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Toxicity assessment of certain insecticides on the red soft scale insect, *Pulvinaria tenuivalvata* (Newstead) infesting sugarcane plants

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A B S T R A C T

Pulvinaria tenuivalvata (Newstead) (Hemiptera: Coccidae) red soft scale insect is one of the most prevalent insect pests that attacks sugarcane plants. Insecticidal efficiency of six selected insecticides (Malatox, Sulfar, Admiral, Nomolt, Tafaban and Biover) was evaluated for their impact against nymphs and adult females of *P. tenuivalvata* on sugarcane leaves using leave dipping methods. This investigation was carried out for two successive seasons (July 2021-2022) at the laboratory of the Plant Protection Research Department at the El-Mattana Agricultural Research Station, Luxor Governorate, Egypt. Obtained results showed that the tested insecticides varied in efficacy on the different stages of pest (nymphs and adult females). Moreover, the nymphal stage of *P. tenuivalvata* was more susceptible to the tested pesticides compared to the adult stage. Admiral and nomolt were the most toxic against the nymphal and adult female stages of *P. tenuivalvata* on sugarcane leaves, sulfar, however, was the least successful in controlling this pest.

1. Introduction

Sugarcane, which accounts for 70% of all local sugar production, is Egypt's principal economic field crop and the main source of the sweetener. In addition, it is used to produce numerous chemicals, fresh juice, and molasses as byproducts.[1] The red-striped soft scale *Pulvinaria tenuivalvata* (Newstead) (Hemiptera: Coccidae) is a particularly harmful pest of sugarcane (*Saccharum officinarum* L.) recently recorded in Upper Egypt governorates.[2] At every stage of development, this bug has a deleterious effect on sugarcane. By sucking sap with its mouthparts, it weakens and deforms the affected plant, which in turn affects the number of leaves, fragile young internodes, the configuration of internodes, and plant mortality, all of which result in a significant loss of sugar. Indirect harm imposed on plant virus transmission. When present in high concentrations, *P. tenuivalvata* can weaken sensitive seedlings generally, make them dry, and even subdue them. Furthermore, the honeydew that bugs excrete can encourage the growth of soot fungi, which constrain photosynthesis.[3-6]

Consequently, it reduces sugarcane's quality and output economically. A 37% decrease in the percentages of extracted sugar was caused by *P. tenuivalvata* infection.[7] Because of their fast activity and great toxicity against *P. tenuivalvata* on sugarcane plants, chemical synthetic pesticides are one of the most popular and commonly used strategies for controlling the parasite in the globe.[7,8,2,9] The effectiveness of several pesticides against *P. tenuivalvata* nymphal and adult female stages that are infesting sugarcane leaves are being examined in the current study under laboratory conditions.

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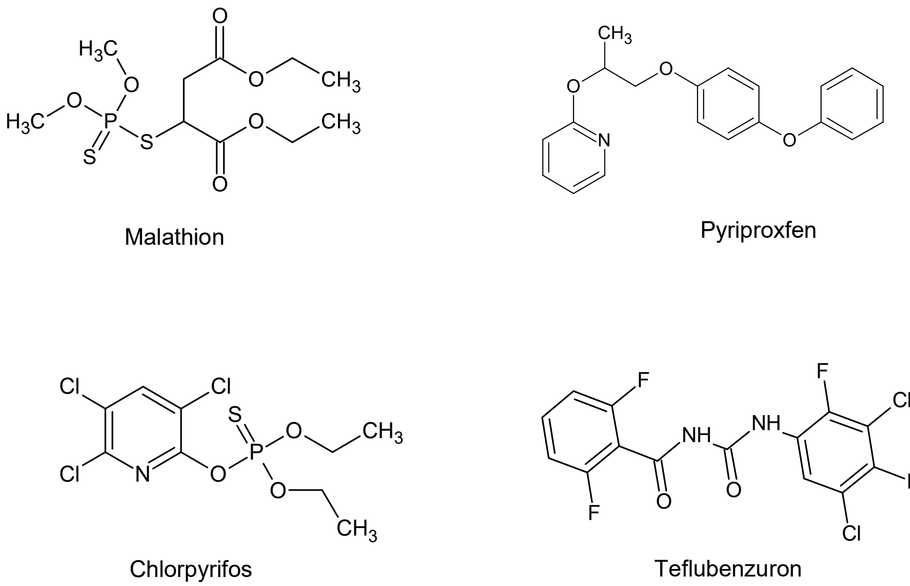
2. Materials and methods

Six chemical insecticides including malathion [(Malatox® 57% EC): diethyl-2-[(dimethoxyphosphorothioyl)sulfanyl]butanedioate], sulfur [(sulfur® 30% L, Pyriproxyfen (Admiral® 10% EC) 4-phenoxyphenyl-2-(2-pyridyloxy)propylether-2-[1-(4-Phenoxyphenoxy)propan-2-yloxy]pyridine], Teflubenzuron (Nomolt**®** 15% SC) *N*-[(3,5-dichloro-2,4-difluorophenyl) carbamoyl]-2,6-difluorobenzamide], Chlorpyrifos (Tafaban® 48%EC) *O,O*-diethyl-*O*-(3,5,6-trichloropyridin-2-yl)phosphorothioate and Biover (Biover® 10% WP) a bio-insecticide, containing 10% *Beauvaria bassiana* and 90 % inert ingredient, used at rate of 200 gm per 100 liter water were used to evaluate the toxicity of them against the red striped soft scale insect*, Pulivanaria tenuivalvata* (nymphs and adult females' stages) infesting sugarcane leaves at Esna district in Luxor Governorate, as shown in **Scheme 1**.



Scheme 1. The chemical structure of Malathion, Pyriproxyfen, Teflubenzuron and Chlorpyrifos.

Laboratory bioassay

Laboratory experiment was carried out to determine the toxicity of selected insecticides against the red striped soft scale insect*, P. tenuivalvata* (nymphs and adult female stages) infesting sugarcane leaves at Esna district in Luxor Governorate. The tested insecticides evaluated for two successive seasons (July 2021-2022) under laboratory conditions. The experiment was carried out in the laboratory of the Plant Protection Research Department at the El-Mattana Agricultural Research Station, Agricultural Research Center in Luxor Governorate.

Three replicates of each of the four concentrations of the tested pesticides were prepared in distilled water according to the manufacturer's recommendations. For each concentration, 30 infected leaves (10 leaves/replicate) were employed. Samples of infested sugarcane leaves with nymphs and adult females of *P. tenuivalvata* were collected randomly and kept in paper bags and then transferred to laboratory. The leave dipping method was applied for this experiment, leaves were dipped in each concentration of the tested insecticides for 30 seconds. Control treatment leaves were immersed in the water. Then the leaves were left to dry for 30 minutes**.** Mortality was recorded after 3 days.[10] The average percentage of corrected mortality of insects for each concentration and control was corrected according to the Abbott formula.[11]

$$\text{Corrected mortality percentage} = \left(1 - \frac{\text{No. in T after treatment}}{\text{No. in C after treatment}}\right) \times 100$$

where: T = Adults mortality percentage in treatment.

C = Adults mortality percentage in control.

Statistical analysis of lines of toxicity according to the technique depicted by Finney style.[12] From which the corresponding toxicity lines (Ld-P lines software) were estimated for the tested insecticides, LC_{50}, LC_{90}, and slope values of tested insecticide. Toxicity indexes were calculated according to Sun equations.[13]

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

3. Results and discussion

The toxic action of Malatox, Sulfur, Admiral, Nomolt**,** Tafaban, and Biover against nymphs and adult females of the red striped soft scale insect*, P. tenuivalvata* infesting sugarcane after 72 h under laboratory conditions is presented in **Table 1** and **Table 2** and **Fig. 1.**.

Table 1. Toxicity of the tested insecticides against nymphs stage of *P. tenuivalvata* infesting sugarcane leaves at Esna district in Luxor Governorate

Treatment	Lethal concentration LC_{50} (ppm) and their limits			Lethal concentration LC_{90} (ppm) and their limits			% Toxicity index at LC_{50}*	Resistance Ratio (RR)	Slope ± SE
	LC_{50}	Lower limit	Upper limit	LC_{90}	Lower limit	Upper limit			
Nymphs stage 1st season									
Malatox	0.198	0.083	0.3	3.264	1.367	52.872	82.323	1.215	1.052±0.292
Sulfar	1.267	0.816	2.030	16.113	5.985	588.062	12.865	7.773	1.161± 0.343
Admiral	0.163	0.058	0.252	2.617	1.169	33.97	100.00	1.000	1.062±0.296
Nomolt	0.17	0.056	0.267	3.234	1.314	73.914	95.882	1.043	1.001±0.293
Tafaban	0.258	0.015	0.557	7.431	3.412	134.980	63.178	1.583	0.878±0.278
Biover	0.404	0.179	0.581	2.331	1.601	5.503	40.347	2.479	1.684±0.394
Nymphs stage 2nd season									
Malatox	0.198	0.068	0.314	4.493	1.595	231.185	54.040	1.850	0.945±0.289
Sulfar	1.365	0.996	1.973	10.251	4.996	69.604	7.839	12.757	1.463 ± 0.351
Admiral	0.107	0.017	0.188	2.198	0.976	45.011	100.00	1.000	0.977±0.301
Nomolt	0.154	0.036	0.254	3.723	1.377	197.156	69.481	1.439	0.927±0.292
Tafaban	0.232	0.015	0.503	5.405	2.755	51.574	46.121	2.168	0.937±0.287
Biover	0.307	0.097	0.483	1.984	1.391	4.387	34.853	2.869	1.580±0.390

*Toxicity index = (LC50 of the most effective insecticide / LC50 of other tested insecticide) ×100.

Table 2. Toxicity of the tested insecticides against adult females' stage of *P. tenuivalvata* infesting sugarcane leaves at Esna district in Luxor Governorate

Treatment	Lethal concentration LC50 (ppm) and their limits			Lethal concentration LC90 (ppm) and their limits			% Toxicity index at LC50	Resistance Ratio (RR)	Slope ± SE
	LC50	Lower limit	Upper limit	LC90	Lower limit	Upper limit			
Adult females stage 1st season									
Malatox	0.415	0.096	0.665	5.396	2.711	63.443	88.675	1.128	1.150±0.347
Sulfar	1.125	0.737	1.620	10.877	4.889	125.299	32.711	3.057	1.301±0.347
Admiral	0.368	0.204	0.698	9.968	2.616	2727.028	100.00	1.00	0.895±0.285
Nomolt	0.381	0.239	0.643	6.477	2.213	212.046	96.588	1.035	1.042±0.288
Tafaban	0.536	0.345	1.218	10.751	2.979	1090.448	68.657	1.457	0.984±0.289
Biover	0.961	0.298	1.668	41.239	10.724	12667.199	38.293	2.611	0.785±0.253
Adult females stage 2nd season									
Malatox	0.579	0.361	1.622	14.475	3.396	5446.311	68.221	1.466	0.917±0.288
Sulfar	1.596	1.144	2.653	14.976	6.167	223.947	24.749	4.041	1.318±0.348
Admiral	0.395	0.255	0.657	5.982	2.158	136.974	100.00	1.000	1.085±0.289
Nomolt	0.436	0.088	0.707	6.776	3.091	154.973	90.596	1.104	1.076±0.341
Tafaban	0.582	0.363	1.649	14.629	3.414	5716.10	67.869	1.473	0.915±0.287
Biover	1.142	0.461	1.978	42.970	11.399	8195.265	34.588	2.891	0.813±0.253

3.1. Nymphs stage of Pulvinaria tenuivalvata:

The different potencies of certain compounds by different concentrations against the nymphs of *P. tenuivalvata* during the two seasons are shown in **Table 1**, and **Fig. 1(A)**, this reduction gradually increased by increasing the used concentration. Data clearly indicated that in the first season Admiral was found to be the highly potent compound with an LC_{50} value 0.163 ±(0.058-0.252) and a toxicity index of 100%, followed by Nomolt, Malatox, Tafaban, Biover, and Sulfar, respectively. The corresponding LC_{50} values were 0.17± (0.056-0.267), 0.198± (0.083-0.3), 0.258 ± (0.015-0.557), 0.404 ± (0.179-0.581) and

1.267 ± (0.816-2.030) ppm, respectively. The toxicity indexes were 95.882%, 82.323%, 63.178%, 40.347% and 12.865%, respectively.

In the second season the toxicities of the tested compounds were the same, whereas Admiral was the most effective with LC_{50} value 0.107 ± (0.017-0.188), followed by Nomolt with LC_{50} value 0.154 ± (0.036-0.254), then Malatox with LC_{50} value 0.198 ± (0.068-0.314), followed by Tafaban with LC_{50} value 0.232 ± (0.015-0.503), then Biover with LC_{50} value 0.307± (0.097-0.483), followed by Sulfar with LC_{50} value 1.365 ± (0.996-1.973). On the other hand, the toxicity indexes of these compounds according to theirLC_{50} values were 100%, 69.481%, 54.040%, 46.121%, 34.853%, and 7.839%, respectively.

Slope values of the log concentration-propit lines in **Table 1** indicated that in the first season Biover has the highest slope value of 1.684. While Tafaban has the lowest slope value of 0.878. For the second season, Biover has the highest slope value of 1.580. However, Nomolt insecticide had the lowest slope value of 0.927.

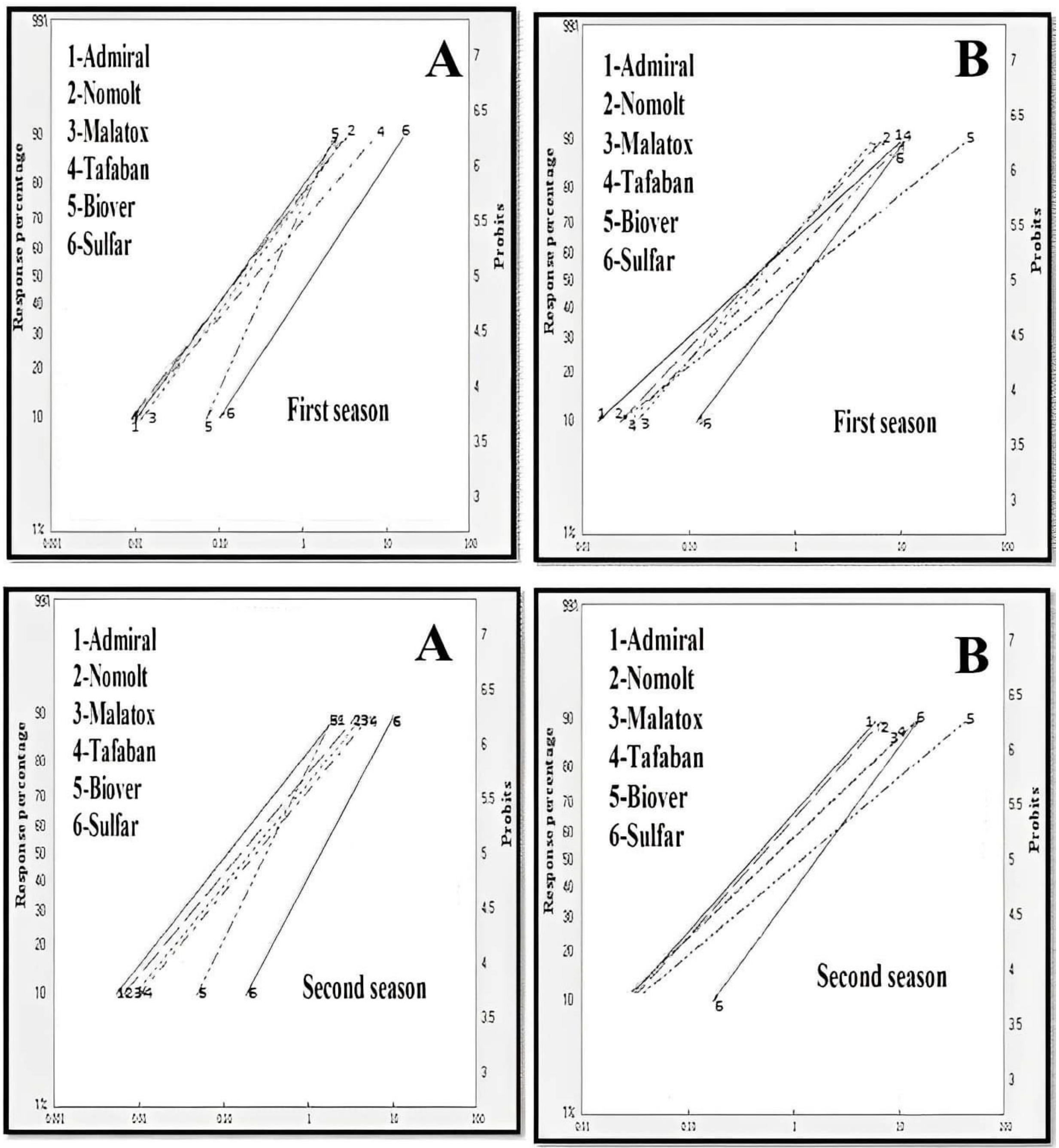


Fig. 1. Toxicity lines of tested compounds against nymphs (**A**) and Adults (**B**) of *P. tenuivalvata* during the two seasons

3.2. Adult females' stage of *P. tenuivalvata*

The chosen insecticides were tested for their toxicity to *P. tenuivalvata* adult females under laboratory circumstances. The obtained results are represented in **Table 2** and **Fig. 1B** indicated the descending order of the toxicity of the tested compounds based on the LC_{50} values in the first and second seasons. For the first season Admiral found to be the highly potent compound, with LC_{50} value 0.368 ± (0.204-0.698) and toxicity index 100%, followed by Nomolt the LC_{50} value was0.381 ± (0.239-0.643) and the toxicity index 96.588%, then Malatox 0.415 ± (0.096-0.665) with toxicity index 88.675%, followed by Tafaban the LC_{50} value was 0.536 ± (0.345-1.218) with toxicity index 68.657 %, followed by Biover the LC_{50} value was 0.961 ± (0.298-1.668) with toxicity index 38.293%, then Sulfar the LC_{50} value was1.125 ± (0.737-1.620) with toxicity index 32.711%.In the second season Admiral also was the most effective compound with LC_{50} value 0.395 ± (0.255-0.657) with toxicity index 100%, followed by Nomolt the LC_{50} value was 0.436 ± (0.088-0.707) and the toxicity index 90.596%, then Malatox LC_{50} value was 0.579 ± (0.361-1.622) with toxicity index 68.221% followed by Tafaban the LC_{50} value was 0.582 ± (0.363-1.649) with toxicity index 67.869%, followed by Biover the LC_{50} value 1.142 ± (0.461-1.978) with toxicity index 34.588%, then Sulfar the LC_{50} value was1.596 ± (1.144-2.653) with toxicity index 24.749%. Slope values of the log concentration-propit lines in Table (2) demonstrated that Sulfar has the highest slope values 1.301 and 1.318 for the first and second seasons, respectively. While, Biover has the lowest slope values 0.785 and 0.813 for the first and second seasons, respectively.

The results are represented in **Table 1** and **Table 2**, *P. tenuivalvata* nymphs were more vulnerable to the investigated chemicals than adult females as reported by **Helmy *et al.***[14] assured that Admiral and Applaud both at (50 ml/100 lit. water) reduce the population of *P. tenuivalvata* by an average of 71.3 and 73.8 %, respectively. **El-Amir**[15] reported that Admiral 10 % EC at a rate of 0.05 % gave a 96.1 %reduction after 3 months of application agents *Parlatoria oleae* infesting olive trees. **Bakry and Mohamed**[16] found that the adult females of *P. solenopsis* mealybug were less susceptible to the tested chemicals than the nymphs. As well, the insecticidal efficiency of Mospilan and Malatox appeared the most toxic against *P. solenopsis* nymphs and adult females inhabiting cotton leaves. **Aly**[2] stated that the adult stage was most liable for tested insecticides while the nymphal stage was the less tolerant one. Malathion was also found to be the most effective compound against *P. tenuivalvata* nymphs and adults. All these findings presented in this paper confirm the importance of organic compounds in different insecticidal activity fields.[17-20]

4. Conclusion

The accomplished investigation claimed that the tested pesticide treatments on *P. tenuivalvata* at the different stages of the pest (nymphs and adult females) in laboratory conditions varied in efficacy. In addition, when compared to the stage of adult females, *P. tenuivalvata* nymphs were most vulnerable to the selected pesticides. Admiral and Nomolt were extremely toxic for nymphal and adult stages of *P. tenuivalvata* that lived on sugarcane leaves. On the other hand, Sulfar was the least successful in suppressing this pest.

5. Recommendation

It might be recommended that Admiral and Nomolt be used to manage *P. tenuivalvata* on sugarcane plants.

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