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Semi-field evaluation of some natural clean insecticides from essential oils on armored and soft scale insects (Homoptera: Diaspididae and Coccidae) infesting mango plants.

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Abstract: This work was carried out to overcome the resistance phenomenon of armored and soft scale insects against conventional scalicides; and to find promising methods to control these insects; besides reducing environmental hazards. Therefore, formulations of Demso, Oregacide, Citrocide and Lemocide were prepared and investigated against white mango scale *Aulacaspis tubercularis (=mangifera)*, yellow scale *Aonidiella citrina* and acuminata scale *Kilifia acuminata* in comparison with the trade neem oil "Trilogy". The obtained results cleared that adult females of *A. tubercularis* responded to these oils by nearly similar percent of reduction 81.86, 87.89, 85.58, 84.39 and 81.03% when sprayed with Demso, Oregacide, Citrocide, Lemocide formulations and Trilogy, respectively. Nymphs population were reduced by 74.08, 88.66, 81.24, 74.1and 76.92% when sprayed by the same formulations, respectively. Both adult females and nymphs population of *A. citrina* were reduced by 93.74, 95.09, 67.34, 50.42 & 68.46% and 99.31, 99.05, 84.09, 80.29 & 90.67% when sprayed with Demso, Oregacide, Citrocide, Lemocide & Trilogy, respectively. Both females and nymphs of *K. acuminata* were reduced by different values.

The combined effect of tested oils on different insect species and different stages together, referred that Lemocide had the lowest effect on tested insects (51.13% reduction); while Oregacide had the highest effect on armored and soft scale insects collectively (95.03% reduction) in comparison with 80.98% of reduction resulted from Trilogy formulation.

Physico-chemical properties of the tested formulations revealed that, all formulations passed emulsion stability, except the commercial compound Trilogy.

Concerning the side effects on chlorophyll, treatments with Demso and Oregacide were effective on increasing chlorophyll contents with time elapsed. Also, nutrient elements such as Fe and Mg increased by these treatments.

Key words: Natural compounds, Essential oils, *Aulacaspis tubercularis, Aonidiella citrina, Kilifia acuminata*, Mango orchards.

Introduction

Armored scale insects such as the white mango scale *Aulacaspis tubereularis* (News.) (Homoptera: Diaspididae), yellow scale *Aonidiella citrina* (Diaspididae); and soft scale insects as the acuminate scale *Kilifia acuminat*a (sig.) (Coccidae) cause enormous injury in ornamental and fruit orchards especially mango orchards. These injuries represented in yellowing and drying leaves [1], decreasing fruit yields and drying branches of trees. These injuries are resulted from sucking plant sap by scale insects by secreting toxic substances into plant tissues; and transmitting diseases to it or honeydew secretions on leaves [2-5].

Due to the continuous and repetitive use of commercial and conventional scalicides to control scale insects, insect resistance was appeared [6,7]. So, in the recent years the integrated pest management of scale insects depends on minimizing conventional scalicides use and seeking on natural alternatives. Many authors tended to use essential oils in controlling various insects such as [8-14].

Pesticides are formulated for increasing effectiveness in the field, enhances each of safety features and handling qualities [15]. Emulsifiable concentrates (EC) (the conventional solvent-based insecticides) consist of an oil-soluble active ingredient dissolved in an appropriate oil-based solvent, emulsifying agent was added and mixed with water then applied as a spray. The physical and chemical properties of a pesticide could be used to determine the type of adjuvant used. Adjuvant research depends on 'trial and error', but it is fastly developing from collections of experimental data to methodical approaches based on physicochemical properties and primary understandings of adjuvant-pesticide conduct [16]. In recent trend increasingly need safer and more appropriate pesticide formulations instead of the conventional solvent-based insecticides (EC) which cause various problems to plants and environment.

Our study aims to use vegetable-based solvents instead of petroleum solvents with some emulsifiable agents and natural active ingredients. Also, evaluating the efficiency and persistence of these prepared natural insecticides in semi-field experiments against *A. tubercularis*, *A. Citrina* and *K. acuminata*, as well as their physical properties and their side effects on chlorophyll (as indication to phytotoxicity) and some elements of sprayed mango plants.

Materials and methods

Insects rearing:

Three tested insects *Aulacaspis tubercularis* (Newst.) *Aonidiella citrina* and *Kilifia acuminata* (Sig.) were reared on mango plants 5 years age. Artificial infestation was done on mango seedlings using crawlers of tested insects. These crawlers were obtained from heavily infested samples with these insects which obtained from mango and ornamental orchards at Barrage district, Kalubeia Governorate. Artificial infestation were made and replicated several times. Continuous examination to mango leaves that artificially infested, to ensure that population build up and reached to satisfactory levels.

Insects identification:

Existed insects on mango trees were temporarily mounted according to [17] and identified using atlases of [18,19] and pictorial keys of [20].

Preparation of the essential oils:

The aerial parts of some medicinal and aromatic plants mentioned in table (1) were processed by hydro distillation for 4 h using steam distillation Clevenger apparatus to obtain the essential oils.

Preparation of the tested formulated compounds:

Four compounds namely as mention in table (1) were naturally prepared as emulsifiable concentrate formulations (EC) as follow:

The tested four compounds were prepared by mixing each of the tested essential oil in appropriate amounts of different types of emulsifiers and natural solvent (mineral and vegetable oils).

Emulsion of each compound in water was sprayed at concentration of 3% 1 L /200 L water. Also, the commercial compound Trilogy (from neem oil) was sprayed at concentration of 1 L /100 L water.

Table 1: Scientific, common names of the tested essential oils and their formulated compounds.

Tested essential oils		Tested formulated compounds
Scientific name	**Common name**	
Ambrosia maretima	Demsisa	Demso
Origanum minutiforum	Oregano	Oregacide
Cymbopogon nardus	Citronella	Citrocide
Cymbopogon citratus	Lemongrass	Lemocide

Physico-chemical properties of tested formulated compounds:

1. Emulsion stability test.

The method was carried out according to CIPAC specifications [21].

1.1. Initial emulsification test

Measuring cylinders (100 ml) were filled to 95 ml mark with distilled water at 30 ± 1 ºC. The emulsifiable concentrate was poured gently (5 ml from a measuring cylinder) on to the surface of the water. The cylinder was stoppered and inverted once. After 30 sec., the formation of froth layer was noted.

1.2. Emulsion stability on standing

The cylinder was inverted 10 times and was allowed to stand undisturbed in the constant temperature bath at 30 ± 1 ºC. The volume (ml) of free oil and/or cream layer, if any, formed either at the top or the bottom of the cylinder was recorded after standing for 30 min and 2 h.

The maximum volume of free oil, cream or solid matter, if any, should not exceed two ml whether, at initial emulsification or emulsion stability on standing.

Foam test

The method was carried out according to CIPAC specifications [21]. The sample was weighted (5 g) and added to (95 ml) of the distilled water in 100 ml measuring cylinder and made up to the mark. The cylinder was stoppered and inverted 30 times. The cylinder was stand on the bench and left undisturbed for one min and examined for foam formation. The foam volumes should be none after one min.

Spontaneous emulsification test

The method was carried out as described by [22]. Ninety-five ml of each type of water was put in 100 ml graduated cylinder. Five ml of emulsifiable concentrate formulation were added at about 5 cm distance up the liquid surface in the cylinder. The amount of formed self-emulsion was recorded, directly, after addition of formulation.

pH determination

The method was carried out according to CIPAC specifications [21]. One g of the tested formulation was transferred to the measuring cylinder containing water (about 50 ml), made up to 100 ml, and shake vigorously for 1 min. The cylinder was allowed to settle and the pH of the supernatant liquid was measured. The pH must be within the range 5.0 to 7.0.

Treatment of the tested compounds:

Spraying, inspections and calculations:

Each compound was sprayed during both 2013 and 2014 on five infested mango plants every once, control treatment was sprayed only with water also on five infested plants. Spraying was done using ordinary back sprayer with one nozzle. Samples of infested leaves were picked up before and after spraying at 3,9,15 and 21 days. Sample size was 30 leaves (five leaves/treatment).Samples were inspected using binoculair microscope

to assess live individuals counts in females and nymphs of each tested insect. Mortality was estimated using conventional method to distinguish between drying of insect body (dead) and fluidity (live).

Percent of reduction in population of females and nymphs population of each insect/spray was calculated according to [23]. Average of persistence of activity for each compound and its efficiency on three insects collectively were estimated.

Estimation of Chlorophyll Contents:

The Estimation of Chlorophyll Contents (chlorophyll a and chlorophyll b) were determined spectrphotometrically as method recommended by [24]. A known weight of fresh leaves was homogenized in 85% aqueous acetone for 5 minutes. The homogenate was centrifuged and the supernatant was mad up to known volume with 85% aqueous acetone. The extraction was measured against a blank of pure 85% aqueous acetone at two wavelengths 663 and 644 nm using spectrocolourimeter VEB Carl Zeiss. Values of Chlorophyll Contents were expressed as mg/g fresh weight.

Nutrients extraction:

Leaves:

Samples were washed with tap water, 0.001 N HCL and distilled water, respectively, then dried at 70 ^{o} C for 24 h and ground in a stainless steel mill, then passed through a 40-mesh nylon sieve and stored in plastic bottles. A part of the dry leaves was wet-digested according to the method of [25].

Nutrient contents measurement:

Plant material was digested using an acid mixture consisting of nitric, perchloric and sulfuric acids in the ratio of 8:1:1 (v/v), respectively [25]. Nitrogen (N) was determined in the dry plant material using the boric acid modification described by [26], and distillation was done using a Buechi320-N2-distillation. Mg and Fe were determined using the Atomic Absorption Spectrophotometer (Perkin-Elmer 100 B).

Results and discussion

The emulsion stability results of different essential oils formulations are presented in table (2). The results revealed that, all tested formulations except Trilogy passed the test after 30 sec (initial emulsification) as there were no formation of forth, oily or creaming layers in these tested formulations, while the creaming layer of Trilogy was 0.2 ml. Similarly, all tested formulations passed the test after 30 min and 2 h (emulsion stability on standing), except Trilogy which failed in the test (creaming layers of Trilogy were 2.5 and 4 ml after 30 min and 2 h, respectively).

Table 2: Physico-chemical properties (emulsion stability) of different essential oils formulations

Essential oils	Separation (ml)		
	Initial emulsification	Emulsion stability on standing	
	after 30 sec	after 30 min	after 2 h
Demso	0	0.8	2
Orgacide	0	0.5	1.5
Citrocide	0	0.4	1.5
Lemocide	0	0.5	1.5
Trilogy	0.2	2.5	4

The results of foam formation, spontaneous emulsification and pH are summarized in table (3). All tested formulations passed the foam test, where the foam layers of these formulations were zero. Concerning spontaneous emulsification, Oregacide and Demso recorded maximum spontaneous emulsification of 15 and 10%, respectively, followed by Lemocide of 8%, while, Trilogy and Citrocide were the least in this respect, with spontaneous emulsification of 6 and 5%, respectively. All tested formulations did not give 100% spontaneous emulsification because these formulations had a specific gravity less than that of water. These data

are in good agreement with the results of [27]. He found that the emulsifiable concentrates which had a specific gravity less than one gave low spontaneous emulsification.

All tested formulations passed pH test. The pH values ranged from 6.2 to 7 of the tested formulations (The pH values of an aqueous dispersion shall be 5 to 7).

Table 3: Physico-chemical properties of different essential oils formulations

Essential oils	Foam (ml)	% Emulsification	pH
Demso	0	10	6.9
Oregacide	0	15	6.4
Citrocide	0	5	7
Lemocide	0	8	6.2
Trilogy	0	6	6.9

The artificially infested mango plants by *A. tubercularis* were sprayed with formulations of Demso, Oregacide, Citrocide, Lemocide and Trilogy; the results showed similar percent reduction in females population by averages 81.86, 87.89, 85.58, 84.39 and 81.03%, respectively (table 4). Also, percent of reduction in nymph populations caused by the same formulations were observed (74.08, 88.66, 81.24, 74.1 and 76.92%, respectively).

The activity of the tested formulations varied in reducing *A. citrine* female populations (table 5), these percent of reduction ranged from (50.42 to 95.09%) for Lemocide and Oregacide, respectively. Also, formulations of Demso and Citrocide had nearly the same efficiency on females (75 and 73.2% reduction), respectively. The percent of reduction in nymphs population were 99.31, 99.05, 84.09, 80.29 and 90.67% when exposed to Demso, Oregacide, Citrocide, Lemocide and Trilogy, respectively.

1- Evaluation of tested formulations on soft scale insects.

The tested formulations on infested mango plants with *K. acuminata* varied and showed differed activity in reducing female and nymphs population (table 6). Percent of reduction in females and nymphs were low in Lemocide (9.8 and 7.75%, respectively), while it were high in Oregacide (99.85 and 99.64%, respectively).

2- Evaluation of tested formulations on armored scale insects.

Table 4: Percent reduction of population in white mango scale *A. tubercularis* sprayed by tested formulations on mango plants.

Insect stages	Tested formulations	Average counts and reduction in live individuals/leaf									Average percent of reduction
		Before spraying	After spraying								
			3 days		9 days		15 days		21 days		
			Live	Reduction %	Live	Reduction %	Live	reduction %	Live	Reduction %	
Adult females	Demso	58.1	39	61.9	19.1	73.57	0.8	98.04	2.0	93.92	81.86
	Oregacide	89.1	28.8	81.65	26	76.54	3.9	93.77	0.2	99.6	87.89
	Citrocide	108.0	60.6	68.14	32.6	75.73	0.2	99.74	0.8	98.7	85.58
	Lemocide	101.8	50.8	71.66	27.8	78.04	2.0	97.2	5.4	90.64	84.39
	Trilogy	112.4	66.4	66.16	56.8	59.37	0.6	99.24	0.6	99.06	81.03
	Control	123.9	218.2	-----	154.1	------	87	------	70.2	------	------
Nymphs	Demso	82.7	77.8	47.4	24.5	77.32	3.0	95.91	13.2	75.7	74.08
	Oregacide	260.1	34.8	92.52	65.5	80.72	43	81.38	0.0	100	88.66
	Citrocide	120.4	86.0	60.06	51.6	67.19	0.0	100	1.8	97.72	81.24
	Lemocide	137.4	51.6	79.0	33	81.61	46.4	61.96	23.6	73.85	74.1
	Trilogy	138.4	84.4	65.9	104.4	42.25	0.6	99.51	0.0	100	76.92
	Control	409.9	733.1	------	535.4	------	363.9	------	269.2	------	------

Table 5: Percent reduction of population in yellow scale *A. citrina* sprayed by tested formulations on mango plants.

Insect stages	Tested formulations	Average counts and reduction in live individuals/leaf									Average percent of reduction
		Before spraying	After spraying								
			3 days		9 days		15 days		21 days		
			Live	Reduction %	Live	Reduction %	Live	Reduction %	Live	Reduction %	
Adult females	Demso	135.7	20.3	81.95	3.8	96.13	1.8	97.94	0.9	98.95	93.74
	Oregacide	154.3	11.3	91.61	10.2	90.86	1.7	98.29	0.4	99.59	95.09
	Citrocide	17.4	17.0	0.0	3.4	72.99	0.0	100	0.4	96.36	67.34
	Lemocide	18.4	25.4	0.0	10.6	20.37	1.4	88.18	0.8	93.11	50.42
	Trilogy	12.6	7.4	29.12	3.0	67.09	1.0	87.67	0.8	89.94	68.46
	Control	197.8	163.9	------	143.1	------	127.3	------	124.8	------	------
Nymphs	Demso	290.8	45.8	99.17	3.7	98.98	0.3	99.89	2.0	99.21	99.31
	Oregacide	589.4	13.0	97.65	7.4	98.99	1.2	99.78	1.2	99.77	99.05
	Citrocide	49	27	41.24	3.0	95.1	0.0	100	0.0	100	84.09
	Lemocide	48.4	29.4	35.23	5.4	91.03	1.2	97.26	1.0	97.64	80.29
	Trilogy	42.6	11.2	71.96	3.0	94.34	1.4	96.37	0.0	100	90.67
	Control	180	168.8	------	224	------	162.9	------	157.6	------	------

Table 6: Percent reduction of population in acuminate scale *K. acuminata* sprayed by tested formulations on mango plants.

Insect stages	Tested formulations	Average counts and reduction in live individuals/leaf									Average percent of reduction
		Before spraying	After spraying								
			3 days		9 days		15 days		21 days		
			Live	Reduction %	Live	Reduction %	Live	Reduction %	Live	Reduction %	
Adult females	Demso	5.2	2.9	32.15	1.6	63.18	1.1	70.3	1.0	82.35	62.0
	Oregacide	88.5	0.2	99.73	0.0	100	0.2	99.68	0.0	100	99.85
	Citrocide	0.6	0.8	0.0	0.0	100	0.6	0.0	0.0	100	50.0
	Lemocide	0.8	0.4	39.17	2.8	0.0	0.8	0.0	1.0	0.0	9.8
	Trilogy	0.8	0.2	69.58	0.0	100	0.0	100	0.0	100	92.4
	Control	7.3	6.0	------	6.1	------	5.2	------	6.7	------	------
Nymphs	Demso	16.7	31.8	0.0	7.4	15.84	5.5	52.49	2.2	87.67	39
	Oregacide	213.2	1.5	99.22	0.3	99.73	0.6	99.6	0.0	100	99.64
	Citrocide	6.4	2.4	58.58	1.0	70.32	2.0	54.92	0.0	100	70.96
	Lemocide	4.6	6.4	0.0	10	0.0	2.2	31.01	9.6	0.0	7.75
	Trilogy	4.0	1.0	72.38	1.0	52.52	0.2	92.79	0.4	90.64	77.08
	Control	26.4	23.9	------	13.9	------	18.3	------	28.2	------	------

3- Comparison on the efficiency of tested formulations on the three tested scale insects:

Data in table (7) demonstrated the cumulative efficiency of each formulation on the three tested insects. They could be arranged descendingly as follows:

Oregacide>Trilogy>Demso>Citrocide>Lemocide

Since, the percent of reduction were 95.03, 80.98, 75, 73.2 and 51.31, respectively.

Table 7: Efficiency of the tested formulations on all scale insects infestation (Adult females and nymphs).

Tested formulations	Reduction percent in insects populations			Average
	A. tubercularis	*A. citrina*	*K. acuminata*	
Demso	77.97	96.53	50.5	75
Oregacide	88.28	97.07	99.75	95.03
Citrocide	83.41	75.72	60.48	73.2
Lemocide	79.25	65.36	8.78	51.13
Trilogy	78.67	79.54	84.74	80.98

The obtained results cleared that, the tested formulations, Demso, Oregacide ,Citrocide and Lemocide which prepared from essential oils of *Ambrosia maretima, Origanum minutiforum, Cymbopogon nardus* and *Cymbopogon citratus*, respectively, as well as the commercial Trilogy (from neem oil) can be used as green insecticides .These formulations from essential oils kill the scale insects through both contact and systemic activity. Spraying these formulations on plants make a thin film from oil solution around the insect wax cover, this film prevent needed oxygen for insect respiration; this followed by soaking the insect. As well as residues of oil solution can penetrate plant tissues and moved with plant sap which sucked by scale insects, and killed it. These agree with findings of [28, 29].

In comparison with the commercial formulation "Trilogy", the results indicated that the tested formulations had a relative advantage and higher efficiency on reducing populations of the tested insects. These results are agreed with that of [11] who cleared that derived rosemary plant oil was more efficient on *A. tubercularis* and mealybug *Icerya seychellarum* than commercial oil "Ibex oily". Also, [30] cleared that neemazal at rate 1.5 ml/liter of water gave medium reduction against the nymphs of black scale, *Saissetia oleae* (Honopteri: Coccidae) and low reduction against adult females. [31] reported that, some compounds which prepared as essential oil formulations (rosacide, sagix and cura) were effective against aphid *Aphis craccivora* when treated systemically or by spray. [8] revealed that neemazal and margosan from (neem oils) able to reduce population of *Insulaspis pallidula*. Our results indicated that formulations from essential oils can be replaced by commercial scalicides or mineral oils in IPM program, this supported by [32] who revealed that jojoba oil is useful in reducing environmental pollution.

Chlorophyll content:

Regarding to Chlorophyll a and Chlorophyll b, the plants which treated with the tested essential oils formulations after different periods of treatments, pre-spray, 3, 9, 15 and 21 days are represented in table 8. Data showed that chlorophyll (a) content after 3 days of treatment had significant decrease for Trilogy and Citrocide (6.64 and 7.17 mg/g fresh weight), respectively compared to pre-spray (11.59 and 11.27 mg/g f.w.), respectively. As for treatment with Lemocide, it causes a reduction in chlorophyll (a) after 9 and 21 days (9.47 and 8.19 mg/g) compared to pre-spray (11.45 and13.14 mg/g), respectively. [33] attributed the reduction in chlorophyll content to the repression of specific enzymes that are responsible for the synthesis of photosynthetic pigments.

On the other hand, treatment with Demso and Oregacide were effective on increasing chlorophyll contents with time elapsed, which may be due to increase in the synthesis of the chlorophyll and/or delayed chlorophyll degradation [34,35]. Also, this increase can be explained by decrease insect infestation (a biotic stress) after 21 days of treatment with the most effective compounds (Demso and Oregacide), since the plants become healthy.

Nutrient contents

The concentrations of iron (Fe), magnesium (Mg) and nitrogen (N) in mango leaves treated with the tested essential oils formulations, in addition, Trilogy commercial insecticide are shown in table (9). The content of Fe increased after 21 days of treatment for all formulations, except Lemocide, that decreased Fe content from 198.9 mg/g at pre-spray to 117.6 mg/g. As for Mg, Demso and Oregacide formulations increased after 21 days of treatment with 0.208 and 0.276 mg/g, respectively, compared to pre-spray of 0.199 and 0.196 mg/g, respectively. These findings confirm our result of chlorophyll content for Demso and Oregacide, which

increased chlorophyll content after 21 days of treatment. On the other hand, Mg content of Triology and Citrocide did not increase after 21 days of treatment which were 0.232 and 0.208 mg/g, respectively, whereas, it were 0.234 and 0.217 mg/g respectively, at pre-spray, while, Lemocide decreased Mg content after 21 days of treatment from 0.206 mg/g at pre-spray to 0.121 mg/g. The content of Mg of all formulations were greater than control after 3 and 9 days of treatment, while, Mg content of Demso and Triology were less than control after 15 days of treatment. Moreover, Mg content of Oregacide formulation was higher than control after 21 days of treatment. Concerning N content, Oregacide formulation increased the content from 1.59 mg/g at pre-spray to 2.59 mg/g after 21 days of treatment, while the other formulations in addition to control decreased the content of N after 21 days of treatment compared to pre-spray. Furthermore, all formulations were higher than control of N content after 9 and 15 days of treatment. In the same trend, the content of N of Demso, Trilogy and Oregacide formulations were higher than control after 21 days of treatment.

Iron is an essential micronutrient for roughly all living organisms in order to its prominence in metabolic processes, as DNA synthesis, respiration, and photosynthesis. In addition, many metabolic pathways are stimulated by iron. Iron is the third extremely limiting nutrient for plant growth and metabolism, in order to the low solubility of the oxidized iron form in aerobic medium[36,37]. Iron deficiency is a common nutritional disturbance in many plants, which leads to poor yields and reduced nurture quality. In plants, iron is participatory in chlorophyll synthesis, it is essential for the preservation of chloroplast structure and function. Magnesium is essential for chlorophyll and seed formation, it helps in adjusting the uptake of other plant foods, behaves as a transporter of phosphorus in the plant, promotes formation of oils and fats.

Growing plants, animals, and microbial populations need a persistent source of N. It is an essential ingredient of the proteins that build cell substance and plant tissue. In addition, it is necessary for the function of other substantial biochemical agents, including chlorophyll (which makes photosynthesis conceivable), many enzymes (which help organisms to perform biochemical processes), and nucleic acids such as DNA, RNA (which are contributed in reproduction).

Table (8): The side effect of the tested compounds on chlorophyll contents on mango plants

Treatment	Concentration of photosynthetic pigments at indicated days													
	Chlorophyll a mg/g							Chlorophyll b mg/g						
	Demso	Oregacide	Citrocide	Lemocide	Trilogy	Control	LSD	Demso	Oregacide	Citrocide	Lemocide	Trilogy	Control	LSD
Pre-spray	11.49	11.46^{b}	11.27^{a}	13.23^{a}	11.59^{a}	11.62	N.S	3.43^{b}	4.79	5.38	5.95	2.35^{b}	5.09	N.S
3	9.25B	7.54^{c}BC	7.17^{bc}BC	12.25^{a}A	6.64^{b}C	11.72A	2.25	3.07^{b}CD	8.90A	4.38BCD	4.75BC	2.15^{bc}D	5.64B	2.56
9	15.68A	12.42^{ab}AB	6.78^{bc}C	9.47^{bc}BC	7.71^{b}C	11.45B	3.63	6.21^{a}AB	7.80A	4.82BC	3.86C	1.71^{c}D	5.72ABC	2.08
15	13.20A	11.61^{b}A	6.13^{c}B	11.19^{ab}A	11.55^{a}A	12.36A	2.89	6.88^{a}A	4.12BC	4.33B	3.03CD	2.34^{b}D	6.06A	1.22
21	16.76A	14.93^{a}AB	9.92^{ab}CD	8.19^{c}D	12.6^{a}BC	13.14BC	3.40	6.26^{a}	6.71	5.84	4.53	3.37^{a}	4.90	N.S
$LSD_{0.05}$	N.S	2.66	3.16	2.14	1.74	N.S	-	2.12	N.S	N.S	N.S	0.45	N.S	-

Each value represents the mean of three replicates ± standard deviation.
Means with different letters were significantly different at the 0.05 level according to Duncan's multiple range test.
Means followed by same small Letters in a column are not significantly different at 0.05 level of probability.
Means followed by same caps. Letters in a row are not significantly different at 0.05 level of probability.

Table (9): The side effect of the tested compounds on nutrient contents on mango plants

Treatment	Concentration of elements at indicated days																	
	Fe						Mg						N					
	Demso	Oregacide	Citrocide	Lemocide	Triology	Control	Demso	Oregacide	Citrocide	Lemocide	Triology	Control	Demso	Oregacide	Citrocide	Lemocide	Triology	Control
Pre-spray	213.69	207.86	193.85	198.6	213.75	199.9	0.199	0.196	0.217	0.206	0.234	0.196	2.28	1.59	2.23	1.6	1.88	1.92
3	209.19	184.18	175	211.4	203.9	224.28	0.185	0.179	0.204	0.258	0.218	0.171	3.08	1.28	1.34	2.02	1.73	1.34
9	198.31	206.34	212.38	182.9	177.14	211.6	0.163	0.188	0.240	0.166	0.207	0.139	1.82	1.62	1.87	1.81	1.63	1.17
15	192.02	244.84	152.72	209.3	197.5	163.41	0.149	0.273	0.234	0.222	0.136	0.192	2.14	1.88	1.72	1.84	1.57	1.16
21	284.16	222.77	231.7	117.6	246.68	212.8	0.208	0.276	0.208	0.121	0.232	0.249	1.84	2.59	1.47	1.53	1.85	1.7

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