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Efficacy of some essential oils on pest insect management in nursery and orchard and their impact on yield and fruit quality of Washington navel orange trees

B. Impact of essential oils on leaf miner and mite's acarida's management and their influence on fruit yields and quality of Washington navel orange trees.

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ABSTRACT

A field experiment was carried out during 2016 and 2017 growing seasons to study the effect of foliar application with natural essential oils versus a mixture of vertimec with mineral oil on both leaf miner population and some citrus mite's acarida's management and their influences on yield and fruit quality of Washington navel orange trees. The treatments were; T1: control trees (sprayed with water). T2: Trees sprayed with flower oil at conc. 0.3%. T3: Trees sprayed with flowers aromatic water at conc. 3.0%. T4 and T5 trees sprayed with leaf oil and leaf aromatic water at conc. 0.3% and 3.0%, respectively. T6: Trees sprayed with a combination of vertimec plus mineral oil. The obtained results indicated that vertimec plus mineral oil, in both season, significantly decreased the population of leaf miner larvae (0.42+3.33 cm/L) and gave the best interaction for reducing leaf miner population number especially in the first season. As for *Tetranychus urticae*, foliar spray with flowers oil in the first season and flower aromatic water in the second one markedly reduced from Tetraranychus individual number compared to control trees other treatments were intermediate. The interaction among three factors was significant, particularly in the second season. Concerning *Chrysomphalus ficus* mites, flower oil and flower aromatic water, in both seasons, significantly decreased individuals number of Chrysomphalus ficus on Washington navel orange trees. Nevertheless, all essential oils experimenting herin markedly reduced of individual's number especially in the second season compared to control trees in this respect. The interactions among different essential oils treatments, second spray and the individual number after spraying treatments were highly significant particularly in the second season. Fruit yield expressed as weight or number; in both seasons, flower oil application has significantly increased fruit yield and acidity percent followed by the mixture of vertimec+ mineral oil. Both flower and leaf aromatic water; in both seasons, significantly increased fruit length and diameter. However, flower aromatic water markedly increased fruit weight, fruit juice percent, T.S.S. / acid ratio and vitamin C content when compared to the control. Moreover, leaf aromatic water significantly augment of plup weight. Conversely, fruit peel percent, in most cases, has not significantly lean influenced by different treatments, yet, peel percent was markedly lower than those of the control especially, in the treatments of Vertemic + mineral oil and leaf aromatic water. Fruit T.S.S. slightly increased when compared with control treatment, especially in the second season. No significant differences were noticed of T.S.S. during the first experimental season.

***Keywords*:** Essential oils, Washington navel orange, fruit yields and quality, Pest insect management, Leaf miner and mites acarida's.

Introduction

Citrus is one of the most important horticulture crops in Egypt due to its high economic value especially through exportation, Egypt has exported about 1400705.446 tons of citrus fruit during 2016/2017 (General Administration of plant Quarantine). Washington navel orange is one of the most important citrus fruits produced in Egypt; the total area occupied by navel orange trees 179876 feddan representing 33.7% of the total area of citrus and produced 1697222 tons of fruits; representing about 36.5%of the total citrus production (Annual Book of Agricultural statistics, 2015) peoples consuming

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about 3435030 tons of fruits (according to World Markets and Trade; January 2018) Washington navel orange leaves and fruits are liable to infestation by insects such as leaf miner larvae's or mites (*Tetranychus urticae* or *chrysomphalus ficus*); These insects feeding predispose trees and attacking both leaves and fruits causing shrinking and damages becoming un acceptable for exportation. Besides, infection by citrus canker and bacterium infection. The main method of suggested toward control of these insects is spraying insecticides, which regarded as harmful to both humans and the environment (Benchouikh *et al.,* 2015).

In recent years, the use of volatile oils derived from citrus leaves and flowers and their aromatic water as low-risk insecticides has increased considerably owing to their population with citrus organic growers and environmentally conscious consumers (Catherine *et al.,* 2012). Essential oils are associated with the presence of complex secretory structures such as glandular trichomes (Lamiaceae), secretory cavities (Rutaceae, Myrtaceae), resin ducts (Asteraceae, Apiaceae). Essential oils are stored in various plant orangs e.g., flowers, leaves, wood, roots, rhizomes, seeds and fruits. Essential oils are easily produced by stream distillation of plant material and contain many volatile, low-molecular weight terpenes and phenol. Essential oil extract have repellent insecticidal and growth reducing or retardant a several insects (eg. Leaf miner or mites acarida's), they have been used effectively to control preharvest and postharvest phytophagous insects and as insect repellents for biting flies and for home and garden insects. One of the explanations for such differences in the percentages of parasitism, due to the differences in chemical composition of citrus leaves and flowers which might play a role in a attracting or repelling the parasitoid adults in some plants while others not. Also the female pests is strongly attracted to the odors arising from damaged citrus trees (Al-Ghabeish and Allawi (2002). Moreover, preceding harvest spraying with volatile essential oils extracted from citrus flowers and leaves to Washington navel orange trees greatly reduced the population numbers of leaf miner and mites acarida's resulted in increased yield components and also improvement fruit quality properties.

The objective of our study was to evaluate the influence of some essential oils on the populations of leaf miners, mites acarida's, yield and fruit quality of Washington navel orange trees.

Materials and Methods

The present study was conducted during 2016 and 2017 seasons on 4 years old Washington navel orange trees (Citrus sinensis Osbeck) budded on sour orange rootstock grown in clay soil in a private orchard located at El-Maadia region, Kafr El-Dawer Center, El-Behera governorate, Egypt. The main target of the study was to examine the influence of natural essential oils extracted from citrus (Washington navel orange) leaves, flowers and their aromatic water against a mixture of vertimic plus mineral oil on yield and fruit quality of Washington navel orange trees and infestation rates of leaf miner and other pests. The selected trees were nearly uniform in vigor and size, spaced at 4x5m.apart.The trees were irrigated with Nile water using surface irrigation system every 12 days during the growing seasons.

Four replicates were selected to represent each treatment twenty four trees for this study. The treatments are presented as follows:

1- Control (sprayed with water)
2-Trees sprayed with extracted-leaf oil at concentration of 0.3%
3-Trees sprayed with extracted-flower oil at concentration of 0.3%
4-Trees sprayed with leaf aromatic water at concentration of 3.0%
5-Trees sprayed with flower aromatic water at concentration of 3.0%
6-Trees sprayed with a mixture of vertemic 0.42cm/l + mineral oil 3.33cm/l.

All treatments were applied using a 20 liters hand sprayer on the foliage until drip point of the solution, spreading agent was added at the concentration 0.5cm/Liter. Guard rows were left around the trees of each spray treatment. Different treatments were repeated on the same trees for the two successive experimental seasons.

A. Spraying dates and microscopic examination:

As for the frequency of spraying ; the first spraying was done on August, 23;whilst second one was on September 23 of each seasons on Washington navel orange trees or other wards the same dates

of the spraying which mentioned in part one of nursery. Before application leaf samples consisted of 3-6 leaves were directly taken from different directional of the trees. Two weeks after each spraying treatment; leaf samples consisted of 3-6 leaves were taken from different places for microscopic examinations and infestation level was also determined in terms of either population or individual number per leaf.

B. Fruit number / tree

In November, 2016 and 2017 seasons fruit number of each tree was recorded and on December, 20 average fruit weight of 12 randomly by selected mature fruit was estimated for each tree. Fruit yield of each experimental tree was then calculated as kg per tree.

C. Fruit quality:

At harvest time (on December, 20) of both seasons, fruit length, diameter, pulp and peel weights and weight of sex fruits, random taken from each experimental tree was determined. Soluble solids content (SSC) in fruit juice was determined by hand refactometer. Fruit juice volume was also recorded. Acidity, as citric acid percent was determined using 0.1N sodium hydroxide. Vitamin C content in the juice was determined by titration with 2, 6-dichlorophenol indophenol dye (A.O.A.C, 2005). The data (yield and fruit quality) were statistically analyzes using a complete randomized block design according to Snedecor and Cochran (1995). The experimental design used R.C.B.D. accord to Snedecor and Cochran (1995) where the main plot was for sex treatments mentioned before, the sub plot for the spraying frequency, while the sub sub plot for time of examination (Before and after spraying). However all data were analyzed using SAS program.

Results and Discussion

Effect of foliar application of natural essential oils extracted from Citrus (navel orange) flowers and leaves versus a mixture of vertimec plus mineral oil on leaf miner population of Washington navel orange trees:

The obtained results shown in Table (1) indicated that a combination of Vertimec plus mineral oil treatment, in both seasons, was the best treatment to reduce the number of leaf miner population; followed by 0.3% flower oil; especially in the first season, compared with the control treatment. On the contrary, both leaf oil and leaf aromatic water of concentration 3% was similar to that of the control, particularly in the first one, while flower aromatic water treatment of concentration 3% was intermediate during both seasons of the study (Table1).

Table 1: Effect of foliar application with essential oils extracted from flowers and leaves of Washington navel orange trees versus a mixture of vertimec plus mineral oil on populations number of leaf miner of Washington navel orange trees during 2016 and 2017 seasons.

Treatments	**1st season**	**2nd season**
	Populations number of leaf miner	
Main effect (A)		
Flower oil 0.3%	1.68 B	2.18 AB
Flower aromatic water 3.0%	2.50AB	2.12AB
Vertimec + mineral oil	1.62 B	1.50 B
Leave oil 0.3%	2.87A	2.18 AB
Leave aromatic water 3.0%	2.81A	2.25AB
Control (water)	3.00A	3.00 A
Sub effect (B)		
Single spray	2.95A	2.33 A
Double spray	1.87 B	2.08 A
Sub sub effect (C)		
Before spray	2.97A	2.58 A
After spray	1.85B	1.83 B

Means within each column of the same letter are not significantly different at level of p = 0.05

As for sub effect (B); data in Table (1) revealed that, duple spray treatment, in both seasons, markedly decreased populations of leaf miner to least level compared to the single spray treatment and the differences were statistically significant in the first season, but insignificant in the second one. The mean values were 2.95 and 2.33 at the single spray and were 1.87 and 2.08 for the douple one in the first and second seasons, respectively.

Concerning sub sub effect (C) results in Table (1) showed that leaf samples collected from Washington navel orange trees after spraying treatments has brought about the lowest leaf miner number compared with that of leaf samples collected before spraying treatments.

The triple interaction among A, B, and C was statistically significant in the first experimental season, yet the differences were not significant in the second one (Table 2). This result was in agreement with those reported by Gharib *et al* (2015) using mandarin trees who applied two foliar insecticidal sprays on early September and late May to control the larva's of citrus leaf miner (CLM). They found that the application of abamectin (Vertimec) with mineral KZ oil mixture has increased its insecticidal activity. They concluded that confidor and a mixture of vertimec with KZ oil gave the highest foliar insecticidal activity and persistence against CLM infestation on mandarin trees. Besides, Ahmed *et al.* (2013) on citrus leaf miners; showed that leaf miner (*Plyllocnistis citrella*) can be effectively controlled without using more toxic pesticides thus saving natural enemies, environment and minimized the cost.

Table 2: Effect of triple interaction among the three factors (flower and leaves essential oils, single and double spray and the examination before and after spray on populations number of leaf miner of Washington navel orange trees during 2016 and 2017 seasons.

Interactions		1st season				2nd season			
		Populations number of leaf miner							
		Single spray		Double spray		Single spray		Double spray	
		Before	After	Before	After	Before	After	Before	After
Triple (AXBXC) interactions	1	1.50 de	1.25 e	2.75 bcde	1.25 e	3.00	1.50	2.75	1.50
	2	4.50 ab	2.25 de	2.25 de	1.00 e	2.50	2.25	2.00	1.75
	3	2.50 cde	1.75 de	1.25 e	1.00 e	2.00	1.00	1.50	1.50
	4	5.57 a	2.75 bcde	1.75 de	1.25 e	2.75	150	3.00	1.50
	5	4.25 abc	2.50 cde	2.75 bcde	1.75 de	3.00	2.25	2.00	1.75
	6	3.25 bcd	3.25 bcd	3.25 bcd	2.25 de	3.25	3.00	3.25	2.50
L.S.D at 0.05.		1.84 (S)				2.22 (N.S)			

Means within each column of the same letter are not significantly different at level of p = 0.05

Moreover, our results, also seemed to be in harmony with those reported by numerous investigators, for example, Catherine (1997), Mishra *et al.* (2012), Adil *et al.* (2015) and Chegini Abbasipour (2017) all pointed out that essential oils appear to be very complex natural mixes. Most of the compounds have ten atoms of carbon (Monoterpenes), 15 atom of carbon (sesquiterpenes) or more rarely 20 atons of carbon (diterpenes). The major of essential oils contain a limited number of compounds, but some of the minor compounds can play an important role as vectors of fragrance and make up the richness of an extract. These compounds of essential oils are presently regarded as a new class of ecological produced for controlling insect pests including leaf miner. They found that the essential oils are volatile with high insecticidal efficiency and very low persistence; the active compounds present in essential oils are specific to particular insect groups and not to mammals; many of them are not dangerous to human. Also, it has been concluded that essential oils has remarkable larvicidal properties. In tomato plants, the studies proved that essential oils as a natural pesticide against the larvae of Tota absoluta . Likewise, Hamdan *et al*. (2013) using navel orange var. Malesy; reported that the hydrodistilled oil and hexan-ether extract of the flower afforded 92 and 34 identified compounds, respectively. Sabinine followed by limonene were represented in higher amount in flower oils extracted with two methods. They concluded that navel orange var-malesy volatile compounds exhibited high significant insecticidal activity against common larvae in citrus orchards. Moreover, Hendrikse (1980) and Finidori-Iogli *et al* (1996) explained the differences in the percentages of parasitism of leaf miner larvae population number and adults in some vegetable plants due to the differences in chemical composition of plant leaves, which might play a role in attracting or repelling the parasitoid adults in some plants, while others not. They also found that parasitoid off spring

increased slowly when the numbers of available leaf miner larvae increased. In addition, the diptera's larvae on the basis of the volatile signals released by the plant –host complex. The female is strongly attracted to the oder arising from damaged bean-plants, thus acting as synonymous.

Effect of foliar application with natural essential oils extracted from citrus flowers and leaves versus a mixture of vertimec plus mineral oil on *Tetranychus Urticae* of Washington navel orange trees:

It is clear from Table (3) that flower oil at 0.3% concentration in the first season as well as flower aromatic water at 3.0% concentration treatments in the second one significantly reduced the number of individuals of *tetranychus urticae* compared to the control treatment (sprayed with water) which significantly contained on the highest number of individuals during both seasons of study. The individual number was 0.43 for flower oil 0.3% and 0.18 for flower aromatic water at 3.0% in the first and second seasons, respectively. Conversely, the control treatment was 0.87 and 0.81 during the first and second seasons, respectively. Meanwhile, other treatments were intermediate in this respect (Table 3).

Table 3: Effect of foliar application with essential oils extracted from flowers and leaves of Washington navel orange trees versus a mixture of vertimec plus mineral oil on individuals number of *Tetranychus urticae* of Washington navel orange trees during 2016 and 2017 seasons.

Treatments	1st season	2nd season
	Individuals number of *Tetranychus urticae*	
Main effect (A)		
Flower oil 0.3%	0.43B	0.50 AB
Flower aromatic water 3.0%	0.75AB	0.18 B
Vertimec + mineral oil	0.81 AB	0.43AB
Leave oil 0.3%	0.75AB	0.50 AB
Leave aromatic water 3.0%	0.62AB	0.37AB
Control (water)	0.87A	0.81A
Sub effect (B)		
Single spray	0.66A	0.85A
Double spray	0.75A	0.08B
Sub sub effect (C)		
Before spray	0.91A	0.64A
After spray	0.50B	0.29 B

Means within each column of the same letter are not significantly different at level of p = 0.05

With regard to sub effect (B); data in Table (3) revealed that the number of individual Tetranychus (mites) were not significantly different during either single spray or second one; especially in the first season, while the difference was significant during the second one. However, douple spray, significantly decreased individual number of mites.

As for the sub sub effect (C); results in Table (3) clearly indicated that leaf samples collected after different spraying treatments contained significantly the lowest levels of the individual's number of *Tetranychus urticae* when compared to those collected before spraying. The mean values were 0.50 and 0.29 after spray treatments. On the contrary, were 0.91 and 0.64 before one in the first and second seasons, respectively (Table 3).

Upon, the triple interaction among A, B, and C factors; the differences were insignificant during the first season; while the differences were statistically significant during the second one (Table 4). Our results proved that natural essential oils constituents may have the potential against botanical acaricides and can be used as alternative for chemical pesticides (acaricides). In this concern, Kheradmand *et al*. (2015) studied the effects of essential oils derived from Cumin, clove and spearmint against two-spotted spider mite and *Tetranychus urticae* (Acari: Tetranychidae). They found that the three extracted essential oils seem to be suitable sources of active vapors that can be used as alternatives for chemical pesticides for controlling this pest (*Tetranychus urticae*). Likewise, Wu *et al.* (2017) indicated that essential oils such as Thyme natural oil (Thymol) and some of its

major constituents have the potential to be developed into botanical acaricides against carmine spider mites (*Tetranychus cinnabarinus* (Boisduval).

Table 4: Effect of triple interaction among the three factors (flower and leaves essential oils, single and double spray and the examination before and after spray on individuals number of *Tetranychus urticae* of Washington navel orange trees during 2016 and 2017 seasons.

Interactions		1st season				2nd season			
		Individuals number of *Tetranychus urticae*							
		Single spray		Double spray		Single spray		Double spray	
		Before	After	Before	After	Before	After	Before	After
Triple (AXBXC) interactions	1	0.50	0.25	0.75	0.25	1.00 abc	0.50 bc	0.50 bc	0.00 c
	2	1.00	0.75	1.00	0.25	0.75 abc	0.00 c	0.00 c	0.00 c
	3	0.75	0.75	1.25	0.50	1.25 ab	0.50 bc	0.00 c	0.00 c
	4	0.75	0.50	1.25	0.50	1.00 abc	1.00 abc	0.00 c	0.00 c
	5	0.75	0.50	0.75	0.50	1.00 abc	0.50 bc	0.00 c	0.00 c
	6	1.00	0.50	1.25	0.75	1.75 a	1.00 abc	0.50 bc	0.00 c
L.S.D. at 0.05		1.68 (N.S.)				1.09 (S)			

Means within each column of the same letter are not significantly different at level of p = 0.05

Effect of foliar application with natural essential oils extracted from citrus (navel orange) flowers and leaves versus a mixture of vertimec plus mineral oil on *Chrysomphalus ficus* of Washington navel orange trees:

Data concerning the effect of natural essential oils and a mixture of Vertimec plus mineral oil on *Chrysomphalus ficus* mite, in both seasons, showed that flower oil at 0.3% concentration and flower aromatic water as well as leaf aromatic water at 3.0% concentration were the most significantly efficient treatments to control this mite and gave the least individuates number of acrides compared with other the treatments including control trees. The mean values of these treatments were 0.75 and 0.25, 0.75and 0.31, 0.81and 0.12 during the first and second seasons; respectively, such result, was supported by statistical significant differences (Table 5). Generally, all essential oils and a mixture of Vertimec + mineral oils treatment significantly reduced the number of individual of mites population compared to the control treatment. This was clear; especially in the second experimental season (Table 5).

Table 5: Effect of foliar application with essential oils extracted from flowers and leaves of Washington navel orange trees versus a mixture of vertimec plus mineral oil on individuals number of Chrysomphalus ficus of Washington navel orange trees during 2016 and 2017 seasons.

Treatments	1st season	2nd season
	Individuals number of *Chrysomphalus ficus*	
Main effect (A)		
Flower oil 0.3%	0.75 B	0.25 B
Flower aromatic water 3.0%	0.75 B	0.31 B
Vertimec + mineral oil	0.87 AB	0.12 B
Leave oil 0.3%	1.75A	0.37 B
Leave aromatic water 3.0%	0.81B	0.12 B
Control (water)	0.87 AB	0.81 A
Sub effect (B)		
Single spray	1.20 A	0.52A
Double spray	0.72 A	0.14 B
Sub sub effect (C)		
Before spray	1.20 A	0.45 A
After spray	0.72 A	0.20 B

Means within each column of the same letter are not significantly different at level of p = 0.05

As for the sub effect (B), results in Table (5) indicated that no statically significant difference was observed between the single spray and the douple one, particularly in the first season (2016).

Conversely, double spray significantly decreased of the individual number during the second season (2017).

With regard to the sub sub effect (C), the results revealed that the same trend was also obtained as those of sub effect (B), i.e. no significant differences were noticed either before or after spraying treatments, during the first season while in the second season, leaf samples collected after spraying treatment contained significantly decreased number of in mite dividual (Table 5).

The interactions among A, B and C factors were statistically significant in controlling the individual number of *Chrysomphalus ficus* on Washington navel orange trees as show in Table (6).

The results obtained herin, generally are in agreement with those reported by Motazedian *et al*. (2012), who concluded that the essential oils obtained from the aerial parts of the three medicinal plants namely: *Mentha longifolia*, *Salvia officials* (both Lamiaceae) and *Myrtus communis* (Myrtaceae) might have the potential as an alternative to synthetic pesticides, since they have a wide range of bio activities against insects and mites. They suggested that essential oils of all the three plants have the potential to be employed in the pest management programs designed for a control of *T. urticae* (mites). Same investigators, notable, Konstant Opoulou *et al.* (1992), Regnault-Roger and Hamraoui (1994) and Weaver *et al.* (1991) have reported that the essential oils and their constituents exert insecticidal effects or reduce and hindered insect growth at different life stage. They added that essential oils is promising not only to manage aphid populations, but also to reduce the spread of plant viruses till in in closed spaces such as greenhouse or plastic tunnels. Moreover, Chiasson *et al*. (2004) investigated essential oils efficiency on many other arthropods are poorly documented; however, a notable exception is the acaricidal activity of a *Cbenopodium ambrosioides* var. ambrosioides against adult mites *Tetranychus urticae* and *panonycbus ulmi*. Besides, essential oils are good penetrants that increase own bioavailability and that of coadministered products; these properties are related to the disruption of lipid bilayers in cell. Likewise, Belzile *et al*. (2000) reported that essential oils have specific modes of action that make then good synergists in particular, a number of compounds are well established inhibitors of insect and mites P450 cytochromes responsible for phase 1 metabolism of xenobiotics, including insecticides. They include phytochemicals containing methylene dioxy rings such as furano coumarins from oil of bergamot (*C. Bergamia*). In addition, Mishra *et al*. (2012) from their observed confirmed that the essential oils which were extracted from some medicinal plants leaves have more repellency against both insect pest and mites. Rim and Jee, (2006) studied the effect of herb essential oils extracted from *Citronella, lemongrass*, tea tree, ylang and rosemary on pyroglyphid mites. They concluded that herb essential oils, in particular, pennyroyal was proved to have potent acaricdal activity.

Table 6: Effect of triple interaction among the three factors (flower and leaves essential oils, single and double spray and the examination before and after spray on individuals number of *hrysomphalus ficu*s of Washington navel orange trees during 2016 and 2017 seasons.

Interactions		1st season				2nd season			
		Individuals number of *Chrysomphalus ficus*							
		Single spray		Double spray		Single spray		Double spray	
		Before	After	Before	After	Before	After	Before	After
Triple (AXBXC) interactions	1	0.75 b	1.00 b	0.75 b	0.50 b	0.75 ab	0.00 c	0.25 bc	0.00 c
	2	0.75 b	0.75 b	0.75 b	0.75 b	0.75 ab	0.50 abc	0.00 c	0.00 c
	3	1.25 b	1.00 b	0.75 b	0.50 b	0.50 abc	0.00 c	0.00 c	0.00 c
	4	4.00 a	1.25 b	1.25 b	0.50 b	0.75 ab	0.50 abc	0.25 bc	0.00 c
	5	0.75 b	1.00 b	1.00 b	0.50 b	0.50 abc	0.00 c	0.00 c	0.00 c
	6	1.25 b	0.75 b	1.25 b	0.25 b	1.00 a	1.00 a	0.75 ab	0.50 abc
L.S.D. at 0.05		1.80 (S)				0.65 (S)			

Means within each column of the same letter are not significantly different at level of p = 0.05

Effect of foliar application with flower and leaf oils, aromatic water and a mixture of vertimec plus mineral oil on fruit yield of Washington navel orange trees:

It is clear from Table (7) that the essential oils extracted from flower oil gave the highest number of fruit per tree, average fruit weight and fruit yield (as Kilogram per tree); followed by a

combination of vertimec plus mineral oil. These results were supported by significance differences when compared to the control treatment (sprayed with water). The aforementioned results held true during both years of study. They also, indicated that both flowers and leaves aromatic water significantly have increased the average fruit weight, particularly in the second season.

Table 7: Impact of foliar spray with flower, leaves essential oils and aromatic waters versus a mixture of vertimec plus mineral oil on fruit number / tree, average fruit weight, fruit yield of Washington navel orange trees during 2016 and 2017 seasons.

Treatments	1st season			2nd season		
	Fruit number / tree	**Average fruit weight (g)**	**Fruit yield (Kg/tree)**	**Fruit number / tree**	**Average fruit weight (g)**	**Fruit yield (Kg/tree)**
Control (water spray)	228.75 cd	228.75 c	46.31 bc	166.75 c	185.25 b	30.89 bc
Flower oil 0.3%	398.75 a	398.75 a	87.68 a	212.50 a	202.25 a	42.85 a
Leaves oil 0.3%	249.30 bc	249.30 bc	48.48 bc	178.75 bc	185.50 b	33.36 b
Flower aromatic water 3.0%	246.25 c	246.25 b	51.93 b	148.30 d	194.75 ab	29.03 cd
Leaves aromatic water 3.0%	203.75 d	203.75 c	36.01 c	136.25 d	203.80 a	27.70 d
Vertamic + mineral oil mixture	282.00 b	282.00 b	52.63 b	190.00 b	190.00 b	40.35 a
L.S.D. at 0.05	35.19	46.80	14.49	12.34	10.34	2.83
	48.66	64.80	20.04	17.07	14.30	3.92

Means within each column of the same letter are not significantly different at level of p = 0.05.

Moreover, a mixture of vertimec plus mineral oil, in the second season, significantly augment Washington navel orange fruit yield when compared with the other treatments including control trees.

The results also showed that the same treatments that caused the production of the highest number of fruits/tree and fruit yield of Washington navel orange trees were also the same treatments (flower oil, flower aromatic water and a mixture of vertimec + mineral oil) that caused the reduction of the populations number of leaf miners as well as in the number of acarida's individual or mites. In other word, the same treatments which increased the fruit yield expressed as either weight or number were also the same treatments which reduced the population's number of leaf miners and acarida's.

The results obtained herin, generally are in agreement with those reported by Pena *et al*. (2000 and Graham *et al* (2004); who found that the leaf miner larvae damage of leaves by creating serpentine feeding mines and leaf wounds which facilitate the infection by citrus bacterial canker, *xanthomonas aronopodis* pv. Citri, which results in blemished fruit, premature fruit drop, leaf drop and finally reduced yield. Muthaiah *et al.* (1998) as well as Shivan Kar *et al.* (2002) reported that to combat both leaf miner and acarida's damage and for qualitative and quantitative increased of yield; sustainable approaches for these pests management are very much essential. They concluded that various control methods have been proposed for the management of both citrus leaf miners and mites or acarida's, these include cultural practices, chemical control, biological control; especially essential oils, etc. Besides, Patil (2013) evaluated the insecticidal activity of sex rovel groups of insecticides for management of citrus leaf miners on acid lime. He found that abamectin (vertimec) 109 EC at the rate of 0.0007 percent recorded minimum infestation of leaves and gave maximum yield of acid lime. In addition, lasota and Dybas (1991) listed that vertimec (abamectin) has demonstrated nematicidal, acaricidal and insecticidal activity.

Effect of foliar application with flowers and leaves oils, aromatic water and a mixture of vertimec plus mineral oil on physical fruit properties of Washington navel orange trees:

Data in Table (8) clearly indicated that leaves aromatic, in both season, resulted in significantly the highest values in fruit length and diameter. Meanwhile, similar results were also obtained from foliar sprays with flower oil which produced fruits were significantly higher in fruit length and diameter when compared to other treatments and the control.

Data presented in Table (8) regards the effect of volatile oils and a combination of vertimec plus mineral oil on both fruit and peel weights, have generally revealed that both flowers and leaves aromatic water achieved significantly the highest values of both fruit and pulp weights when compared with other treatments including the control treatment (sprayed with water). This result held true throughout the study. The only exceptional case, was noticed when foliar spray was conducted by

using flower aromatic water treatment which resulted the least values in pulp weight, particularly in the second season (Table 8). Similary, a combination of vertimec+mineral oil resulted in the lowest values in both fruits and pulp weights. This result agree with the finding of Ibtesam Badawy *et al*. (2011) who reported that spraying with lime essential oil at 10% significantly increased fruit weight and reduced fruit weight loss percentage compared with controls. They discussed the main cause of the positive effects of oils on increasing fruit and pulp weights or decreasing fruit weight loss might be attributed to make a thin film of oils surrounding the fruit peel and induced a modification of microclimatic of fruits, also, these results are in agreement with Golam Rabbany and Mizutani (1996) and Samra *et al*. (2006). Likewise, Abdelwahab (2015), using nectarine fruits, suggest that the use essential oils specially Bergamot oil exhibited the pest results in maintenance of overall quality parameters and promise to get a product safe and healthy, especially to produce organic nectarines. Besides, Fatimi *et al.* (2011) showed that peppermint (*Mentha piperita*) oil used to maintain quality of the orange fruits and reduced weight loss percentage. Again, Abd Elwahab (2015) mentioned that essential oils could be work as barrier water loss and protecting fruit skin and delaying dehydration and therefore less weight loss (increase fruit weight). Also, the positive effect of essential oils in reduction of weight loss in different fruit crops were reported by Mohammadi and Aminifard (2012) and Mapho *et al.* (2013).

Table 8: Impact of foliar spray with flower, leaves essential oils and aromatic waters versus a mixture of vertimec plus mineral oil on physical fruit properties of Washington navel orange trees during 2016 and 2017 seasons.

Treatment	Fruit Length (cm)	Fruit diameter (cm)	Fruit weight (g)	Pulp weight (g)	Peel percent (%)	Juice percent (%)
	1st season					
Control (water spray)	7.33 b	7.03 b	205.75ab	171.25 bc	17.00 a	33.54 d
Flower oil 0.3%	8.03 a	7.36 a	175.25 c	155.00 d	13.15ab	41.19 b
Leaves oil 0.3%	7.00 c	7.10 b	194.25 b	161.50 cd	16.80 a	31.17 e
Flower aromatic water 3.0%	7.38 b	7.13 b	218.50 a	182.00 ab	14.43 ab	73.66 a
Leaves aromatic water 3.0%	7.86 a	7.30 a	211.25ab	184.00 a	11.60 b	40.15 b
Vertamic +mineral oil mixture	7.32 b	7.00 b	185.00 c	166.25 cd	11.18 b	36.78 c
L.S.D. at 0.05	0.18	0.15	17.66	12.04	4.42	1.85
	2nd season					
Control (water spray)	7.30 b	5.71 d	185.25 d	137.25 d	25.17 a	35.83cd
Flower oil 0.3%	7.41 ab	7.18 a	191.50cd	152.00 bc	20.67 a	38.81 b
Leaves oil 0.3%	6.99 c	6.81 c	185.50 d	145.00 cd	21.64 a	33.42d
Flower aromatic water 3.0%	7.51 a	6.95 b	206.75 a	153.75 bc	25.29 a	42.72 a
Leaves aromatic water 3.0%	7.50 a	7.18 a	203.75 ab	177.50 a	12.36b	38.32bc
Vertamic +mineral oil mixture	7.40 ab	7.05 b	196.25 bc	161.25 b	11.40b	38.33 bc
L.S.D. at 0.05	0.16	0.11	10.20	9.29	4.68	2.96

Means within each column of the same letter are not significantly different at level of p = 0.05.

Concerning the effect foliar sprays with flowers, leaves oils and their aromatic waters and a mixture of vertimec plus mineral oils on fruit peel percentages; the results in Table (8) revealed that, in both season, no significant differences were observed among the different spraying treatments and control. Yet, foliar application with leaves aromatic water and a combination of vertimec plus mineral oil achieved significantly the lowest values in fruit peel percent. The mean values of these two treatments were 11.60 and 11.18 in the first season, while in the second one, mean values were 12.36and 11.40 for leaves aromatic water and a mixture of (vertimec + mineral oil); respectively.

Regarding fruit juice percent; data in Table (8) showed that flower aromatic water followed by flower oils treatments caused a significant increase in fruit juice percentages compared with control treatment. This result held true during both seasons of investigation. The mean values of fruit juice percent due to foliar spray of leaves aromatic water and flower oils were 73.66% and 41.19% the first season were 42.72% and 38.81% in the second one; respectively. The mean values of control treatment were 33.54% and 35.83%, in the first and second seasons, respectively.

Effect of foliar application with essential oils and a mixture of (vertimec + mineral oil) on chemical fruit properties of Washington navel orange trees:

From Table (9) it was clear to notice that both flower and leaves oils, in both seasons, markedly increased fruit total soluble solids content; but the differences were not high enough to be significant, especially in the first experimental season. On the contrary, in the second season foliar application with vertimec plus mineral oil greatly reduced of total soluble solids percentages and was similar to those of the control (Table 9). This result agrees with the finding of Ibtesam Badawy (2011) using orange trees; who found that preceding harvest spraying with lime essential oil at conc. of 10% (v/v) caused significant increase in TSS% compared with control. Abd Elwahab (2015) using Nectarin fruits, she reported that use essential oils especially Bergamot oil exhibited the best results in maintenance of overall quality parameters. Moreover, Fatimi *et al*. (2011) using the orange fruit; found that Bergamot and peppermint oils showed a positive effects on total soluble solids. Besides, Bergamot oil consists of a volatile fraction (93-96%), whose main components are limonene (40%), linalool (8%) and linalyl acetate (28%) and consists of a nonvolatile fraction (4-7%) as pigments, wax and above all coumarins (citropten) and psoralens (bergapten + Bergamottin). While, Serban *et al.* (2011) mentioned that peppermint oil main components are Menthone 31.01%, Menthol 19.5% and Eucalyptol 9.62%.

Table 9: Impact of foliar spray with flower, leaves essential oils and aromatic waters versus a mixture of vertimec plus mineral oil on chemical fruit properties of Washington navel orange trees during 2016 and 2017 seasons.

Treatments	First season			
	Total soluble solids (%)	**Acidity (%)**	**TSS/Acid ratio**	**Vitamin C (%)**
Control(water spray)	15.50 a	0.77 b	20.23ab	43.93 c
Flower oil 0.3%	15.75a	0.88 a	18.33bc	54.36 b
Leaves oil 0.3%	15.75 a	0.75b	20.95ab	50.80b
Flower aromatic water 3.0%	15.50 a	0.74 b	21.12 a	60.89 a
Leaves aromatic water 3.0%	15.50 a	0.88 a	18.11c	42.26c
Vertamic + mineral oil mixture	15.50 a	0.80b	19.61abc	41.59c
L.S.D. at 0.05	0.35	0.06	1.68	5.59
	Second season			
Control(water spray)	15.25 b	0.82b	18.49 a	43.35 d
Flower oil 0.3%	15.50 ab	0.95a	16.64 b	46.17 b
Leaves oil 0.3%	15.75a	0.94a	16.61 b	46.55 b
Flower aromatic water 3.0%	15.50ab	0.84b	18.65 a	54.22 a
Leaves aromatic water 3.0%	15.50 ab	0.84 b	18.46 a	45.48 bc
Vertamic + mineral oil mixture	15.25b	0.87b	18.08 a	43.72 cd
L.S.D. at 0.05	0.39	0.05	1.36	1.96

Means within each column of the same letter are not significantly different at level of p = 0.05.

Concerning, Acidity percentages, data presented in Table (9) showed that foliar application of flower oil to Washington navel orange trees; in both seasons; significantly increased fruit acidity percent when compared to the control. Similarly, foliar application of leaves aromatic water in the first season and leaves oil in the second one, also, significantly raised fruit juice acidity percent when compared to other treatments including control fruits. In general, these results are in agreement with Fatimi *et al.* (2011) using orange fruits who, found that peppermint oil (*Mentha piperita* L.) increased acidity and maintain quality of orange fruit, and showed that positive effects on titrable acidity. Conversely, Ibtesam Badawy *et al.* (2011) reported that preharvest spraying with lime essential oil at conc. of 10% did not significantly affect total acidity and the differences were not significant and concluded that preharvest treated fruit with lime oil; total acidity less than controls. In the same time, Mohamed and Abou-Goukh (2003) indicated the same trend which mentioned above.

TSS/Acid ratio character, results in Table (9) indicated that the foliar application of essential oils, in some cases, slightly increased TSS/Acid ratio parameter particularly in the first season. Although, flower aromatic water treatment, in both seasons, markedly raised TSS/Acid ratio. On other hand, both leaves oil and leaves aromatic water reduced TSS/Acid ratio.

As for vitamin C (ascorbic acid), results in Table (9) indicated that foliar spray with flower aromatic water, in both seasons, significantly increased fruit vitamin C content; followed by in a descending order both flowers and leaves oils when compared with other treatments and the control. Fatemi *et al.* (2011) reported that Thyme (*thymus capitates* L.*)* and peppermint (*Mentha piperita* L.) oils greatly preserved the amount of vitamin C and maintain quality of the Valencia orange fruit. Likewise, Abd Elwahab (2015) stated that the highest content of vitamin C was obtained from nectarine fruits treated with essential oils treatments compared to control fruits. The author explained that the maximum retention of vitamin C was observed with essential oils treatments because these treatments reduced the oxidation in the fruits as the main compounds of oils had antioxidant properties and inhibited damage which causing oxidation of ascorbic acid. Similarly, Zeng *et al.* (2012) and Mohamed and ELBadawy (2013) reported that some essential oils were effective in maintaining ascorbic acid as Thyme and Clove oils of orange fruits.

Conclusion

Overall, it could be concluded that the application of natural essential oils extracted from flowers and leaves of Washington navel orange trees particularly, flower oil, flower aromatic water as well as a mixture of vertimec plus mineral oil to the foliage of Washington navel orange trees resulted a significant reduction in the populations number and individuals of leaf mines and acaride's (mites). Moreover, it increased fruit yield (weight &number), improved physical fruit properties and maintained chemical fruit properties, except acidity which was markedly increased. Such treatment is considered as safe and friendly environment.

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