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EFFECT OF INFESTATION WITH TWO SCALE INSECTS ON THE CONTENT, FRUIT CHARACTERS AND YIELD OF THE FLOWERS OIL OF SOUR ORANGE.

G. H. Mohamed * and Mehasen. H. R. A. **
** Plant Protection Research Institute, (A.R.C.), Dokki, Giza 12618, Egypt.*
***Horticulture Research Institute, (A.R.C.), MAPs Department, Giza, Egypt.*

ABSTRACT

This work was carried out to investigate the effect of infestation with two diaspid, Florida red scale, Chrysomphalus aonidum (L.) and Black parlatoria scale, Parlatoria ziziphi (Lucas) (Hemiptera: Diaspididae) flowers oil content, fruit characters and yield of sour orange at Kafr EL-Sohaby, Qalubyia Governorate during 2008/09 and 2009/10 seasons.

A delay was observed in inflorescence emergence date between uninfested and infested ones over the two seasons. Mean reduction of infestation with C. aonidum and P. ziziphi of inflorescences per meter (67, 75.5 %), flowers yield (72.75, 84.85 %), and flowers' volatile oil content (35.25, 69.4 %), in 2008 - 09 & 2009 -10 seasons, respectively. The reduction of the volatile oil, (physical and chemical properties) and the main components of the volatile oil of sour orange.

The results showed an increment in the reduction percentage of the volatile oil content and effect on the physical and chemical properties of volatile oil. In the same trend the main components percentage in the volatile oil were affected of the deferent types of the scale insects specially linalool and linalyl acetate. There were a heavy loss of yield per tree (39.49, 41.07 %), due to infestation by C. aonidum and P. ziziphi, respectively. While it was a low decreasing as a result of infestation by C. aonidum and P. ziziphi in fruit weight (2.58, 2.74 %), however height of fruit (3.83, 3.7 %) and diameter of fruit (3.21, 3.34 %) over the two seasons respectively. On the other hand, there were a low loss due to infestation of C. aonidum and a heavy decrease in infestation of P. ziziphi. In fruit juice acidity (3.54, 10. 45 %), percent of protein (4.48, 14.15 %), percent of total sugars (4.45, 18.15 %) and percent of vitamin C (4.45, 7.24 %) in 2009 and 2010 seasons, respectively.

Key words: Infestation, scale insects, fruit characters and yield, flowers oil, sour orange

INTRODUCTION

Sour orange, *Citrus aurantium* L. (Family: Rutaceae) is one of the important rutaceous members, it used for its volatile oil (which is used in perfume and as a flavoring), herbal medicine as a stimulant of appetite suppressant, and replaced the banned stimulant ephedrine in many herbal weight loss products Casabianca *et al.*, (1997). Sour oranges fruits are cut in half, salted, coated with a paste of hot chili peppers, and eaten in Southern Indian Hess and Sullivan, (2005) and used to make jam.

Armored scale insects attack sour orange trees, which affect tree health, productivity, fruit and flowers oil qualities. These insects suck plant sap. This mechanism disturbs the plant physiology and results in weaken the tree Willcocks, (1925). Sour orange trees were recorded to be infested by nine species of scale insects with different degrees of importance and distribution Ghabbour and Mohammad, (1996). Florida red scale, *C. aonidum* (L.) and Black parlatoria scale, *P. ziziphi* (Lucas) (Hemiptera: Diaspididae) are two of the most important pests attack sour orange trees. (Mohamed, 1999) studied the effect of infestation with *Hemiberlesia latania* (Signoret) (Hemiptera: Diaspididae) on olive tree phonology, fruits, oil content and oil quality. Mohamed (2002) found that no differences between the olive oil content extracted from normal and infested trees by *Parlatoria oleae* (Colvee) (Hemiptera: Diaspididae). Fruit characters (*i.e.* fruit weight, yield per tree) were significantly affected by *P. oleae* infestation level and fruits juice acidity was significantly affected by infestation of Apple fruits (Mohamed, 2004). Tawfik (1985) reported that citrus infestation with *P. ziziphus* affected the juice volume and the fruit fresh weight. Also, Tawfik (1996) reported that infestation with *Lepidosaphes beckii* (Newman) (Homoptera: Diaspididae) reduced orange fruits fresh weight and juice volume, while the ascorbic acid was increased as a result of infestation.

Therefore, this work aims to clarify the effect of two diaspid *C. aonidum* and *P. zizip* insects of infestation on sour orange trees phonology, oil content of flowers and fruit characters.

MATERIALS AND METHODS

This study was carried out in Kafr EL-Sohaby, Qalubyia Governorate, during 2008 - 2010 using 45sour orange trees (20 years old) in the same orchard. Two experiments were conducted to clarify the effect of infestation with two scale insects on sour orange (flowers and fruits). Every experiment was divided to three groups of sour-orange trees. Each group included five trees infested with *C. aonidum*, *P. ziziphi* as well as uninfested group as a control. The first experiment was carried out to study the effect of infestation with the mentioned diaspid species on inflorescence first emergence date, blooming period, number of inflorescence per-meter, flowers yield, volatile oil content, and the chemical composition of volatile oil of each treatment (the active ingredients). While second experiment was assigned to study the effect of infestation with same insects on fruit diminution (height and length), fruits yield and fruit quality of sour orange.

Samples of 20 leaves each group was picked up at monthly intervals throughout the two successive years of study. All alive insects (pre-adults, adult females) found in each sample were assorted and recorded. Identification of *C. aonidum* and *P. ziziphi* were carried out by first author, using the insect cutes collection list.

Results were recorded as the following parameters:-

The first experiment:-

- ***Inflorescence emergence:-*** Date of inflorescence emergence was recorded as soon as the first sign of inflorescence was seen.
- ***Blooming period:*** - Dates of beginning and full bloom were recorded when 10 and 80 % of total flowers opened.
- ***Number of inflorescence parameter***:- Five branches were chosen at random and labeled for every replicated tree, number of flower buds per shoot and per meter were recorded.
- ***Total flowers per inflorescence***:- Samples of 25 inflorescences located in inner and outer portions of the tree were sampled from the middle portion of branches. The percent of perfect flowers to the total number of flowers was calculated.
- ***Source of volatile oil:-*** The volatile oil samples were extracted by steam distillation in Clevenger apparatus for three hours from the flowers of sour orange trees (British pharmacopoeia 1963). The flowers were taken from the experimental farm of (Kafr EL-Sohaby, Qalubyia governorate) during two seasons (2008 - 09 and 2009 - 10).

-Determination of physical and chemical properties of volatile oils:- optical rotation, refractive index, acid value and specific gravity were determined according to the method described by A.O.A.C. (1975).
-Identification and determination of the volatile oil composition:- The samples of the volatile oil through the two seasons were analyzed using GLC (Gas liquid chromatography).

The second experiment:-
- ***Yield estimation:-*** Yield per tree picked up and weighted recorded.
- ***Determine fruit weight, fruit dimension length and diameter***:- Samples for each replicate of twenty mature fruits were taken.
- ***Determination of cell sap acidity (pH)***:- pH of fresh corn grains was determined directly after homogenization of the grains, using a Metrohm / Brinkmann pH -103 model ph meters at 25 ^{o}C.
- ***Determination of vitamin C***:- Analysis of vitamin C was performed as recommended by A. O. A. C. (1975) method using dichlorophenol dye in the direct colorimetric determination.
- ***Total proteins*** were determined as described by Brad ford (1976).
- ***Total sugars*** were estimated in acid extract by the phenol sulphuric acid reaction according to Dubois *et al.*(1956).

Statistical analysis:

Statistical analysis by using analysis for variance was conducted to clarify the significance between unifested, infested with *C. aonidum* and infested with *P. ziziphi*, on sour orange.

The percent of reduction was calculated of physical and chemical properties of sour orange according to the flowing equation :-

$$\text{Reduction} = \text{Uninfested} - \text{Infested} / \text{Uninfested} \times 100$$

RESULTS AND DISCUSSION

Results in Table (1) show monthly count of *C. aonidum* and *P. ziziphi* on leaves of sour orange trees, during 2008-09 & 2009-10 seasons at Kafr EL-Sohaby, Qalubyia Governorate. The insect counts on sour orange trees leaves began from Mar., 2008 to Feb., 2009 and Mar., 2009 to

Feb., 2010. Total monthly counts during 2008/09 and 2009/10 of *C. aonidum* ranged between 102.2 – 481.1 (mean 277.2) and 114.9 – 450.9 (mean 232.8), respectively, while total monthly counts of *P. ziziphi* ranged between 634.3 –254.2 (mean 430) and 301.3 – 603.4 (mean 418.9), respectively. Results show that the higher mean counts of *P. ziziphi* than *C. aonidum*.

Obtained results are presented in Table (2) observed a delay in inflorescence emergence date between uninfested and infested ones over the two years, Infested trees with *C. aonidum* had 9 days delay in 2008/09 and 18 days in 2009/10. In the mean time infestation with *P. ziziphi* seemed to case 13 days delay in 2008/09 and 21 days in 2009/10 compared with the uninfested. Blooming period infested trees with *C. aonidum* had 4 days in 2008/2009 and 6 days in 2009/10. In the mean time infestation with *P. ziziphi* seemed to case 5 days in 2008/09 and 10 days in 2009/10 compared with the uninfested (6 days both above two seasons). Blooming period was slightly longer in the infested trees in 2009/2010. These results are in line with Mohamed. (1999) found blooming period was similar in 1995 and slightly longer in the infested trees in 1996, Blooming period was 9 days delay in 1995 and 4 days in 1996 infested with *H. latania* on olive trees.

Inflorescences per-meter was 238.32 in uninfested trees compared with 82.64 and 63.54 for infested trees with *C. aonidum* and *P. ziziphi,* respectively in 2008/09. The same parameters in 2009/10 were 225.62 in the uninfested compared with 70.54 and 50.26 for infested with the same insects, respectively. This indicated significance differences between uninfestation and infestation. *P. ziziphi* was more harmful to the plants than *C. aonidum*. Infestation with *C. aonidum* and *P. ziziphi,* resulted in reduction of (65.32 & 73.34%) and (68.74 &77.72 %), respectively in two years of observation. This result was agreement with Mohamed, (1999) who showed that inflorescences per meter were 49.5 in uninfested trees compared with 42.0 when infested with *H. latania* on olive trees.

Infestation with *C. aonidum* and *P. ziziphi* reduced flowers yield per tree compared with the uninfested ones. Flowers yield for uninfested trees was 10.32 and 8.38 kg./tree in two seasons, respectively compared with 2.68 and 2.43 kg./tree when infested with *C. aonidum* and 1.78 and 1.14 Kg./ tree with *P. ziziphi* over the two seasons, respectively. Infestation with *C. aonidum* and *P. ziziphi* resulted in reduction of 74.03 and 82.75%, respectively in 2008/09 and 71.00 and 86.40 %, respectively in 2009/10. This reduction was not clearly significance between different of infestation. *P. ziziphi* was more harmful to the plants than *C. aonidum*.

Results in Table (3) indicated that general reduction of flowers oil content in infested trees compared with uninfested ones. In case of trees infested with *C. aonidum* oil content was 0.71 and 0.65% during 2008/09 & 2009/10, respectively (*i.e.* reduction in oil content as 35.00 and 35.45 %, respectively). Infestation with *P. ziziphi* reduced the same parameter to 0.19 and 0.18 % during 2009 & 2010, respectively (*i.e.* reduction in oil content as 82.73 and 56.10%, respectively). This reduction was significant from other infestation and uninfested. Mohamed, (1999) found that fruits oil content was 25 and 17% for uninfested, infested with and *H. latania*, respectively.

Also, for optical rotation at 20°C, the data in Table (3) indicated that the highest value recorded with uninfested insect in both seasons (5.2 and 6.4 respectively), however the lowest one recorded with *P. ziziphi* in both seasons (4.6 and 6.2, respectively). In the same trend the data showed that both species of the experimental insects gave the refractive index in every season (1.474/first season and 1.473/second season). For the acid value, the highest result was 1.20 with *P. ziziphi* in the first season; however it was 1.30 with the same later types of insect through the second season. Finally, for specific gravity at 25 °C, the result indicated that it was not affected by scale insect infestation.

Table (4) indicated the chemical composition of sour orange flowers oil which affected by scale insect species. It could be noticed that the various constituents of sour orange flowers volatile oil could be classified on the base of their functional group; the results in this concern were as follow:-

-Alcoholic compounds include linalool were ranged in the selected samples from 34 to 37 % through two seasons; the lowest value was recorded with uninfested. While the rest of the treatments showed higher values with *P. ziziphi*.

- Esters, included linalyl acetate, the results recorded a range from 22 to 23 % through two seasons, the highest value was reported with uninfested, and however all the species of insects gave the same value (22%).

- Sabinene ranged from 2.2 to 2.4 % through two seasons, the highest value was reported with uninfested 2.4 and 2.3 % in two seasons respectively; however all the types of insects gave the same value (2.2 %).

On the other hand, methyl anthranilate ester was ranged from 0.54 - 0.69 % in both seasons, the results were upset with this component and gave the lowest value with uninfested in both season (0.54 and 0.60 %, respectively, however the highest value recorded in the second season with *P. ziziphi* (0.69 %). It could be concluded that, the different factors in

Table 4: Effect of infestation with two scale insects on active ingredients percentage of the volatile oil of sour orange flowers during 2008/09 and 2009/10 seasons.

Infestation	Active ingredients percentage of the volatile oil							
	Linalool, %		Linalyl acetate, %		Sabinene, %		Methyl anthranilate, %	
	2008 / 09	2009 / 10	2008/ 09	2009/ 10	2008/ 09	2009 /10	2008/ 09	2009/10
Uninfested	**34**	**35**	**23**	**23**	**2.4**	**2.3**	**0.54**	**0.60**
C. aonidum	**35**	**36**	**22**	**22**	**2.2**	**2.2**	**0.63**	**0.65**
P. ziziphi	**36**	**37**	**22**	**22**	**2.2**	**2.2**	**0.62**	**0.69**

this study caused a relatively increasing in the volatile oil composition as the linalol and main components were increased in comparison with uninfested. However, all values were found to be within the standard range, Bankowski *et al.* (1969) and Khatri and Nasir (1989) in Pakistan studied the effect of infestation with aphid on *rosa indica* which is grown for its volatile oil. The main constituents of the plant were Citronellol (36.3%), Geraniol (24.4 %) and Nerol (12.1 %).

The highest mean of yield per tree 60.84 and 59.67 kg. were obtained from the uninfested trees in 2008/ 09 & 2009/ 10, respectively, followed by the ones infested by *C. aonidum* 37.03 and 35.90 kg, during 2008/09 & 2009/10, while lowest mean of yield was obtained from the infested trees during 2008/09 & 2009/10 by *P. ziziphi* 13.88 and 13.61 kg., respectively (Table, 5). The reduction reached 39.14 & 77.19 % and 39.84 & 77.19 % during 2008/09 & 2009/10 seasons, respectively by *C. aonidum* and *P. ziziphi*. This reduction was significant with *P. ziziphi*, *C. aonidum* and uninfested. These results are in line with Mohamed, (2004) who recorded significant reduction in yield of apple trees as a result of infestation by *P. oleae*. This reduction reached 49.39 %. Mohamed and Asfoor (2004) mentioned that yield per tree of two oranges varieties infested by *A. aurantii* were reduced by 27.2 and 31.1 %.

Results in Table (5) indicated that, the decrease in fruit weight (g) were 2.51 and 7.27 % during 2008/09 while it were 2.64 and 7.54 % during 2009/10 due to infestation *C. aonidum* and *P. ziziphi*, respectively. This reduction showed significance between uninfested and infested by *P. ziziphi*. These results are in line with Tawfik, (1996) which recorded

reduction in fruit weight of two citrus varieties (Navel and Valencia) as a result of sever infestation by *L. beckii* 26.82 and 12.94 %, respectively. Mohamed and Asfoor (2004) recorded reduction 2.4 and 18.25 % in fruit weights of two orange varieties as a result of sever infestation by *A. aurantii*.

From Table (5) the height of fruit were 9.75, 12.09 and 9.06, 11.23 (cm) during 2008/09 & 2009/10 seasons, by *C. aonidum* and *P. ziziphi*, respectively This result was in agreement with Tawfik, (1996) who recorded highest loss in infested (Navel and Valencia) oranges with *L. beckii* than uninfested. Mohamed (1999) obseved increasing the infestation with height, length and weight of olive fruit due to H. *latania*. Also, Table (5) showed that the diameter of fruit reached [(13.11& 13.79 cm) and (12.26 & 12.87 cm)] and the reduction reached 3.18, 3.23 and 9.45, 9.68 % during 2008/09 & 2009/10, respectively, by *C. aonidum* and *P. ziziphi*. These results are in line with Mohamed, (2004) who recorded significant reduction in fruit length of apple trees as a result level of infestation by *P. oleae*. No significance difference in the reduction of fruit dimensions between infestation by *C. aonidum* and *P. ziziphi*.

Results in (Table, 6) indicated that, uninfested fruits resulted in highest mean fruit juice acidity 2.8 and 2.84 % over the two seasons, respectively. The increase in acidity, (3.21 & 10.7) and (3.87 & 11.97) through two seasons for infested fruits *C. aonidum* and *P. ziziphi*, respectively. Acidity of extracted olive oil was not affected by infestation by *H. latania* or *P. oleae*, Mohamed (1999) & Mohamed (2002). Mohamed (2004) recorded the same results on apple trees infested with *P. oleae*.

On the other hand, protein was ranged from 638 - 635 (mg/100) with uninfested fruits in both years, the results gave the lowest loss percent value with that infested by *C. aonidum* in both seasons (3.45 - 5.51 %), respectively, however the highest loss percent value recorded in both seasons with *P. ziziphi* (13.64 -14.65 %). These results are in line with Decheva *et al.*, (1986) investigated boas of flowers of rose plants infested with aphids. The infestation caused changes in the free amino acid and protein from Aug. to Mar. in buds of flowers of rose plants. Emam, (2009) declared that infestation with aphid of rose *Macrosiphum rosae* (L.) (Hemiptera: Aphididae) caused change induced in the protein banding pattern (amino acids).

Also, data in the same Table (6) revealed that the reduction percent of total sugars increased with infestation by *P. ziziphi* and recorded 17.60 and 18.40 % in both years respectively, while the low reduction percent with infestation by *C. aonidum* recorded 5.69 - 6.40 % in both seasons.

These results are in line with Atiqui and Murad (1992) assessed the loss of sucrose content of sugarcane infestation by *Saccharicoccus sacchari* (Cockerell) (Hemiptera: Pseudococcidae).

Table (6) included the loss percent of vitamin C (mg/100 ml of juice) of sour orange trees. The loss percent were (4.00 and 7.00 %), (4.90 and 7.84 %) in fruits infested by *C. aonidum* and *P. ziziphi* during 2008/09 & 2009/10 seasons, respectively. These results are in line with Mohamed and Goma'a (2008) who reported that the loss percent of vitamin C were 14.25, 4.36 and 16.24 % in Guava trees infested by*Pulvinaria psidii* Maskell (Homoptera: Coccidae), *H. latania* and *Icerya sychellarum* (Westwood) (Homoptera : Margaarodidae), respectively.

Generally, the obtained results from Table (6) indicated that fruit juice acidity and total sugars did not significantly affected between infestation by *C. aonidum* & *P. ziziphi* and uninfested, but reduction was significant between *P. ziziphi* & *C. aonidum* and uninfested for protein and vitamin C.

Conclusively,

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تأثير الإصابة بحشرتين قشريتين على محتويات زيت أزهار ومحصول وصفات ثمرة النارنج

جمـــال الـــــدين حســـين محـمد* و حسام الدين رمضان عواد محيسن.**
* معهد بحوث وقاية النباتات - الدقى - الجيزة - ١٢٦١٨ - مصر.
**قسم بحوث النباتات الطبيه والعطريه- معهد بحوث البساتين - مركز البحوث الزراعية - الجيزه - مصر.

أجرى هذا العمل لدراسة تأثير نوعين من الحشرات التابعة لعائلة الحشرات القشرية المسلحة (الحشرة القشرية السوداء و حشرة النبق القشرية) على أشجار النارنج فى كفر الصهبى محافظة القليونية خلال عامي (٢٠٠٨ /٢٠٠٩ - ٢٠٠٩ /٢٠١٠). وجد أ ن الإصابة تسبب تأخر خروج أول زهرة وكذلك تطيل فترة تفتح الأزهار وأن هناك نقص كبير فى عدد الأزهار فى المتر الطولى (٦٧ و ٧٥,٥ %) ، وزن محصول الأزهار (٧٢,٧٥ و ٨٤,٨٥ %) وكذلك محتوى الزيت الطيار المستخلص من الأزهار (٣٥,٢٥ و ٦٩,٤ %) عند الإصابة بالحشرتين خلال موسمى الإصابة على الترتيب. كما أستهدف العمل أيضا دراسة الإصابة بالحشرتين محل التجربة على الصفات الطبيعية والكيميائية للزيت والمكونات الرئيسية فى الزيت الطيار ومن ثم أشارت النتائج مدى التأثير على الخصائص الطبيعية والكيميائية للزيت الطيار مثل الدوران الضوئي و معامل الانكسار و رقم الحموضة و الكثافة النوعية. في نفس الإطار وجد ان نسبة المكونات الرئيسية للزيت الطيارتأثرت بالإصابة بالحشرتين القشريتين خاصة الينالول وخلات الليناليل.وعند دراسة تأثيرالحشرتين على محصول الثمار وجد حدوث نقص كبير فى محصول الشجرة من الثمار(٣٩,٤٦ ، ٤١,٠٧ %) خلال موسمى الدراسة. وكان هناك نقص قليل فى وزن وطول و عرض الثمرة وكان متوسط النقص (٢,٥٨ ، ٢,٧٤ %) و (٣,٣٨ ، ٣,٧ %) و(٣,٢١ ، ٣,٣٤ %) على الترتيب عند الإصابة بالحشرتين خلال فترة الدراسة. و كما أظهرت الدراسة أن تأثيرالإصابة بالحشرة القشرية السوداء كان أقل من تأثير حشرة النبق القشرية على حموضة العصير الناتج ونسبة كل من البروتين والسكريات ونسبة فيتامين (ج) حيث كان متوسط النقص (٣,٥٤ ، ١٠,٤٥ %) و (٤,٤٨ ، ١٤,١٥ %) و (٤,٤٥ ، ٧,٢٤ %) فى العصير الناتج من الثمارالمجموعة من الأشجار المصابة مقارنة بالثمارالمجموعة من الأشجارالغير مصابة خلال موسمى الدراسة.