Comparative Toxicity of Five Pesticides Against *Tetranychus urticae* (Koch), *Myzus persicae* (Sulzer) and *Aphis nerii* (Boyer de Fonscolombe)

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ABSTRACT

Contact toxicity assay of chlorpyrifos, profenofos, deltamethrin, lambda-cyhalothrin and spinosad were tested against three species of arthropod pests; the two-spotted spider mite *Tetranychus urticae*, the oleander aphid *Aphis nerii* and the green peach aphid *Myzus persicae* under laboratory conditions. The biological assessment was carried out using a slide-dip technique. The results of the acaricidal activity showed that lambda-cyhalothrin and spinosad caused the highest toxicity against *T. urticae* with LC_{50} of 4.88 and 6.72 $mg.L^{-1}$, respectively, followed by chlorpyrifos, deltamethrin and profenofos (LC_{50} = 11.44, 12.86 and 16.47 $mg.L^{-1}$, respectively). Based on the toxicity index values, it is quite clear that the toxicity of lambda-cyhalothrin against *T. urticae* was 1.3 fold more toxic than spinosad and 2.3 and 2.6 fold more toxic than chlropyrifos and deltamethrin, respectively. The results of the aphicidal activity showed that deltamethrin has a high toxic effect against *A. nerii* and *M. persicae* with LC_{50} of 0.31 and 1.11 $mg.L^{-1}$, respectively whereas, spinosad was the least toxic one (LC_{50} = 22.13 and 30.92 $mg.L^{-1}$, respectively). Based on the toxicity index, it is apparent that deltamethrin is the most potent compound against *A. nerii* followed by lambda-cyhalothrin, chlorpyrifos, profenofos, and spinosad with toxicity index values of 100, 34.04, 3.95, 3.47 and 1.40 but followed by lambda-cyhalothrin, profenofos, chlorpyrifos and spinosad against *M. persicae* with toxicity index values of 100, 42.52, 27.61, 9.07 and 3.59, respectively. *M. persicae* was relatively more tolerant than *A. nerii* to profenofos, spinosad, chlorpyrifos, lambda-cyhalothrin and deltamethrin with tolerance level of 0.45, 1.40, 1.56, 2.87 and 3.58, respectively.

Key words: acaricidal activity, aphicidal activity, *Tetranychus urticae*, *Aphis nerii*, *Myzus persicae*

INTRODUCTION

Mites and aphids are considered the most important sucking pests that attacking agricultural crops (Taha *et al*., 2001, Slosser *et al*., 2002 and FAO, 2008). They cause a great damage through their feeding and draining of the plant sap from various plant parts. In addition to damages, they caused directly through feeding behavior, the sooty mold induced by the great amount of aphid honeydew (Butler and Henneberry, 1986, Harris *et al.*, 1992, Bridges *et al*., 2001, Liu and Yue, 2001, Gray and Gildow, 2003 and Rana, 2005).

The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) is a serious pest and responsible for significant yield losses in many horticultural, ornamental and agricultural crops including cotton, corn, soybeans and many orchard crops (Helle and Sabelis, 1985, Nachman and Zemek, 2002 and Zhang, 2003). It ingests leaf cell contents, thus reducing plant photosynthesis (Park and Lee, 2002), and potentially decreasing fruit quality and yield (Flaherty and Wilson, 1999). It causes direct effects include small spots on the upper side of the leaf due to chlorophyll depletion, webbing, defoliation; necrosis may occur in young leaves and stems or even the death of the plant (Brandenburg and Kennedy, 1987).

The peach-potato aphid *Myzus persicae* Sulzer (Hemiptera: Aphididae) is a small green aphid. It is the most significant aphid pest of peaches, cuasing shrivelling of the leaves and necrosis of various tissues. Moreover, it is a serious pest on a wide range of other agricultural and horticultural crops due to its ability to transmit virus diseases and to cause substantial direct damage (Foster *et al.,* 2000). The oleander aphid *Aphis nerii* Boyer de Fonscolombe (Hemiptera: Aphididae), sometimes called the milkweed aphid, is a common pest of several ornamental plants in the families Apocynaceae and Asclepiadaceae. It is bright yellow with black legs and usually appears in late spring. It ingests sap from the phloem of its host plant and the damage caused by aphid colonies is mainly aesthetic due to the large amounts of sticky honeydew produced and the resulting black sooty mold that grows on the honeydew. In addition, the growing terminals can be deformed. It is able also to transmit several viruses including sugarcane mosaic and papaya ring spot potyvirus (Hall and Ehler, 1980 and Blackman and Eastop, 2000).

The control of aphid pests measures have largely been depending on the use of chemical pesticides including chlorinated hydrocarbons and organophosphates, carbamates (Blackman and Eastop, 2000, Shetlar, 2001 and Han and Li, 2004). However, the most widely used methods for controlling *T. urticae* are based on the application of natural and synthetic acaricides (Basta and Spooner-Hart, 2002, Chiasson *et al.,* 2004, Choi *et al.,* 2004 and Calmasur *et al.,* 2006).

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One of the major problems in the control of such pests is their ability to rapidly develop resistance to many pesticides (Foster *et al.,* 2000, Devine *et al.,* 2001, Herron *et al.,* 2001 and Li *et al.,* 2003).

Therefore, this paper describes a laboratory study that assessed the potential of certain pesticides including two organophosphates (chlorpyrifos and profenofos), two pyrethroids (deltamethrin and lambda-cyhalothrin) and a microbial pesticide (spinosad) against three species of arthropod pests; the two-spotted spider mite (*T. urticae*), the oleander aphid (*A. nerii*) and the green peach aphid (*M. persicae*).

MATERIALS AND METHODS

Tested compounds

Five commercial pesticides were used and the dosages were calculated on the basis of active ingredient as $mg.L^{-1}$. Common names, trade names, chemical names and formulations for the tested insecticides are shown in Table 1.

Test Pests

Three species of arthropod pests tested in this study included the adult females of two-spotted spider mite *T. urticae* Koch (Acari: Tetranychidae), the oleander aphid *A. nerii* Boyer de Fonscolombe (Hemiptera: Aphididae) and the green peach aphid *M. persicae* Sulzer (Hemiptera: Aphididae). A colony of *T. urticae* was obtained from a culture maintained in Pesticide Chemistry Department, Faculty of Agriculture, Alexandria University and was reared on caster-oil plant *Ricinus communis* L., leaves and kept under laboratory conditions at 26 ± 2°C and 65 ± 5% R.H. with a 12:12 light:dark photoperiod. Samples of *A. nerii* and *M. persicae* were collected from the infested plants of the peach orchard and oleander plants, respectively and tested directly without further rearing.

Toxicity bioassay

To measure the toxicity of the tested compounds against *T. urticae, A. nerii* and *M. persicae*, the FAO recommended slide-dip method with a little modification was used (Anonymous 1980). Twenty adult of the test aphid or mite were placed on their dorsum with a fine brush on a double-side adhesive tape on a glass slide. The insecticides were dissolved in distilled water to obtain a series of concentrations (ranged from 1 to 250 $mg.L^{-1}$). The slides were dipped in a test solution for 5 seconds. Three replicates with three slides were maintained for each treatment and control. The slides were placed in a chamber at 26 ± 2°C and 65 ± 5% R.H., with a 12:12 light : dark photoperiod. Mortality was determined 24 h after treatment under a microscope and corrected mortality (%) was calculated using Abbott's formula (Abbott, 1925). LC_{50} values were calculated according to Finney (1971). Toxicity index of the tested compounds was determined according to Sun (1950) as follow:

$$\text{Toxicity index} = \frac{LC_{50} \text{ of the most effective compound}}{LC_{50} \text{ of the tested compound}} \times 100$$

The tolerance level for each compound against aphid species was calculated as follow:

$$\text{Tolerance level} = \frac{LC_{50} \text{ value of } \textit{M. persicae} \text{ of any compound}}{LC_{50} \text{ value of } \textit{A. nerii} \text{ of the same compound}}$$

Statistical analysis

Statistical analysis was performed by a SPSS software version 12.0 (Statistical Package for Social Sciences, USA). The values of LC_{50} were considered to be significantly different if the 95% confidence limits did not overlap.

Table 1. The commercial pesticides used in bioassays

Common name	Trade name	Chemical name	Formulation
Klorozd	Chlorpyrifos	*O,O*-diethyl-*O*-(3,5,6-trichloro-2-pyridyl) phosphorothioate	48% EC (KZ Co.)
Selean	Profenofos	*O*-(4-bromo-2-chlorophenyl)-*O*-ethyl-*S*-propyl phosphorothioate	72% EC (KZ Co.)
Kafrothrin	Deltamethrin	(*S*)-α-cyano-3-phenoxybenzyl (*1R,3R*)-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane carboxylate	2.5% EC (KZ Co.)
Lmdathrin	Lambda-cyhalothrin	(*S*)-α-cyano-3-phenoxybenzyl (Z)-(*1R,3R*)-3-(2-chloro-3,3,3-trifluoro-1-propenyl)-2,2-dimethylcyclopropane carboxylate)	5% EC (KZ Co.)
Tracer	Spinosad	a mixture of spinosyns A and D that are tetracyclic-macrolide compounds produced by an actinomycete, *Saccharopolyspora spinosa*	24 % SC (Dow AgroSciences)

RESULTS AND DISCUSSIONS

Acaricidal activity against *T. urticae*

The data of the acaricidal activity of the tested insecticides against *T. urticae* are presented in Table 2. Based on the LC_{50} values, all of the compounds showed a varied degree of the toxicity. Lambda-cyhalothrin, as a pyrethroid, caused the highest acaricidal activity (LC_{50} = 4.88 mg.L^{-1}) followed by spinosad, chlropyrifos, deltamethrin and profenofos (LC_{50} = 6.72, 11.44, 12.86 and 16.47 mg.L^{-1}, respectively). Concerning on the toxicity index values (Table 2), it is quite clear that the toxicity of lambda-cyhalothrin against *T. urticae* was 1.3 fold more toxic than spinosad and 2.3 and 2.6 fold more toxic than chlropyrifos and deltamethrin, respectively. While the toxicity of lambda-cyhalothrin was 3.3 fold more toxic than profenofos.

The current results are in agreement with the previous finding of many investigators. For example, McKee and Knowles, (1985) reported that FMC-54800 [1,1′-biphenyl-3yl methyl *cis*-3-(2-chloro-3,3,3-trifluoro-1-propenyl)-2,2-dimethyl cyclopropane carboxylate], as a pyrethroid, gave the most toxic effect to *T. urticae* based on both respiration and mortality studies, while permethrin, fenvalerate and fluvalinate were intermediate in pharmacokinetic efficiency. Marshall and Pree, (1991) found that the fenpropathrin at the field rate, was highly toxic to nymphs and adults of the European red mite *Panonychus ulmi* (Koch) at 48 h where 98 and 100% of the *P. ulmi* nymphs and adults were killed, respectively. Recently, Ismail *et al.*, (2006) studied the effect of cypermethrin against *T. urticae* on three different host plants (castor bean, green bean and tomato) using leaf disc dip technique. They found that cypermethrin has a moderate toxic effect on the three host plants discs with LC_{50} of 166.9, 139.7 and 122.9 ppm for castor bean, green bean and tomato, respectively.

Our result also indicated that, chlorpyrifos has a moderate toxic effect (LC_{50} = 11.44 mg.L^{-1}) on the adult females of *T. urticae* comparing to the other insecticides. El-Khodary *et al.*, (2007) evaluated the toxicity of fenitrothion as an organophosphate, against the adult females of *T. urticae* under laboratory conditions. They found that fenitrothion has toxic effect against *T. urticae* with an LC_{50} of 411.22 ppm.

Spinosad is a novel insect control agent derived by fermentation of the actinomycete bacterium, *Saccharopolyspora spinosa.* The active ingredient is composed of two variants, spinosyn A and spinosyn D (Thompson *et al.*, 2000). Spinosad controls many caterpillar pests in some fruit and vegetables, thrips in tomatoes, peppers and ornamental cultivation and dipterous leaf miners in vegetables and ornamentals (Miles, 2003). Our results indicated that spinosad showed a high contact acaricidal activity against *T. urticae* (LC_{50} = 6.72 mg.L^{-1}). DeAmicis *et al.*, (1997) reported that this compound caused 100% mortality when applied directly to *T. urticae* at 400 ppm. El-Khodary *et al.*, (2007) added that biofly (*Beauvaria bassiana*) and agerin (*Bacillus thuringiensis*) as biopesticides were effective against the adult female of *T. urticae* with LC_{50} of 57857.8 conidia/ml and 103.2 ppm, respectively.

Aphicidal activity against *A. nerii* and *M. persicae*

The acute toxicity of chlorpyrifos, profenofos, deltamethrin, lambda-cyhalothrin and spinosad against *A. nerii* and *M. persicae* was examined under laboratory condition after 24 h and the data are shown in Tables 3 and 4, respectively. The results of *A. nerii* (Table 3) showed that the deltamethrin and lambda-cyhalothrin were the most toxic insecticides (LC_{50} = 0.31 and 0.91 mg.L^{-1}, respectively). Chlorpyrifos and profenofos, as organophosphates, were moderately toxic (LC_{50} = 7.84 and 8.94 mg.L^{-1}, respectively). However, spinosad was the least active one compared to the others (LC_{50} = 22.13 mg.L^{-1}).

Table 2. Toxicity of chlorpyrifos, profenofos, deltamethrin, lambda-cyhalothrin and spinosad to the adult females of *T. urticae* after 24 h of treatment

Insecticide	LC_{50} (mg.L^{-1})	95% confidence limits (mg.L^{-1})		Slope ± SE	Intercept ± S.E	Chi square (χ^2)	Toxicity index*
		Lower	Upper				
Chlorpyrifos	11.44	5.17	18.16	0.75±0.13	-0.79±0.2	0.02	42.66
Profenofos	16.47	1.56	33.09	1.04±0.30	-1.27±0.61	0.03	29.63
Deltamethrin	12.86	8.43	17.50	1.37±0.16	-1.52±0.26	0.02	37.95
Lambda-cyhalothrin	4.88	2.49	7.26	1.68±0.25	-1.15±0.34	0.85	100
Spinosad	6.72	3.10	9.79	1.47±0.29	-1.22±0.39	0.85	72.62

*Toxicity index was calculated with respect to Lambda-cyhalothrin as the most effective compound

Table 3. Toxicity of chlorpyrifos, profenofos, deltamethrin, lambda-cyhalothrin and spinosad against the *A. nerii* after 24 h of treatment

Insecticide	LC_{50} ($mg.L^{-1}$)	95% confidence limits ($mg.L^{-1}$)		Slope ± SE	Intercept ± S.E	Chi square (χ^2)	Toxicity index*
		Lower	Upper				
Chlorpyrifos	7.84	5.69	10.12	0.99±0.12	-0.85±0.12	1.22	3.95
Profenofos	8.94	6.33	12.99	0.87±0.11	-0.82±0.12	0.17	3.47
Deltamethrin	0.31	0.07	0.66	0.83±0.14	-0.42±0.12	0.16	100
Lambda-cyhalothrin	0.91	0.13	2.09	0.45±0.11	-0.02±0.11	0.10	34.07
Spinosad	22.13	15.80	28.60	1.14±0.18	-1.54±0.27	1.11	1.40

***** Toxicity index was calculated with respect to deltamethrin as the most effective compound

Based on the toxicity index values (Table 3), it is apparent that deltamethrin was the most potent compound against *A. nerii* followed by lambda-cyhalothrin with toxicity index values of 100 and 34.07, respectively. While chlorpyrifos and profenofos were slightly less toxic compounds with toxicity index of 3.95 and 3.47, respectively. However, spinosad was the least active one with a toxicity index of 1.40.

The data of the toxicity of the tested insecticides against *M. persicae* is presented in Table 4 showed that deltamethrin was also significantly the most toxic among the insecticides tested with LC_{50} of 1.11 $mg.L^{-1}$, followed by lambda-cyhalothrin and profenofos (LC_{50} = 2.61 and 4.02 $mg.L^{-1}$, respectively). However, chlorpyrifos proved to be slightly less toxic (LC_{50} = 12.23 $mg.L^{-1}$) and spinosad was the least toxic one (LC_{50} = 30.92 $mg.L^{-1}$).

Based on the toxicity index values (Table 4), the data revealed that deltamethrin was the highly toxic compound against *M. persicae* with a toxicity index of 100 followed by lambda-cyhalothrin with a toxicity index of 42.52. However, profenofos has a moderate toxic action with a toxicity index of 27.61. In addition, spinosad was the least toxic one with toxicity index of 3.59.

In addition, the tolerance level for each compound was calculated by dividing the LC_{50} value of *M. persicae* of any compound by the LC_{50} value of *A. nerii* of the same compound and the data are presented in Table 5. The data indicated that *M. persicae* was relatively more tolerant than *A. nerii* to profenofos, spinosad, chlorpyrifos, lambda-cyhalothrin and deltamethrin with tolerance levels of 0.45, 1.40, 1.56, 2.87 and 3.58, respectively.

Table 4. Toxicity of chlorpyrifos, profenofos, deltamethrin, lambda-cyhalothrin and spinosad against the *M. persicae* after 24 h of treatment

Insecticide	LC_{50} ($mg.L^{-1}$)	95% confidence limits ($mg.L^{-1}$)		Slope ± SE	Intercept ± S.E	Chi square (χ^2)	Toxicity index*
		Lower	Upper				
Chlorpyrifos	12.23	5.70	25.9	0.96±0.08	-1.05±0.12	3.95	9.07
Profenofos	4.02	2.95	5.25	1.14±0.10	-0.69±0.11	3.47	27.61
Deltamethrin	1.11	0.54	1.80	0.82±0.09	-0.04±0.11	100	100
Lambda-cyhalothrin	2.61	1.93	3.37	1.11±0.11	-0.46±0.10	34.07	42.52
Spinosad	30.92	21.65	42.95	0.92±0.81	-1.36±0.27	1.40	3.59

*****Toxicity index was calculated with respect to deltamethrin as the most effective compound

Table 5. LC_{50} values and the tolerance levels for *A. nerii* and *M. persicae* of the tested insecticides

Insecticide	LC_{50} ($mg.L^{-1}$) for *A. nerii*	LC_{50} ($mg.L^{-1}$) for *M. persicae*	Tolerance level* (LC_{50} ratio)
Chlorpyrifos	7.84	12.23	1.56
Profenofos	8.94	4.02	0.45
Deltamethrin	0.31	1.11	3.58
Lambda-cyhalothrin	0.91	2.61	2.87
Spinosad	22.13	30.92	1.40

*Tolerance level = LC_{50} of *M. persicae* / LC_{50} of *A. nerii*

From Tables 3 and 4, it can be noticed that deltamethrin and lambda-cyhalothrin had a highly toxic effect against the two species of aphids since LC_{50} were 0.31 and 0.91 $mg.L^{-1}$against *A. nerii* and 1.11 and 2.61 $mg.L^{-1}$ against *M. persicae*, respectively. Moreover, spinosad was the least toxic compound against the two aphid species used in this study. Our results showed that pyrethroids insecticides (deltamethrin and lambda-cyhalothrin) were more toxic than organophosphates insecticides (chlorpyrifos and profenofos) against the two tested aphid species. These results can be supported with those obtained by several investigators. For example, Khalequzzaman and Nahar, (2008) reported that the cypermethrin, as a pyrethroid, was the most toxic compound against aphids of *A. craccivora, A. gossypii*, *M. persicae* and *Lipaphis erysimi* showing LC_{50} as 12.55, 12.29, 12.55 and 12.10 $\mu g.cm^{-2}$, respectively. While, malathion, as an organophosphate, was the least toxic having LC_{50} of 327.97, 333.92, 305.26 and 313.77 $\mu g.cm^{-2}$ for *A. craccivora, A. gossypii*, *M. persicae* and *L. erysimi*, respectively. Mohamed *et al.,* (2006) investigated the pesticidal efficiency of Actellic [pirimiphos-methyl] at recommended rate of 385 cm^3/100 L and 38.5 cm^3/100 L against cabbage aphid (*Brevicoryne brassicae*) by spraying on highly infested cabbage plants and they found that this compound at the full recommended rate (385 cm^3/100 L) showed the highest efficacy against *B. brassicae*. In addition, El-Khodary *et al.,* (2007) reported that fenitrothion had a high toxic effect against *A. gossypii* with an LC_{50} value of 1.66 ppm.

When we consider the susceptibility of the aphids to the tested insecticides in our study, another point deserves attention; these compounds were more toxic on *A. nerii* than *M. persicae* as shown in Table 5 by tolerance levels. The obtained results are in agreement with those of Khalequzzaman and Nahar, (2008) who reported that azadirachtin had LC_{50} of 0.34 $\mu g.cm^{-2}$ for *A. gossypii* and 0.44 $\mu g.cm^{-2}$ for *M. persicae*. However, cypermethrin, as a pyrethroid, had LC_{50} of 12.29 and 12.55 $\mu g.cm^{-2}$ against *A. gossypii* and *M. persicae*, respectively.

CONCLUSION

The acute toxicity of chlorpyrifos, profenofos, deltamethrin, lambda-cyhalothrin and spinosad was tested against *T. urticae*, *A. nerii* and *M. persicae* using a slide-dip technique. The results of the acaricidal activity indicated that lambda-cyhalothrin and spinosad caused the highest toxicity against *T. urticae* followed by chlorpyrifos, deltamethrin and profenofos. Based on the toxicity index values, it was quite clear that the toxicity of lambda-cyhalothrin against *T. urticae* was 1.3 fold more toxic than spinosad and 2.3 and 2.6 fold more toxic than chlropyrifos and deltamethrin, respectively. The results of aphicidal activity showed that deltamethrin has a special position in aphid chemical control because of its high toxic effect and its high toxicity index against *A. nerii* and *M. persicae*. Based on the tolerance level, *M. persicae* was relatively more tolerant than *A. nerii* to profenofos, spinosad, chlorpyrifos, lambda-cyhalothrin and deltamethrin, respectively.

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الملخص العربي

السمية النسبية لخمس مبيدات ضد الإناث البالغة للعنكبوت الأحمر(تترانيكس يورتيكا) ومن التفلة (افيس نرياى) ومن الخوخ(ميزس برسيكا)

إنتصار إبراهيم ربيع

تم دراسة التأثير السام بالملامسة لبعض المبيدات مثل: الكلوربيرفوس والبروفينفوس والدلتامثرين واللامداسيالوثرين والمركب الطبيعى سبينوساد وذلك ضد بعض الآفات الماصة الحيوانية والحشرية مثل الإناث البالغة للعنكبوت الأحمر (تترانيكس يورتيكا) ومن التفلة (افيس نرياى) ومن الخوخ (ميزس برسيكا).

تم تقييم النشاط الإبادى الأكاروسى والحشرى بطريقة غمـــر الأوراق وذلك تحت الظروف المعملية وتم التعبير عن النتـــائج عـــن طريق التركيز المسبب لقتل ٥٠% من الأفراد المعاملة. أوضـــحت النتائج أن مبيد اللامداسيالوثرين والمركب الطبيعى سبينوساد أظهرا أعلى نشاط إبادى أكاروسى ضد الإناث البالغة للعنكبوت الأحمر حيث كانت قيمة التركيز الذى يقتل ٥٠% من الأفراد المعاملة هى ٤,٨٨ و ٦,٧٢ ملجم/مل على التوالى يليه مبيد الكلوربيريفوس والدلتامثرين ثم البروفينفوس ١١,٤٤، ١٢,٨٦و ١٦,٤٧ ملجم/مل على التوالى.

ومن ناحية التأثير الإبادى الحشرى ضد المن كان مبيد الدلتامثرين أعلى كفاءة إبادية ضد كل من افيس نرياى وميزس برسيكا بينما مبيد سبينوساد كان أقل المبيدات سمية. وكانت حشرة ميزس برسيكا أكثر تحملا من افيس نرياى بالنسبة للمبيدات البروفينفوس وسبينوساد وكلوربيريفوس واللامداسيالوثرين والدلتامثرين بمستوى تحمل ٠,٤٥ ، ١,٤٠ ، ١,٥٦ و ٣,٥٨ على التوالى.