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FIELD EVALUATION OF CERTAIN INSECTICIDES AGAINST SOME INSECT PESTS INFESTING ORANGE TREES

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ABSTRACT

The present study aimed to evaluate the efficacy of Thiamethoxam, Imidacloprid, Spirotetramat, Sulfoxaflor, Buprofezin, Dimethoate, Phosmet and Mineral oil against *Phyllocnistis citrella* Stainton, *Planococcus citri* (Risso), *Lepidosaphes beckii* (Newman) and *Ceroplastes floridensis* Comstock infesting orange trees (*Citrus sinensis* L. (Rutacea)) under field conditions. The experiments were conducted in the Experimental Farm, Faculty of Agriculture, Mansoura University, Dakahlia Governorate, Egypt. The obtained results showed that the highest effective treatment on *P. citrella* was that of Thiamethoxam (the mean reduction percentages was 82.9%) followed by Imidacloprid (78.6%), Dimethoate (76.6%) and Sulfoxaflor (76.2%). Dimethoate ranked the highest treatment against *P. citri* followed by Imidacloprid and Thiamethoxam, where their general mean reductions reached 89.9, 82.9 and 82.3%, respectively. With respect to *L. beckii*, Dimethoate ranked the highest treatment followed by Phosmet which recorded general mean reductions of 90.8 and 90.7%, respectively. Also, Dimethoate was the highest insecticide against *C. floridensis* (the general mean reduction percentages was 90.2%) followed by Thiamethoxam (86.9%) and Imidacloprid (86.1%).

INTRODUCTION

Egypt stands among the largest oranges producing countries in the world and occupies the third rank in production amongst the Mediterranean basin countries (FAO, 2011). Egyptian citrus has relative advantages in terms of yield and fruit quality, early ripening, relative low labor cost and nearness to international importing markets. It contains large amounts of phytochemicals which offer health benefits such as ascorbic acid and carbohydrates (Latif *et al.*, 2013). Unfortunately, citrus trees are attacked by several insect pests among them the citrus leaf miner, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae), the citrus mealybug, *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae), the purple scale, *Lepidosaphes beckii* (Newman) (Hemiptera: Diaspididae) and the Florida wax scale, *Ceroplastes floridensis* Comstock (Homoptera: Coccidae).

Phyllocnistis citrella is an important pest of citrus orchards (Heppner, 1995). It occurs all the year round and attacks more than half of the new leaves produced on citrus trees (Wilson, 1991). Citrus nursery production systems are especially susceptible to *P. citrella* damage because seedlings and young trees flush nearly continuously and their ability to store nutrients is limited (Villanueva-Jimenez and Hoy, 1998). The damage is directly related to the ratio of the young leaves and the total canopy of the young trees (Argov and Rossler, 1998). Bautista-Martinez *et al.* (1998) suggest that *P. citrella*

can augment the severity of citrus canker, *Xanthomonas citri* Dowson and other fungus pathogens such as *Alternaria* on damaged leaves.

The citrus mealybug, *P. citri* is one of the important pests attacking citrus plantations. Ahmed and Abd-Rabou (2010) reported that it found to infest 65 plant species belonging to 36 families in Egypt.

The purple scale *L. beckii* is a polyphagous species that has been recorded from hosts belonging to 45 genera in 11 plant families including citrus which attacks leaves, trunk and fruits (Davidson and Miller, 1990). It is a major destructive pest of citrus in Egypt and is widely distributed throughout the tropical and subtropical regions of the world (Danzig and Pellizzari, 1998).

C. floridensis is widely distributed in tropical and subtropical regions around the world (Ashmead, 1980). It attacks a great number of host plants especially *Citrus* spp. Its main damage is due to the copious production of honey dew (especially in the large populations) which serves as a substrate for various sooty mould fungi (Podoler *et al.*, 1981).

Scale insects and mealybugs injure citrus trees by feeding on the plant sap through leaves, twigs and fruits causing defoliation and drying up of young twigs, so affecting the commercial value of fruits and their export potential. Therefore chemical control is necessary to keep the population of insect pests below economic threshold level.

Systemic insecticides are being developed and used for insect control on the variety of crops around the world (Yue *et al.* 2003). Among these neonicotinoid groups, Imidacloprid has a broad spectrum activity and low mammalian toxicity; it has long a unique property of excellent translaminar activity (Chauhan *et al.* 2013). Also, Thiamethoxam, comes from a family of insecticides known as the second-generation neonicotinoids.

The present study aimed to compare the efficacy of the neonicotinoid (Thiamethoxam & Imidacloprid) and other insecticides (*i.e* Spirotetramat, Sulfoxaflor, Buprofezin, Dimethoate, Phosmet & Mineral oil) against *P. citrella*, *P. citri*, *L. beckii* and *C. floridensis* infesting orange trees.

MATERIALS AND METHODS

Experiments were conducted in The Experimental Farm, Faculty of Agriculture, Mansoura University, Dakahlia Governorate, Egypt to evaluate efficacy of certain insecticides (Table 1) against the insects under study of the lepidopterous pest, *P. citrella* (Family: Gracillariidae) in addition to the hemipterous pests, *P. citri* (Family: Pseudococcidae), *L. beckii* (Family: Diaspididae) and *C. floridensis* (Family: Coccidae) infesting orange trees (*Citrus sinensis* L. (Rutacea)) under field conditions.

The design of experiment was conducted in a Randomized Block Design. The selected orange trees (about of 20 years old) received all the recommended agricultural practices. The experimental area divided into nine treatments, eight of them treated with tested insecticides at the recommended rates, while the 9th treatment served as a control. The tested compounds were applied on the 26th of August, 2014 using motor sprayer of 600 liters in capacity. Treatments including the untreated (check) were

replicated five times with sixteen trees per replicate making a total of 80 orange trees per treatment, approximately having similar size, shape, height, and vigor. The tested insecticides were applied as complete coverage.

One hundred leaves from each treatment (20 leaves/replicate) were collected immediately before spraying and after 1, 2, 3 and 4 weeks (for *P. citrella*) & after 2, 4, 6 and 8 weeks (for *L. beckii*) of application. Fifty twigs (approximately 20 cm in length) from each treatment (10 twigs/replicate) were collected immediately before spraying and after 1, 2, 3 and 4 weeks (for *P. citri*) & after 2, 4, 6 and 8 weeks (for *C. floridensis*) of application. The picked samples were put in marked cloth bags and transferred to the laboratory for counting insects using the stereoscopic binocular microscope. Reduction percentages in both population and infestation were estimated according to Henderson and Tilton's formula (1955). Data were analyzed using analysis of variance (ANOVA) followed by Least Significant Difference (LSD). Probability of 0.05 or less was considered significant. All statistical analysis was done with CoHort Software 2004.

Table1. The tested insecticides

Common name	Trade name	Field recommended rate	Group
Thiamethoxam	Actara 25% WG	25 gm/100 L	Neonicotinoid
Imidacloprid	Chinook 35% SC	75 ml/100 L	Neonicotinoid
Spirotetramat	Movento 10% SC	40 ml/100 L	Tetramic acid
Sulfoxaflor	Transform 50% WG	125gm/fed.	Sulfoximine
Buprofezin	Applaud 25% SC	600 ml/fed.	Chitin synthesis inhibitors
Dimethoate	Dancothoate 40% EC	150 ml/100 L	Organophosphate
Phosmet	Imidan 50% WP	140 gm/100 L	Organophosphate
Mineral oil	Tiger 97% EC	1.5L /100L	lubrication fraction of petroleum oil

RESULTS

1. The citrus leaf miner, *P. citrella*:

After one week of application, Thiamethoxam exhibited the highest reduction percentage of *P. citrella* population (67.1%); while, Dimethoate was the worst recording the lowest reduction percentage of 52.7%. After two weeks of treatment, both Imidacloprid and Dimethoate as well as Thiamethoxam exhibited relatively high reduction percentages in *P. citrella* population and then their effects increased gradually till the fourth week of treatment (Table, 2).

The highest effective treatment on *P. citrella* population was that of Thiamethoxam (the mean reduction percentage was 82.9%). While, Imidacloprid treatment ranked the second effective treatment (the mean reduction percentage was 78.6%) followed by Dimethoate (76.6%) and Sulfoxaflor (76.2%). Buprofezin was the lowest effective compound on *P. citrella* population (the mean reduction percentage was 72.1%) (Table, 2).

Table (2). Effect of certain insecticides against the citrus leaf miner, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) on orange trees.

Treatment	Pre-spray	Mean number and % reduction after treatment (in weeks)									
		1		2		3		4		Mean	
		No.	R%	No.	R%	No.	R%	No.	R%	No.	R%
Thiamethoxam	9.8±2.5	4.0±1.0	67.1	2.2±0.8	81.2	1.0±0.7	91.8	1.2±0.8	90.8	2.1	82.9
Imidacloprid	11.6±4.7	5.8±0.8	59.6	3.0±0.7	78.4	1.6±0.5	88.9	2.0±0.7	87.0	3.1	78.6
Spirotetramat	9.4±2.7	4.8±2.2	58.8	3.2±1.3	71.5	1.8±1.5	84.5	2.2±0.8	82.4	3.0	74.5
Sulfoxaflor	10.4±3.2	5.2±2.5	59.6	3.2±1.3	74.3	1.8±0.8	86.0	2.2±0.8	84.0	3.1	76.2
Buprofezin	8.6±4.8	5.0±1.6	62.1	3.4±0.5	66.9	2.2±0.8	79.4	2.3±0.8	79.8	3.2	72.1
Dimethoate	11.6±4.0	6.8±1.6	52.7	3.2±0.8	76.9	1.4±0.5	90.3	2.0±0.7	87.0	3.4	76.6
Phosmet	10.2±2.2	5.8±3.8	54.1	3.6±1.5	70.5	1.2±0.8	90.5	1.8±0.8	86.7	3.1	75.7
Mineral oil	10.2±3.3	5.6±2.1	55.7	3.6±1.3	70.5	1.8±0.8	85.8	2.0±0.7	85.2	3.3	74.1
Control	9.2±3.3	11.4±2.1	----	11.0±1.2	----	11.4±1.3	----	12.2±1.5	----	11.5	----
L.S.D.$_{P=5\%}$	4.5	2.7	----	1.4	----	1.2	----	1.1	----	----	----

Note: No. = Number of insect / 20 leaves and R% = Reduction percentage.

2. The citrus mealybug, *P. citri*:

As shown in Table (3), Dimethoate exhibited the highest reduction percentage after one week of application. On contrary, Mineral oil and Spirotetramat were the lowest effective insecticides after one week. But, after two weeks, Mineral oil exhibited relatively high reduction percentage in *P. citri* population and its effects gradually increased till the fourth week of treatment (Table, 3).

In general, Dimethoate showed the highest value of % reduction of *P. citri* followed by Imidacloprid and Thiamethoxam where their general mean reductions were 89.9, 82.9 and 82.3%, respectively. The other tested insecticides exhibited general mean reductions between 78.2 and 79.8%.

Table (3). Effect of certain insecticides against the citrus mealybug, *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae) on orange trees.

Treatment	Pre-spray	Mean number and % reduction after treatment (in weeks)									
		1		2		3				Mean	
		No.	R%	No.	R%	No.	R%	No.	R%	No.	R%
Thiamethoxam	6.8±1.1	2.2±0.8	68.8	1.8±0.8	80.1	1.0±0.8	86.8	0.4±0.8	93.6	1.6	82.3
Imidacloprid	6.0±1.0	2.0±0.7	67.9	1.6±0.5	80.0	0.6±0.5	91.0	0.4±0.5	92.8	1.4	82.9
Spirotetramat	6.6±1.5	3.0±1.0	56.2	2.2±1.1	75.0	0.6±0.8	91.8	0.6±0.8	90.2	1.6	78.2
Sulfoxaflor	5.4±1.5	2.0±1.0	64.3	1.6±1.3	77.8	0.8±0.8	86.7	0.6±0.5	88.8	1.3	78.3
Buprofezin	5.8±0.8	2.0±0.7	66.7	2.0±1.0	74.1	0.8±0.4	87.6	0.4±0.5	92.6	1.3	79.8
Dimethoate	8.0±0.7	1.8±0.7	78.3	1.0±0.7	90.6	0.6±0.5	93.2	0.2±0.4	97.3	0.9	89.9
Phosmet	6.2±1.3	2.2±0.8	65.8	2.0±1.0	75.8	0.8±0.8	88.4	0.6±0.8	89.5	1.4	79.7
Mineral oil	4.4±0.5	2.1±0.5	54.0	1.0±0.7	83.0	0.6±0.5	87.7	0.4±0.5	90.2	0.8	78.7
Control	5.4±1.3	5.6±1.5	----	7.2±1.8	----	6.0±1.2	----	5.0±1.0	----	6.0	----
L.S.D.$_{P=5\%}$	1.5	1.1	----	1.3	----	1.0	----	0.9	----	----	----

Note: No. = Number of insect / 10 twigs and R% = Reduction percentage.

3. The purple scale insect, *L. beckii*:

After two weeks of treatment, Dimethoate and Phosmet exhibited the highest reduction percentages; while, Mineral oil exhibited the lowest one. After eight weeks, Phosmet ranked the highest insecticide against *L. beckii*

population followed by Mineral oil (reduction percentages were 94.4 and 91.1%) (Table, 4).

The obtained results showed that both Dimethoate and Phosmet recorded the highest values of general mean of % reduction in *L. beckii* population of 90.8 and 90.7%, respectively. The other tested treatments exhibited general mean reductions between 82.5 and 88.7% (Table, 4).

Table (4). Effect of certain insecticides against the purple scale, *Lepidosaphes beckii* (Newman) (Homoptera: Diaspididae) on orange trees.

Treatment	Pre-spray	Mean number and % reduction after treatment (in weeks)									
		2		4		6		8		Mean	
		No.	R%	No.	R%	No.	R%	No.	R%	No.	R%
Thiamethoxam	16.0±4.5	4.2±0.8	79.3	2.6±0.5	89.0	1.4±0.5	94.5	2.6±0.9	90.2	2.7	88.7
Imidacloprid	13.0±3.5	4.2±1.3	74.6	2.8±1.1	85.4	1.8±0.8	91.4	2.8±0.8	87.0	2.9	85.1
Spirotetramat	16.0±4.3	4.4±1.1	78.3	3.2±0.8	86.5	2.2±0.8	91.4	2.8±0.8	89.4	3.2	86.7
Sulfoxaflor	14.6±4.2	4.0±1.2	78.4	2.6±0.5	87.9	1.8±0.8	92.3	2.4±0.5	90.0	2.7	87.7
Buprofezin	14.2±2.9	4.2±0.8	76.7	2.8±1.3	86.6	1.6±0.9	93.0	2.6±0.9	88.9	2.8	86.9
Dimethoate	16.0±4.3	2.8±0.8	86.2	2.2±0.8	90.7	1.4±0.5	94.5	2.4±0.5	90.9	2.2	90.8
Phosmet	17.2±2.3	3.6±0.9	83.5	2.4±1.1	90.5	1.8±0.8	93.5	1.6±0.6	94.4	2.4	90.7
Mineral oil	12.2±1.8	4.8±0.8	69.0	3.6±0.5	80.0	2.4±1.1	87.7	1.8±0.6	91.1	3.2	82.5
Control	12.6±1.5	16.0±2.7	----	18.6±2.4	----	20.2±1.9	----	20.8±2.2	----	18.9	----
L.S.D.$_{P=5\%}$	4.4	1.7	----	1.5	----	1.3	----	1.3	----	----	----

Note: No. = Number of insect / 20 leaves and R% = Reduction percentage.

Table (5). Effect of certain insecticides against the Florida wax scale, *Ceroplastes floridensis* Comstock (Homoptera: Coccidae) on orange trees.

Treatment	Pre-spray	Mean number and % reduction after treatment (in weeks)									
		2		4		6		8		Mean	
		No.	R%	No.	R%	No.	R%	No.	R%	No.	R%
Thiamethoxam	8.0±1.0	2.2±0.8	73.2	1.2±0.8	85.0	0.6±0.9	93.2	0.2±0.4	97.7	1.1	86.9
Imidacloprid	8.2±2.9	2.2±0.8	73.9	1.4±0.5	82.9	0.8±0.8	91.2	0.4±0.5	95.5	1.2	86.1
Spirotetramat	7.0±2.1	3.2±0.8	55.5	1.2±0.8	82.9	0.8±0.8	89.7	0.6±0.5	92.1	1.5	79.6
Sulfoxaflor	7.6±1.5	3.0±0.7	61.5	1.6±0.5	78.9	0.8±0.8	90.5	0.8±0.8	90.2	1.6	80.0
Buprofezin	7.2±2.2	2.4±1.1	67.5	1.2±1.3	83.3	0.6±0.5	92.5	0.4±0.5	94.9	1.2	84.2
Dimethoate	7.8±1.8	2.0±0.7	75.0	0.8±0.8	89.7	0.2±0.4	97.7	0.2±0.4	97.6	0.8	90.2
Phosmet	8.8±1.6	2.6±1.1	71.2	1.6±1.1	81.8	0.8±0.8	91.8	0.6±0.9	93.7	1.4	84.9
Mineral oil	7.0±1.2	3.0±0.7	58.2	1.6±0.5	77.1	0.4±0.9	94.8	0.4±0.9	94.7	1.4	81.0
Control	7.6±1.1	7.8±1.6	----	7.6±2.5	----	8.4±1.5	----	8.2±1.3	----	8.0	----
L.S.D.$_{P=5\%}$	2.3	1.3	----	1.5	----	1.1	----	1.0	----	----	----

Note: No. = Number of insect / 10 twigs and R% = Reduction percentage.

4. The Florida wax scale, *C. floridensis*:

Dimethoate, Imidacloprid and Thiamethoxam were the most effective insecticides after two weeks of treatment. While, Mineral oil and Spirotetramat were the lowest treatments after the same period. After eight weeks of treatment, Thiamethoxam and Dimethoate were the most effective treatments against *C. floridensis* population (Table, 5).

Data illustrated in Table (5) indicate that Dimethoate was the best compound against *C. floridensis* recording general mean reduction percentage of 90.2% followed by Thiamethoxam (86.9%) and Imidacloprid (86.1%). While, Spirotetramat showed the lowest general mean reduction percentage (79.6%).

Discussion

The present study was conducted to evaluate the efficacy of Thiamethoxam, Imidacloprid, Spirotetramat, Sulfoxaflor, Buprofezin, Dimethoate, Phosmet and Mineral oil against some pests (*P. citrella*, *P. citri*, *L. beckii* and *C. floridensis*) infesting orange trees under field conditions.

The obtained data showed that Thiamethoxam and Imidacloprid were the most effective treatments in controlling *P. citrella*. These results are in agreements with Raga *et al.* (2001) and Latif *et al.* (2013). They reported that Thiamethoxam and Imidacloprid significantly reduced the *P. citrella* population on citrus leaves. Salas *et al.* (2006) also conducted experiment to control *P. citrella* in nursery lemon plants with systemic insecticides. They concluded that *P. citrella* control with systemic insecticides such as Imidacloprid and Thiamethoxam was possible because they gave good control.

After one week of treatment, Thiamethoxam exhibited high reduction percentage of *P. citrella* population. Also, Latif *et al.* (2013) stated that Thiamethoxam showed a significant reduction of *P. citrella* larvae after five days of application.

With respect to the citrus mealybug, *P. citri*, all used insecticides had negative effect on its population. Dimethoate, Imidacloprid and Thiamethoxam were the highest effective insecticides against this pest; while, Spirotetramat recorded a relatively low effects against *P. citri*. According to Willmott (2012), Thiamethoxam, a neonicotinoid-based insecticide, provided the highest *P. citri* mortality. Also, Castle and Prabhaker (2011) reported that there was a significant difference between water control and both Thiamethoxam and Imidacloprid treatments against pink hibiscus mealybug, *Maconellicoccus hirstus* (Green). Moreover, the same authors reported no significant differences between Thiamethoxam and Imidacloprid. On another hand, Kahramanoglu and Usanmaz (2013) reported that the organophosphorus, Chlorpyrifos-ethyl is commonly used for control of *P. citri* also, added that Spirotetramat had a significant effect on *P. citri* population. While, Satar *et al.* (2013) recorded that Spirotetramat have lesser effect on *P. citri* than Imidacloprid, Chlorpyrifos-ethyhl, Buprofezin and summer oil. Also, they added that all of these treatments have significant effects on *P. citri*.

The highest effect of Imidacloprid and Thiamethoxam had been recorded after 3-4 weeks of treatment. Also, previous results reported that the highest effects of neonicotinoid-based insecticides on mealybugs were recorded after 3 weeks (Willmott, 2012) and 4 weeks of treatment (Castle and Prabhaker, 2011). Despite this, in these studies, the treatments took 3-4 weeks before the highest mortality was observed, which suggest that factors such as water solubility and plant growth rate may affect translocation, thus

influencing the efficacy of systemic insecticides. For instance, the water solubility of Imidacloprid is 0.6 g/L at 20°C whereas the water solubility of Thiamethoxam is 4.1 g/L at 20°C (Jeschke *et al.*, 2011). Therefore, Thiamethoxam may have been absorbed and translocated throughout the plants more rapidly than Imidacloprid.

The highest effective treatments on scale insects (*L. beckii* and *C. floridensis*) were those of Dimethoate, Phosmet, Thiamethoxam and Imidacloprid, respectively. These results come in agreement with those obtained by Helmy and Tawfik (1989); found that organophosphorus insecticides had high effects against *L. beckii* on orange trees. Also, Leibee and Savage (1994) mentioned that Dimethoate was the highest effective treatment against the diaspidid, *Pseudaulacaspis cockerelli* (Cooley). Dewer *et al.* (2012) stated that using of IGRs reduced the target pests, *L. beckii* and California red scale, *Aonidiella aurantii* Maskell. According to Hassan and Radwan (2014), the effect of the organophosphorus, Chlorpyrifos methyl was more effective in controlling the black parlatoria, *Parlatoria ziziphi* (Lucas) in comparison with Imidacloprid and Thiamethoxam. Also they added that the effect of insecticides on the total populations showed gradual decrease in density by the time elapsed from spraying. These results come with same line of the present results.

Some of the newer insecticides, such as Thiamethoxam, Imidacloprid Spinosad, Indoxacarb and Emamectin benzoate, have been shown to be relatively safe on predacious hemipterans, mites, coccinellids, lacewings and some parasitoids (Elzen, 2001). So, by using Thiamethoxam and Imidacloprid which give high reduction percentages in *P. citrella*, *P. citri*, *L. beckii* and *C. floridensis* populations not only protects our natural enemies but also our environment.

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التقييم الحقلي لبعض المبيدات الحشرية ضد بعض الآفات الحشرية التي تصيب أشجار البرتقال

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تهدف تلك الدراسة إلى تقييم كفاءة بعض المبيدات وهي ثيامثوكسام، اميداكلوبراید، اسبيروتترامات، سلفوكسافلور، بيبروفيزين، دايمثويت، فوسمت و الزيت المعدني ضد صانعة انفاق أوراق الموالح، بق الموالح الدقيقي، حشرة الموالح الشمعية، حشرة الموالح الارجوانية على اشجار البرتقال تحت الظروف الحقلية. وقد تم اجراء التجارب بالمزرعة البحثية لكلية الزراعة – جامعة المنصورة بمحافظة الدقهلية – مصر. وقد أوضحت النتائج أن ثيامثوكسام كان الأعلى كفاءة ضد حشرة صانعة انفاق أوراق الوالح يلية اميداكلوبراید ثم سلفوكسافلور و دايمثويت. أما على بق الموالح الدقيقي فقد كان دايمثويت هو الأعلى كفاءة في خفض التعداد يليه اميداكلوبراید وثيامثوكسام. كما أوضحت النتائج أن دايمثويت كان الأعلى كفاءة في خفض تعداد حشرة الموالح الارجوانية يليه فوسمت. أيضاً كان دايمثويت الأعلى كفاءة ضد حشرة الموالح الشمعية يليه ثيامثوكسام ثم اميداكلوبراید.