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RESEARCH ARTICLE

Toxicity of three insecticides and some alternatives against cottony cushion scale, *Icerya purchasi* (Maskell) under laboratory conditions

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Abstract

On citrus leaves, a laboratory trial was conducted to test the effect of several compounds against the nymphs of the cottony cushion scale, *Icerya purchasi*, under laboratory conditions at Plant Protection Dept., Faculty of Agriculture, South Valley University, Qena governorate, Egypt. Two insecticides (thiamethoxam 25% and malathion 57%), mineral oil (active cable 2), three plant oils (clove oil, mint oil and ginger oil) and two plant extracts (garlic and moringa) were used. The results demonstrated that under laboratory circumstances, the investigated substances on *I. purchasi* were varied. The tested compounds could be descendingly arranged as follows: thiamethoxam 25%, malathion 57%, active cable 2, clove oil, mint oil, ginger oil, garlic and moringa. The corresponding LC_{50} values after 72 h. were 0.02, 0.24, 0.91, 3.11, 3.44, 4.17, 31.36 and 35.06 ppm. While, LC_{90} values were 0.10, 1.11, 4.56, 6.87, 7.92, 11.36, 121.96 and 178.86 ppm. Also, the insecticidal efficiency of thiamethoxam 25% and malathion 57% showed the highest toxicity against nymphs of scale insect on citrus leaves, while the plant extract, moringa showed the lowest effect.

Keywords: Citrus; Control; *Icerya Purchasi*; Insecticides; Mineral Oil; Plant Extracts.

1. Introduction

Pests infest citrus trees in diverse ways. The cottony cushion scale, *Icerya purchasi* (Maskell) (Hemiptera: Coccomorpha: Monophlebidae), is one of the most damaging citrus pests (Moursi *et al.*, 2013). This pest is a very polyphagous insect pest that feeds on 123 different plant species from 49 different plant families (Ben-Dov *et al.*, 2009). Feeding on host tissues and injecting poisons into host plants cause damage. Mealybugs also exude honeydew, that acts as a breeding ground for the fungus, which robs plants of their photosynthetic powers and kills them (Abd El-Gawad and Mangoud, 2004). Many insects attacking the tree's parts causes a significant loss of sap, resulting in dryness, early leaf drop and nutrient deprivation, ultimately reducing the quantity and quality of the fruit and reducing vitality of the tree (Mangoud, 2000). Controlling this scale with pesticide spray can be challenging due to their waxy hydrophobic covering, thus touch pesticides are the most effective. Controlling this pest using mineral oils is highly recommended, especially during the fruiting season. As a result, we should test alternative substances to mineral oils, such as plant oils, to manage the scale. (Franco *et al.*, 2009; Mangoud *et al.*, 2007). The aim of investigation is to evaluate the efficacy of new and conventional compounds against *I. purchasi* on citrus trees under laboratory conditions.

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2. Materials and methods

Toxicological studies were executed to study the toxicity effect of many chemical and non-chemical compounds against immature stages (nymphs) of the cottony cushion scale, *I. purchasi* on citrus leaves, under laboratory conditions at Plant Protection Dept., Faculty of Agriculture, South Valley University, Qena governorate, Egypt.

2.1. Insecticides

Three insecticides (trade name, formulation type, recommended rate and percentage of active ingredient) were used to evaluate their toxicity against the (nymphs) of the cottony cushion scale, *I. purchasi* under laboratory conditions Table (1).

Table 1. Insecticides used in the study.

Common name	Trade name	Type of Formulation	Recommended Rate	Conc.%
Thiamethoxam 25% WG	Actara	WG	25 gm/100 liter water	25
Malathion 57% EC	Malason	EC	100 cm^3/20 liter water	57
Mineral oil	Active cable 2	-	1 liter/100 liter water	-

2.2. Insecticide alternatives used in the study

Crude extracts of two plants [garlic (bulb), *Allium sativum* and moringa (seeds), *Moringa oleifera*] were prepared in the laboratory and three essential oils (clove, *Eugenia caryophyllus*; ginger, *Zingiber officinale* and mint, *Mentha varidis*. L) were bought from the local market used in this study to determine their toxicity against cottony cushion scale, *I. purchasi* nymphs through laboratory conditions.

2.2.1. Preparation of Allium sativum crude extract

Fresh garlic was obtained at a nearby market. The garlic extracts were obtained by sterilizing 100 g of cleaned garlic with ethanol. In a sterile laminar flow chamber, the ethanol was allowed to evaporate, and the garlic was homogenized aseptically with a sterile mortar and pestle. Using sterile cheese cloth, the extract was squeezed out aseptically (Indu *et al.,* 2006).

2.2.2. Preparation of Moringa oleifera seeds crude extract

The seed coat and wings of *M. oleifera* were manually removed from good quality dry seeds. Using the coffee mill attachment of the Moulinex household food blender, the kernel was ground to a fine powder. After that, the pulverized powder was sieved through a 210 m sieve. In an electro-thermal Soxhlet extractor, the seed powder was defatted with hexane. (Ali, 2010) examine the weight of 10 g of *M. oleifera* seed powder and placing it in the thimbles of the electro thermal Soxhlet extraction chamber with adding 170 mL of hexane to the heating chamber then evaporate it with hexane in three cycles for 30 minutes each to ensure oil extraction from the seeds (until the hexane became colorless); drying the *M. oleifera* cake residue from the Soxhlet thimbles. (Muyibi *et al.,* 2003) reported that the moringa seeds extract was made using the *M. oleifera* cake leftover stock after oil extraction. A measured amount of defatted moringa seed powder was dissolved in distilled water and made up to 1000 mL in a beaker. As described in the experimental design, the active components were extracted by mixing with a stirrer at a pre-set mixing speed for a pre-set mixing period. No. 1 Whatt-man filter paper was used to filter the mixture.

2.3. Collection of the insects

Immature stages (nymphs) of the cottony cushion scale, *I. purchasi*, on infested citrus leaves (Mandarin) were selected at random from an affected farm in Qena district, maintained in paper bags, and then transported to the laboratory to be tested for various pesticides and alternatives.

2.4. Bioassay experiment

The cottony cushion scale, *I. purchasi* nymphs was used in a laboratory experiment to see how different pesticides and their alternatives affected the cottony cushion scale, *I. purchasi* nymphs. In distilled water, three concentrations of each tested pesticide and its alternatives (three conc. per treatment) were created; for each concentration three replicates were utilized. The infected citrus leaves (Mandarin) were randomly collected and preserved in paper bags before being transported to the laboratory; thirty nymphs were utilised for each conc. (10 nymphs / duplicate). The leaves were dipped by the tested insecticides and their alternatives for 10 seconds, the control leaves put into water only and the leaves were left for dryness, the dried leaves were placed on a slightly moistened filter paper covering the bottom of petri dishes (8 cm diameter × 1.5 cm height). Ten nymphs of *I. purchasi* were carefully placed using a fine soft brush in each petri dishes and kept under laboratory conditions. Died nymphs were counted and recorded after 72 h (Shah *et al.*, 2016). Nymphs were considered as dead when they were not able to move back to the ventral position after being placed on their dorsum.

2.5. Statistical analysis

According to (Abbott, 1925), the average percentage of adjusted insect mortality for each conc. and control was computed.

$$\textbf{Corrected mortality percentage} = \left(\frac{M - M1}{100 - M1}\right) x\ 100$$

Where:

M = mortality percentage in treatment.

M1 = mortality percentage in control.

According to the method described by **(**Finney**,** 1971) the toxicity lines were statistically analyzed. From which the corresponding toxicity lines (Ldp Line Program) were estimated of the tested insecticides and their alternatives; LC_{50}, LC_{90}, Chi-square and slope values of tested compounds were estimated. Toxicity index (TI) were calculated according to (Sun, 1950).

Toxicity index = (LC_{50} of the most effective compound / LC_{50} of other tested compound) x 100.

3. Results and discussions

3.1. Toxicity of tested insecticides against nymphs of Icerya purchasi under laboratory conditions after 72 h

Data in Table (2) and Fig. (1) represented the relative toxicity of the toxic action of malathion 57%, thiamethoxam 25% and active cable 2 against nymphs of *Icerya purchasi* using leaf dipping method after 72 h.

Data clearly indicate that the tested insecticides could be descendingly arranged as follows: thiamethoxam 25% WG, malathion 57% EC and active cable2. Based on the LC_{50} values, thiamethoxam 25% was the most efficient among the tested insecticides with LC_{50} 0.02 ppm, the toxicity index was 100.00 %, followed by malathion 57% and active cable 2 with LC_{50} 0.24 and 0.91 ppm, respectively. (T.I) values at LC_{50} for these tested insecticides were 8.33 and 2.20, respectively.

Table 2. Toxicity of tested insecticides against *I. purchasi* nymphs under laboratory conditions after 72 h.

Insecticides	χ^2	LC_{50} *ppm	Confidence limits of LC_{50}'S *ppm		LC_{90} *ppm	Slope	Index (T.I.)
			Lower	Upper			
Thiamethoxam 25%WG	0.39	0.02	0.02	0.03	0.10	1.88 ±0.57	100
Malathion 57% EC	0.10	0.24	0.08	0.35	1.11	1.94 ±0.62	8.33
Active cable	0.18	0.91	0.56	1.33	4.56	1.83 ±0.57	2.20

T.I. - Toxicity index compared with thiamethoxam. Toxicity index= [(LC_{50} of the most toxic tested compound/LC_{50} of the tested compound) x 100]
χ^2 = Chi-square ***** = ppm based on a:i

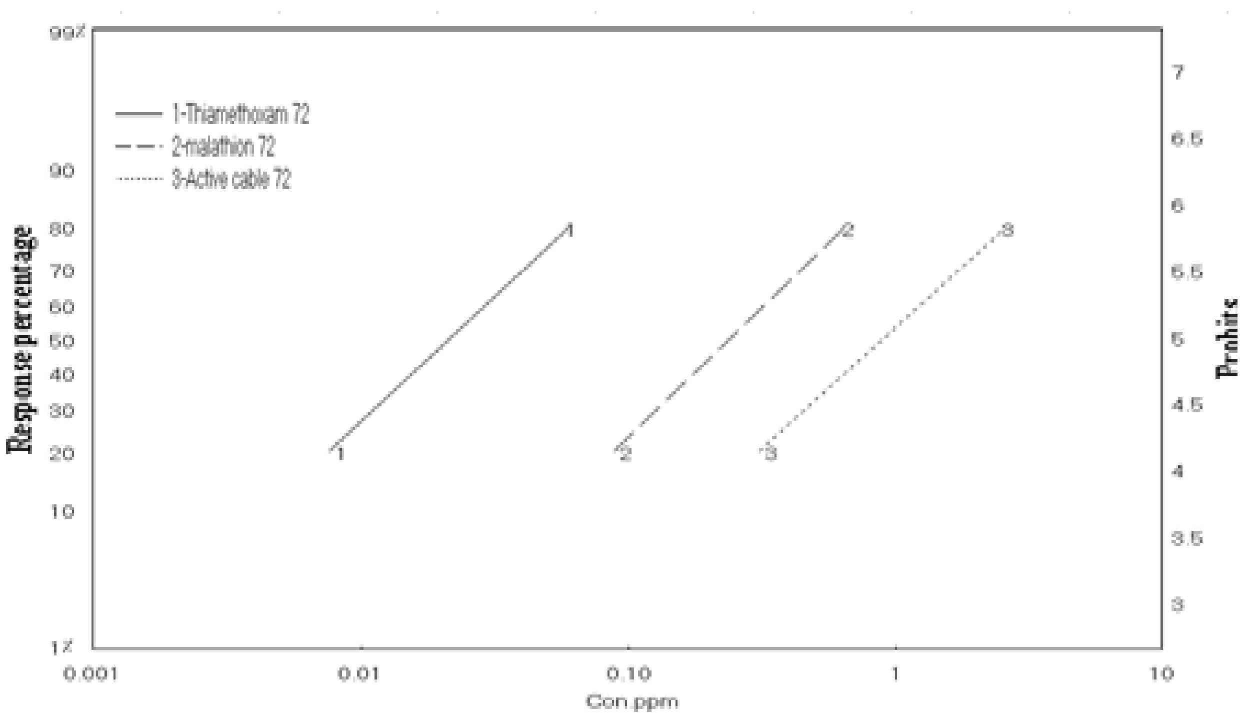

Figure 1. Toxicity lines of tested insecticides against *I. purchasi* nymphs under laboratory conditions after 72 h.

3.2. *Toxicity of alternatives of insecticides against nymphs of I. purchasi under laboratory conditions after 72 h.*

Data in Table (3) and Fig. (2) represented relative toxicity for toxic action of mint oil, clove oil, ginger oil, garlic and moringa against nymphs of *I. purchasi* using leaf dipping method after 72 h.

Data clearly indicate that the tested alternatives of insecticides could be descendingly arranged as follows: clove oil, mint oil, ginger oil, garlic and moringa. Clove oil was the most effective among the tested alternatives of insecticides with LC_{50} 3.11 ppm, the toxicity index at LC_{50} was 100.00 %, then mint oil, ginger oil, garlic and moringa with LC_{50} 3.44, 4.17, 31.36 and 35.06 ppm, consecutively. (T.I) values at LC_{50} for these tested alternatives were 90.41, 74.58, 9.92 and 8.87, respectively.

Table 3. Toxicity of alternatives of insecticides against *Icerya purchasi* nymphs under laboratory conditions after 72 h.

Treatments	χ^2	LC_{50} *ppm	Confidence limits of LC_{50}'S *ppm Lower	Upper	LC_{90} *ppm	Slope	Index (T.I.)
Clove oil	0.26	3.11	2.47	3.72	6.87	3.72 ±0.77	100
Mint oil	0.01	3.44	2.76	4.17	7.92	3.54 ±0.76	90.41
Ginger oil	0.09	4.17	3.32	5.55	11.36	2.94 ±0.75	74.58
Garlic	0.19	31.36	16.92	42.34	121.96	2.17 ±0.61	9.92
Moringa	0.02	35.06	16.80	49.58	178.86	1.81 ±0.58	8.87

T.I. - Toxicity index compared with clove oil χ^2 = Chi-square ***** = ppm based on a:i

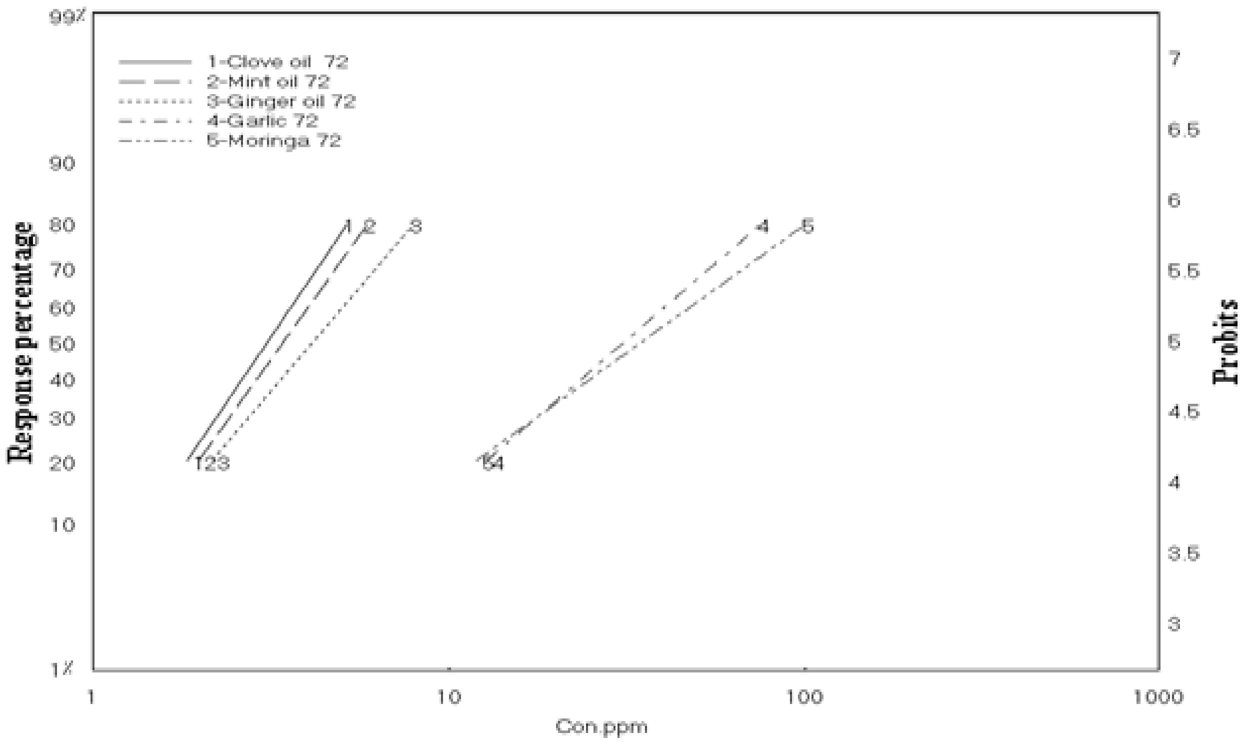

Figure 2. Toxicity lines of alternatives of insecticides against *I. purchasi* nymphs under laboratory conditions after 72 h.

It is also obvious, as shown in Table (2) and Figure (1), that thiamethoxam 25% had the steepest toxicity line and active cable 2 had the flattest, however malathion 57% lie in between. This reflects the superiority of thiamethoxam 25% and inferiority of active cabl2. On the other hand, as shown in Table (3) and Figure (2) clove oil had the steepest toxicity line and moringa extract had the flattest, however mint oil (plant oil), ginger oil (plant oil), and garlic extract lie in between. This reflects the superiority of clove oil and inferiority of moringa extract. These findings matched those of (Mangoud and Abd El-Gawad, 2004) in Egypt, recommended to reduce *Icerya purchasi* nymphs and adult females on citrus, using malathion at a rate of 2 ml/liter of water. (Suresh *et al.*, 2010) stated using pesticides such thiamethoxam 0.6 g/L, profenofos 50 percent EC 2 ml/L, chlorpyriphos 20 percent EC 2 ml/L and dimethaote 2 ml/L on a need-based basis. (Galanihe *et al.*, 2010) recommended thiamethoxam and imidacloprid insecticides for PMB control in Srilanka. (Mani and Shivaraju, 2016) clarified that normally, chemicals are used to control the mealybugs. However, the crawler stage is not covered with wax, and consequently, this is perhaps one of the most susceptible stages of mealybug to chemicals. In Egypt, (Mohamed and Bakry, 2018) found that mineral and plant oils were ineffective in suppressing *Icerya aegyptiaca* (Douglas) (Hemiptera: Monophlebidae) on citrus leaves. (Mandal and Ghosh, 2020) found that botanical extract of garlic 50.00 ml/L (5%) (48.73% reduction of mealy bug population). Plant essential oils (EOs) with adjuvant, according to (Mwanauta *et al.*, 2021), are a safe approach for papaya mealybug management because they contain a rich source of natural compounds that disintegrate the insect wax covering. (Mwanauta *et al.*, 2022) proposed using plant-based pesticides, mostly plant essential oils, and the benefits of doing so to encourage farmers to increase papaya yield while reducing chemical pesticide use to avoid PMB resistance. While, (Allam *et al.*, 2022) found that, Fenpyroximate, bifenazate, emamectin benzoate, buprofezin, sulphur, K. Z oil, and chilli AgNPs were effective in controlling *T. urticae* on tomato plants with mean reduction percentages of infestation of 76.91, 67.00, 71.64, 55.54, 69.40, 64.96, and 72.23 percent. In the 2018/2019 season, the means of infestation decrease percentages were 83.55, 80.55, 78.62, 77.30, 78.29, 73.20, and 72.37 percent, respectively.

4. Conclusion

Current study proved that thiamethoxam 25% and malathion 57% appear very toxic and efficiency against *I. purchasi* on citrus trees while the plant extract (moringa extract) gave low effect; it was unsuitable to control this pest. Also, the tested treatments on *I. purchasi* were different under laboratory conditions**.** It could be bested, thiamethoxam 25%wg at conc. 25gm /100 Liter water and malathion 57%EC with rate of 100 cm^3 per 20 L. water for controlling *I. purchasi* infested citrus trees. In other complete trials, the essential oil was found effective as an addition for traditional insecticides to control this insect, increasing their efficacy while decreasing their rate of administration.

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All Institutional Review Board Statements are confirmed and approved.
Data Availability Statement
Data presented in this study are available at fair request from the respective author.
Ethics Approval and Consent to Participate
This work carried out at the plant protection department and followed all the department instructions.
Consent for Publication
Not applicable.
Conflicts of Interest
The authors declare no conflict of interest.

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