxam and dinotefuran against cabbage aphids that observed in this study might be due to the difference in the mode of action, chemical structure and formulations. The potent insecticidal activity of thiamethoxam came from its physical characteristics where it is a nicotinic acetylcholine receptor (nAChR) agonist (Elbert et al., 2008). Similarly, Elbert et al. (2008); Abdu-Allah (2012); Rouhani et al. (2013) found that thiamethoxam acts on the central nervous system of insects by binding with a nicotinic acetylcholine receptor at a specific site that causes an excitation of the nerves and eventual paralysis followed by a death. Furthermore, Rouhani et al. (2013) and Elbert et al. (2008) reported that thiamethoxam's chemical structure is slightly different from other neonicotinoid insecticides that making it the most water-soluble one of this family so it moves readily into plant tissues. In addition, dinotefuran's mode of action is different from thiamethoxam, by mimicking the action of the neurotransmitter on the unique acetylcholine receptor in the insect nerve synapse (Wakita et al., 2005).

In conclusion, the effect of thiamethoxam and dinotefuran against cabbage aphids under laboratory and field conditions in Assiut Governorate indicated that both tested insecticides exhibited efficiency against the pest and thiamethoxam was more efficient than dinotefuran. Thus, we suggest using thiamethoxam as foliar application for cabbage aphid control in canola fields in Assiut Governorate; however more trails are needed about which in other Egyptian Governorates.

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