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Research Article

Insecticidal Efficiency of Some Insect Growth Regulators (Igrs) and Plant Oils Against the Seychellarum Mealybug, *Icerya Seychellarum* and the Striped Mealybug, *Ferrisia Virgata* Infesting Guava Trees

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Abstract

Three IGRs: Match, Runner and Dimilin, three plant oils: orange oil, sesame oil and jasmine oil were tested against two species of mealybugs *Icerya seychellarum* and *Ferrisia virgata* infested guava trees at Ismailia Governorate as alternatives to mineral oils. Toxicological study as expressed by LC50 and toxicity index indicated that all IGRs showed high toxicological effect than plant oils, Runner showed the highest toxic effect against *I. seychellarum* followed by Dimilin, KZ- oil, Match and orange oil while jasmine oil and sesame oil showed the lowest toxic effect. In case of *F. virgata*, Runner showed the highest toxic effect followed by KZ- oil, Dimilin, Match and jasmine oil while both orange oil and sesame oil showed the lowest toxic effect. Results of field evaluation experiment of the tested materials against the two species of mealybugs *I. seychellarum* and *F. virgata* infested guava trees at Ismailia Governorate indicated that the effect increase as both concentration and period after application increased, also nymphs of mealybugs were more sensitive than adults. IGRs showed high insecticidal efficiency than plant oils, it could be recommended Runner and Dimilin at 1.5% as alternatives to mineral oils for controlling these pests in guava crop, while Match require to increase its application rate, plant oils showed moderate insecticidal efficiency and could be used as potential to conventional insecticides used for controlling these pests, then possibility of decreasing their application rate. All tested materials did not showed any phytotoxic effect on guava trees up to four weeks of treatment.

Introduction

Guava trees are subjected to infestation by different pests. Among these pests, the mealybug, *Icerya seychellarum* (Westwood) (Homoptera: Monophlebidae) and the striped mealybug, *Ferrisia virgata* (Cockerell) (Homoptera: Pseudococcidae) are considered one of the most main destructive pests of guava trees Sayed [1]. Mealybug is represented by the largest family of scale insects with about 300 genera and 2000 species and has been reported from 35 localities of various ecological zones of the globe Abbas et al. [2], Ben-Dov et al. [3], Downie and Gullan [4] and Miller and Williams [5]. These pests are soft, oval, wax-covered insects that feed on many plants. Nymphs and adult female mealybugs suck plant sap and some species cause considerable economic damage to fruit crops. Sap depletion results in loss of plant vigour, reduced yield, poor growth, dieback of twigs and branches, leaf drop, and sometimes death of the plant Williams [6] and Miller et al. [7]. Also, they causes indirect damage by fouling foliage with their sugary honeydew excretions, providing a growth medium for sooty mould fungi. Mold growth blocks light and air from the leaves, interfering with photosynthesis, and may cause poor growth and fruit yield, leaf drop, reduced fruit sugar content and disfigured fruits Mckenzie [8]and Miller and Kosztarab [9]. These pests attack tender shoots, twigs, veins of leaves, branches and fruits of guava. The mealybug feeding on the sap sucked from the host plant tissues. As this sap contains only a very low concentration of protein, the insect sucks a great amount of sap from which it obtains the amount of protein sufficient for its growth and egg development. The high number of insects, attacking leaves, branches and fruits of the tree, resulting in a great loss of sap, thus leading to defoliation, dryness, wilting, early leaves drop, malformations, dwarfing, and deprive the trees from its nutrients, ultimately quality and quantity of the fruit is severely reduced and reduction of the tree vitality El-Said [10], Mangoud [11] and Reda et al. Due to their waxy hydrophobic covering, managing mealybugs with pesticide sprays can be difficult and contact insecticides are most effective. Recommendation of controlling mealybugs with mineral oils is very important especially during fruiting period. Since mineral oils used in high amount in one side and increasing of using mineral oils in petrochemical industries in other side, therefore efforts should be directed towards testing and using other materials as alternative to mineral oils, insect growth regulators and plant oils are suggested for controlling the two species of mealybugs Dreistadt [12] and Franco et al. [13]. Infested guava trees causing economic damage at Ismailia Governorate so this research aimed to study insecticidal activity of some (IGRs) and plant oils compared with recommended mineral oil (KZ- oil) against *I. seychellarum* and *F. virgata* under laboratory and field conditions.

Materials and Methods

Insect growth regulators (IGRs)

a. Match® 5% EC (lufenuron), produced by Syngenta Agro Switzerland. Recommended for controlling cotton leaf worm on cotton at rate 100 cm3/Faddan.

b. Runner® 24% SC (methoxyfenozide), produced by Dow Agro Sciences CO., England. Recommended for controlling cotton leaf worm on tomato at rate 37.5 cm3/100L.

c. Dimilin® 48% SC (diflubenzuron), produced by Chemtura Europe LTD, Booklands Farm, Cheltenham Road. Recommended for controlling cotton leaf worm on cotton at rate 125 cm3/ Faddan.

Plant oils

a. Orange oil (plant oil), produced by ORO-AGRI, USA. Recommended for controlling white fly on tomato at rate 400 cm3/100L.

b. Sesame oil (plant oil), produced by Captain CO. (Cap. Farm).

c. Jasmine oil (plant oil), produced by Captain CO. (Cap. Farm).

d. (Tween 80: used at rate 0.3% for emulsification plant oils in water).

Mineral oil

KZ- oil 95% EC, it is a mineral oil, recommended for controlling mealybugs at concentration 1.5% (V./V.), produced by Kufr el-Zayaat Co. for Pesticides and Chemicals, Kufr el- Zayaat, Egypt.

Laboratory Treatment

Laboratory experiment was carried out to determine the toxicity of the suggested (IGRs) and plant oils compared with recommended mineral oil against two species of mealybugs *I. seychellarum* and *F. virgata* on guava leaves under laboratory conditions. Five concentrations of each tested insecticides and oils were prepared in distilled water, three replicates were used for each concentration. Samples of infested guava leaves were collected randomly from infested guava trees and kept in paper bags then transferred to laboratory; thirty infested leaves were used for each concentration. The leaves were dipped by the tested insecticides and oils, the control leaves were sprayed by distilled water only and the leaves were left for dryness. Died and live insects were counted and recorded after 3 days. The average percentage of corrected mortality of insects for each concentration and for control was calculated according to Abbott (1925).

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

Where: T = Adults mortality percentage in treatment.

C = Adults mortality percentage in control.

The toxicity lines were statistically analyzed according to the method described by Finney [14]. From which the corresponding toxicity lines (Ld-P lines) were estimated of the tested insecticides and oils, LC10, LC25, LC50 and LC90 and slope values of tested compounds were also estimated. Toxicity index were calculated according to Sun [15]: Toxicity index = (LC50 of the most effective compound / LC50 of other tested compound) x 100.

Field Treatment

The field experiment was carried out against two species of mealybugs *I. seychellarum* and *F. virgata* by choosing 24 infested guava trees for tested (IGRs), oils and control. Three concentrations (0.5%, 1% and 1.5%) were prepared in water; each concentration was applied at 1 tree on 3 branches considered as 3 replicates. Thirty infested leaves (10 infested leaves X 3 replicates) were collected from each tree before spraying as pre-treatment samples and thirty infested leaves were collected from each tree after spraying as post treatment (after 1,2,3 and 4 weeks). Samples were kept in paper bags then taken to laboratory for examination. The insecticides and oils were sprayed using a hand laboratory sprayer equipped with a flat-fan nozzle 2 litters capacity on June 2018. Data of the pre-treatment, post-treatment and control samples were recorded for alive pre-adults and adult females to calculate reduction percentage according to (Henderson and Tilton, 1955) as follow:- % Reduction Percentage =100 {1-(Cb/Ca x Ta/Tb)}

Where: Cb: the control counts before spraying, Ca: the control counts after spraying, Tb: the treatment counts before spraying and Ta: the treatment counts after spraying. Phytotoxic effect: It was determined by recording any flaming, curl and color changes occurred in leaves of treated tress up to 4 weeks of treatments.

Results and Discussion

Toxicity of tested materials against mealybugs

As shown in (Tables 1 & 2), (Figures 1 & 2) insect growth regulators showed high toxic effect against two species of mealybugs similar to KZ-oil or more toxic such as in case of Runner and Dimilin against *I. seychellarum* and Runner against *F. virgata*, while all tested plant oils showed low toxic effect than KZ-oil as LC50 and toxicity indexes indicated. Results also indicated that *F. virgata* is more sensitive to tested materials than *I. seychellarum* except in case of Dimilin (IGRs) and plant oils orange oil and sesame oil *I.*

seychellarum was more sensitive. Generally, Runner was the most toxic tested material against *I. seychellarum* followd by Dimilin, KZ-oil, Match and orange oil while jasmine oil and sesame oil showed the lowest toxic effect. In case of *F. virgata*, Runner showed the highest toxic effect followed by KZ- oil, Dimilin, Match and jasmine oil, while both orange oil and sesame oil showed the lowest toxic effect as indicated by both LC50 value and % toxicity index (Table 1).

Table 1: Toxicity of some IGRs and plant oils against, *Icerya seychellarum* under laboratory conditions.

Treatment	Lethal concentrations and their limits (ppm)				Slope ± SE	Line equation regression of probit (y) on log concentration (x)	%Toxicity index at LC50
	LC10	LC25	LC50	LC90			
Dimilin 48% SC	2.09 ± (0.32-4.73)	7.39 ± (2.63-12.44)	30.01 ± (19.15-51.60)	429.59 ± (169.54-3766.78)	1.10 ± 0.24	Y= 28.72 + 1.10X	82.94
Match 5% EC	2.46 ± (0.31-5.65)	9.54 ± (3.41-16.01)	43.02 ± (26.80-90.73)	751.87 ± (243.11-13556.61)	1.03 ± 0.24	Y= 24.63 + 1.03X	57.86
Runner 24% SC	2.04 ± (0.37-4.45)	6.68 ± (2.50-11.11)	24.89 ± (16.03-39.54)	303.21 ± (134.87-1789.56)	1.18 ± 0.24	Y= 30.81 + 1.18X	100
Orange oil 6%	3.12 ± (0.56-6.56)	11.06±(4.64-17.79)	45.12 ± (28.84-90.69)	652.19 ± (230.48-8045.07)	1.10 ± 0.243	Y= 22.38 + 1.10X	55.16
Sesame oil	28.65±(12.50-47.50)	74.84±(44.51-107.38)	217.51±(156.59-309.72)	1651.25 ±(945.05-4191.79)	1.45 ± 0.20	Y= 6.56 + 1.45X	11.44
Jasmine oil	9.19 ± (4.12-14.32)	22.13±(14.18-31.00)	58.74 ± (41.49-98.55)	375.27 ± (185.84-1523.22)	1.59 ± 0.28	Y= 9.46 + 1.59X	42.37
KZ-oil 95%	3.29 ± (0.75-6.54)	10.58 ± (4.80-16.57)	38.66 ± (25.61-68.14)	453.70 ± (185.92-3315.15)	1.19 ± .245	Y= 22.88 + 1.19X	64.38

Table 2: Toxicity of some IGRs and plant oils against, *Ferrisia virgata* under laboratory conditions.

Treatment	Lethal concentrations and their limits (ppm)				Slope ± SE	Line equation regression of probit (y) on log concentration(x)	%Toxicity index at LC50
	LC10	LC25	LC50	LC9D			
Dimilin 48% SC	3.33 ± (0.94-6.27)	9.61 ± (4.66-14.69)	31.22 ± (21.33-48.97)	292.70±(140.06-1320.77)	131 + 0.247	Y=24.41 +1.311	69.57
Match 5% EC	2.66 ± (050-5.62)	9.00 ± (3.66-14.56)	34.81 ± (22.68-61.13)	455.01 ±(181.27-3738.81)	1.14 ± 0.241	Y= 25.55 +1.14X	62.39
Runner 24% SC	2.08 ± (0.45-4.35)	6.32 ± (2.52-10.33)	21.72 ±(14.13-32.86)	226.32 ±(110.85-991.84)	1.25 ± 0.242	Y= 3232 +1.25X	100
Orange oil 6%	3.44 ± (057-7.27)	12.78±(5.43-20.63)	54.89 ± (34.05-127.53)	875.32±(276.96-16329.50)	1.06 ± 0.244	Y= 20.47 +1.061	39.57
Sesame oil	11.81 ± (2.19-27.04)	48.31±(18.79-82.27)	231.10 -(146.58-395.63)	4521.19±(1740.78-32603.73)	0.99 + 0.18	Y= 23.80 +0.99X	9.4
Jasmine oil	4.84 ± (1.41-8.81)	14.52 ± (7.64-21.82)	49.19 ± (32.91 -90.46)	499.81 ± (207.12 -3431.70)	1.27 ± 0.25	Y= 17.65 +1.27X	44.15
KZ-oil 95%	2.55 ± (0.59-5.16)	7.80 ± (3.35-12.41)	26.93 ± (17.92 -42.10)	283.66 ± (132.68-1398.29)	1.25 + 0.243	Y= 28.2 + 1.251	80.65

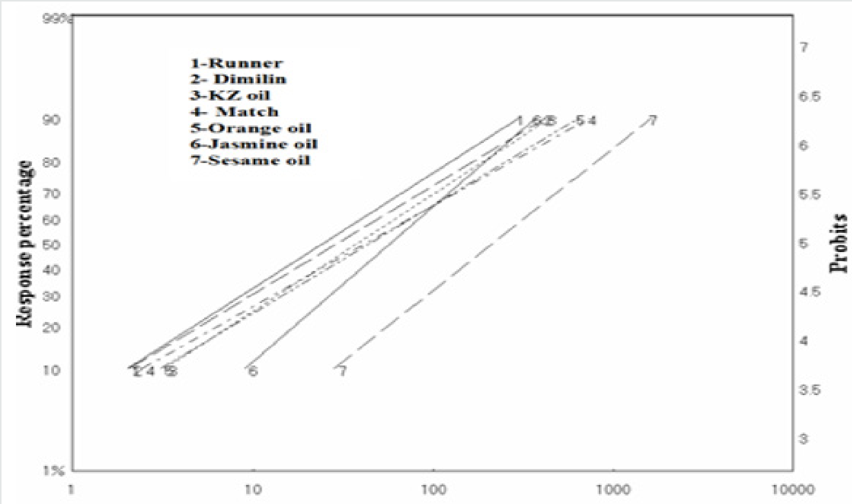

Figure 1: Toxicity lines of tested IGRs and plant oils against *Icerya seychellarum*.

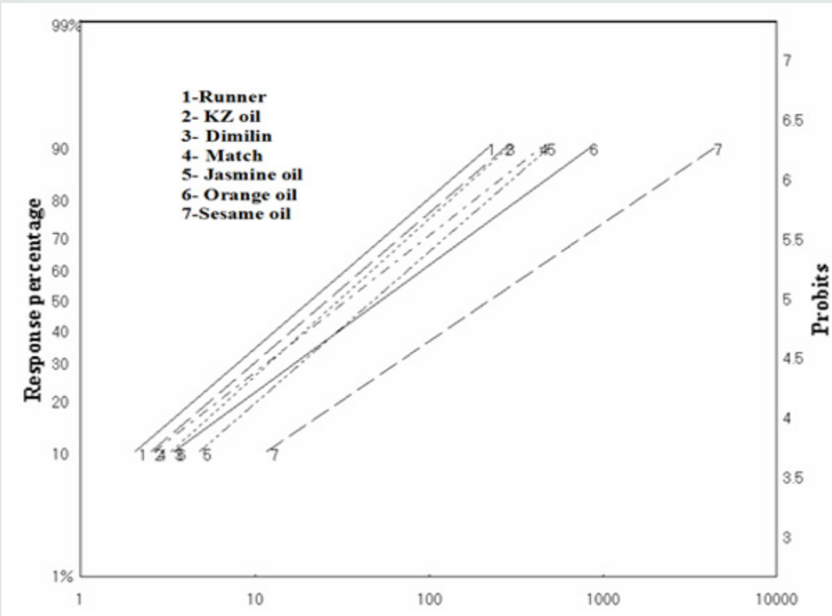

Figure 2: Toxicity lines of tested IGRs and plant oils against *Ferrisia virgata*.

Insecticidal efficiency of the tested materials against mealybug infested guava trees

As shown in Tables 3 & 4, insecticidal efficiency against two species of mealybugs *I. seychellarum* and *F. virgata* expressed as % reduction percentage in a live individual was increased as both concentration and period after spraying increased up to 4 weeks. Results in the same tables also indicated that all tested materials showed highly insecticidal efficiency against nymphs than adults of two species of mealybugs. According to Ministry of Agriculture recommendations, succeeded materials should give % mean reduction in a live mealybugs not less than 75% for alternatives or similar to recommended rate of mineral oil after 4 weeks of spraying according to this rule two IGRs Runner and Dimilin considered be succeeded at rate 1.5%. While Match gave moderate effect and required to increase its concentration and evaluation in other complete experiment. On the other hand plant oils showed lowest insecticidal efficiency than IGRs therefore, they could be used as potantiator materials by mixing them with recommended insecticides to reduce their recommendation rate (Table 2).

Mode of Action

The anti moulting compounds: Runner, Match and Dimilin exhibits a specific mechanism of action, differing essentially from conventional insecticides. It interferes with the deposition and biosynthesis of chitin and thereby inhibits ecdysis and finally leads to death of insect Grosscur [16], Salama and Magd El- Din [17]and Radwan et al. [18]. Thus the treated insect are not killed immediately but later on during or after moulting either because rupture of the new cuticle or because starvation. The effect of plant oils against nymphs and adults of mealybugs is due to suffocation effect a result of blocking of respiration as a present of oil film Smith and Pearce [19], Deong et al. [20], also due to their antifeedant and developmental effect Mousa and El-Sisi, [21-24] Phytotoxic effect: no any phytotoxic effect was observed on guava trees as a result of the tested materials up to 4 weeks of treatment (Tables 3 & 4).

Table 3: Insecticidal efficiency of some IGRs and plant oils against *Icerya seychellarum*.

Insecticides and concentrations		% reduction after weeks of spraying											
		1 week			2 weeks			3 weeks			4 weeks		
		12/6/2018			19/06/2018			26/06/2018			3/7/2018		
		Pre-adults	Adult females	Mean	Pre-adults	Adult females	Mean	Pre-adults	Adult females	Mean	Pre-adults	Adult females	Mean
Dimilin	0.50%	31.62	27.76	29.69	65.38	40.11	52.75	63.88	49.32	56.6	76.92	63.8	70.36
	1.00%	55.85	35.35	45.6	57.69	49.32	53.51	75.92	65.78	70.85	88.46	57.22	72.84
	1.50%	62.43	58.97	60.7	76	63.8	69.9	79.13	71.04	75.09	88	71.04	79.52
Match	0.50%	24.79	17.62	21.2	37.39	13.53	25.46	32	22.35	27.18	44	15.29	29.65
	1.00%	33.33	16.52	24.93	55.85	16.34	36.1	50	25.49	37.75	61.54	37.25	49.4
	1.50%	31.77	18.52	25.15	47.37	34.84	41.11	63.8	50.6	57.2	63.16	56.56	59.86
Runner	0.50%	23.81	19.37	21.59	39.5	36.36	37.93	46.22	43.08	44.65	59.09	59.66	59.38
	1.00%	26.96	24.79	25.87	45	34.84	39.92	63.8	53.04	58.42	71.04	60	65.52
	1.50%	50	39.59	44.79	58.82	57.89	58.36	82.35	56.06	69.21	76.47	73.68	75.08
Orange oil	0.50%	5.14	2.56	3.85	25.93	15.49	20.71	34.3	11.96	23.13	40.74	15.88	28.31
	1.00%	25.93	11.11	18.52	22.73	20.88	21.8	33.6	27.6	30.6	45.45	34.84	40.15
	1.50%	28.89	17.39	23.14	37.5	24.71	31.1	49.83	46.8	48.32	54.17	49.8	51.99
Sesame oil	0.50%	17.8	2.56	10.18	15.7	7.32	11.51	16.67	7.78	12.22	25.49	4.49	14.99
	1.00%	18.84	3.7	11.27	18.84	8.6	13.72	22.22	8.6	15.41	37.04	5.88	21.46
	1.50%	22.87	4.4	13.64	23.74	12.96	18.35	22.87	15.88	19.38	30.43	13.73	22.08
Jasmine oil	0.50%	27.76	3.7	15.73	22.73	12.35	17.54	26.92	9.8	18.36	31.76	9.9	20.83
	1.00%	33.33	2.4	17.87	32	10.88	21.44	35.79	12.96	24.37	46.15	13.73	29.94
	1.50%	37.39	4.6	21	50.59	9.1	29.84	41.57	18.73	30.15	48	21.57	34.78
Kz oil	1.50%	74.6	63.48	69.04	80	73.11	76.55	84.35	79.83	82.09	85	86.36	85.68

Table 4: Insecticidal efficiency of some IGRs and plant oils against *Ferrisia virgata*.

Insecticides and		% reduction after weeks of spraying											
		concentrations			% reduction after weeks of spraying			3 weeks			4 weeks		
		% reduction after weeks of spraying			19/06/2018			26/06/2018			3/7/2018		
		Pre-adults	Adult females	Mean	Pre-adults	Adult females	Mean	Pre-adults	Adult females	Mean	Pre-adults	Adult females	Mean
Dimilin	0.50%	52.62	50.77	51.69	75.11	64.5	69.8	82.08	73.63	77.85	84	78.7	81.35
	1.00%	65.54	63.64	64.59	79.26	74.83	77.04	88	76.92	82.46	86.56	78.57	82.57
	1.50%	79.29	73.33	76.31	88.46	83.22	85.84	88.03	84.62	86.32	91.38	84.42	87.9
Match	0.50%	30.52	4	17.26	42.78	7.69	25.24	51.61	26.15	38.88	56.65	46.43	51.54
	1.00%	33.16	10	21.58	43.13	7.69	25.41	55.17	30.77	42.97	61.38	48.57	54.98
	1.50%	40.17	20	30.09	50.07	38.46	44.27	69.23	62.96	66.1	72	68.5	70.25
Runner	0.50%	56.92	54.66	55.79	61.79	57.4	59.59	67.03	52.84	59.94	78.95	66.43	72.69
	1.00%	59.62	56.36	57.99	74.07	58.04	66.06	76.67	76.62	76.65	83.33	78.7	81.02
	1.50%	80	77.56	78.78	87.04	82.69	84.86	90.67	83.93	87.3	91.67	88.46	90.06
Orange oil	0.50%	21.03	9.09	15.06	34.32	2.7	18.51	40	7.69	23.85	44	23.81	33.9
	1.00%	28.21	12	20.1	38.55	12.82	25.68	50	10.69	30.35	54.5	29.87	42.19
	1.50%	29.33	24.44	26.89	41.67	16.92	29.29	51.85	44.62	48.23	54.37	48.57	51.47
Sesame oil	0.50%	14.81	7.69	11.25	21.43	4.43	12.93	26.67	2.28	14.48	23.08	7.82	15.45
	1.00%	20	16.88	18.44	25.87	18.52	22.2	28.57	17.48	23.03	44	21.03	32.51
	1.50%	30.91	15.38	23.15	37.14	25.33	31.24	38.46	27.41	32.93	38.46	36.67	37.56

Jasmine oil	0.50%	10	2.22	6.11	20	7.14	13.57	23.08	7.69	15.38	25	7.69	16.35
	1.00%	14.29	4.73	9.51	20.23	11.11	15.67	26.77	12.41	19.59	26.92	14.29	20.6
	1.50%	23.57	12	17.79	34.97	20.86	27.91	36.44	20	28.22	41.94	20	30.97
Kz oil	1.50%	53.85	52	52.92	72.31	59.26	65.78	81.54	75	78.27	84	82.86	83.43

Conclusion

Carried study proved that IGRs showed high toxic and insecticidal efficiency against mealybug specially in case of Runner and Dimilin enough to control these pests in guava trees while all studied plant oils showed lowest effect, they were unsuitable to control these pests.

Recommendation

It could be recommended (IGRs) Runner and Dimilin at concentration 1.5% for controlling mealybug infested guava trees but Match require increasing its concentration in other experiment. All plant oils suitable to be used as additives to conventional insecticides used in controlling this pest, to increase their effect then decreasing their rate of application in other complete experiments.

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