Jordan Journal of Agricultural Sciences, Volume **5**, No.**2**, 2009

Evaluation of the Efficacy of Conventional and Non-Conventional Insecticides on Fig Wax Scale *Ceroplastes rusci* L. (Homoptera: Coccidae) and Its Parasitoid, *Scutellista Cyanea* Motsch (Hymenoptera: Pteromalidae)

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ABSTRACT

The effects of dormant and summer sprays with conventional and non-conventional insecticides were evaluated against fig wax scale *Ceroplastes rusci* L. (Homoptera: Coccidae), in the field and in the plastic house in 2006 and 2007.Adding of insecticides to mineral oils did not improve significantly the efficacy of this oil in 2006. Dormant spray with mineral oil in combinations with Ultracidin, Confidor and Dursban corresponded to 98.5%, 92.2% and 87.7% of mortality in 2007. The summer application of Actara, Dursban and Patron gave sufficient control of fig wax scale (FWS). FWS fecundity was significantly affected by the different treatments. The effects of dormant and summer spray on the parasitoid *S. cyanea* Motsch (Hymenoptera: Pteromalidae) were also considered. Percentages of parasitism in all insecticides were significantly lower than the control. The lowest number of *S. cyanea* were in Actara, Patron and Dursban.

Keywords: Fig wax scale, *Ceroplastes rusci* L., Insect growth regulator, Dormant spray, Summer spray, *Scutellista cyanea* Motsch.

INTRODUCTION

The fig wax scale (FWS) *Ceroplastes rusci* L. is the most dominant pest of fig trees in Jordan in orchards and home gardens (Al-Antary and Sharaf, 1994). This pest not only causes yield reduction but can lead to the loss of the whole tree since plantation owners get rid of infested trees or prune them very severely after failing in several trials to control the scales. The lack of indigenous knowledge of appropriate control measures could be the reason after the spread of this insect.

Three parasites and three coccinellid predators have been recorded in Jordan (unpublished PhD research) with a potential efficiency for controlling FWS infestation in abandoned orchards only. This means that pesticide applications might cause disruption of FWS natural enemies. So, efforts should be directed these days towards using selective insecticides against the insect to lower the undesirable side effects on the natural enemies of the insect and give them the opportunity to work properly.

Two strategies were proposed for controlling FWS. 1- Dormant oil alone (Argyriou and Santorini, 1980; Held, 2005) or in combination with other pesticides prior to bud break working by suffocation which is a physical impact rather than a pesticide action with no residual and little hazard to non-target organisms. Winter spraying would appear to be more suitable, because the parasites

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Received on 31/12/2007 and Accepted for Publication on 21/10/2008.

and predators are not actively present in the orchards and because there is a longer period in which spraying can be conducted (Argyriou and Santorini, 1980). However, winter spraying would have the disadvantage that more developed stages are resistant to standard insecticides because of the wax which covers the insect dorsal side. 2- Spray of summer oil alone (Abu-Huiege, 1962; Ka'bour, 1976), mixing of summer oil with other insecticides or spray insecticides alone after growth begins in spring (Abu-Huiege, 1962; Onder and Akman, 1980; Calabretta *et al.*, 1985; Benfatto, 1994). Horticultural oils (dormant and summer) or other insecticides are effective in killing the young, relatively unprotected nymphs. Because of that, summer spray during spring must be timed to coincide with the emergence of the crawlers.

In Jordan, chemicals labeled for fig wax scale control are limited due to sensitivity of fig trees to some insecticides (Khabour, 1977). The most common insecticides used in controlling this insect are Supracide (methidathion) and Dursban (chlorpyrifos). Recently, controlling fig wax scale could be more difficult because of the withdrawal of some registered chemicals from the market. However, as older chemicals are banned or canceled, it is important to replace these chemicals by others which live up to regulatory standards. Insect growth regulators (IGR) are gaining widespread use against coccoid insects (Wakgari and Giliomee, 2001). However, using IGR to control FWS has not widely been documented (Ismail and Abdalla, 2001). Many researchers reported the non-toxic nature of insect growth regulator insecticides to parasitoids (Peleg, 1982; Ismail and Abdalla, 2001; Ishaaya *et al.* 1989), but their effect on natural enemies of FWS especially *S. cyanea* is not documented. Many attempts were done by many workers to test many chemicals like potassium nitrate (Yardeni and Shapira, 1995) and botanical oils, including soybean oil against others scale insects (Deyton *et al*., 2002; Ludwig, 2005). However, these chemicals were not tested against FWS.

The present research was conducted to evaluate the efficacy of winter and summer sprays and to compare several insecticides of different modes of action and IGRs in controlling this insect to develop appropriate control practices. This is essential to expand insecticides labeled to FWS, to produce healthy fruit. In addition, the side effect of insecticide application on the parasitoid *S. cyanea* Motsch is studied.

MATERIALS AND METHODS

The Sites

Al-Salt

An orchard of 5 dunoms cultivated with fig and olive in Al-Salt was chosen for carrying out the present investigation. Five trees of fig 'Khdari' about 15 years old were selected. These trees were heavily infested with FWS to which no control measures were applied for several years before this study. The study orchard was surrounded by other olive and fruit tree orchards. Winter (2006) and summer (2006 and 2007) sprays were carried out at this site.

Madaba

A home garden planted with fig in mix with olive was selected in Madaba, 32 km south of Amman. The site is situated about 790 m above sea level in an area characterized by relatively cold winter and hot dry summer, compared with other Jordanian regions. Five trees of fig 'Khdari' about 5 years old were selected. These trees were heavily infested with FWS to which no control measures were applied for several years. Winter spray (2007) was carried out at this site.

Al-Mushaqar

Plastic house pesticide screening was conducted in

2007 at Mushaqar Regional Center which belongs to the National Center for Agricultural Research and Agricultural Extension (NCARAE) in Madaba Governorate, 32 km south of Amman.

Dormant Spray

Tested Pesticides

The pesticides used in dormant spray as commercial formulations were:

1- Winterol-S, 300ml / 20L (mineral oil 96%EC), Vapco.

2- Dimilin 25W, 12 g/ 20L (diflubenzuron, benzoyl phenylurea), Uniroyal Chemical.

3- Dursban, 30 ml /20L (chlorpyrifos, organophosphate), DOW AG.

4- Ultracidin, 30 ml/20L (methidathion, organophosphate), Vapco.

5- Confidor 200 SL, 25ml/20L (imidacloprid, neonicotinoid), Bayer.

Dimilin is replaced by Confidor in dormant spray 2007.

Insecticide Application and Parameters

The insecticides were diluted with water and sprayed using knapsack sprayer 20 L (Record ®) to point of run-off. The trial involved the use of individual branches as an experiment unit. From each tree, 5 terminal twigs, each about 3 m long, were selected randomly and tagged as an experimental unit. Care was also taken that the twigs didn't touch other branches. There were four treatments in addition to the control with five replications. Plot design was a randomized complete block (RCB). Number of overwintering scales on 10 cm twigs was counted prior to spraying. Scales from previous generations remained on the twigs. The alive scales were differentiated from dead ones by their red, flat and fresh appearance. One week after spraying, insecticide efficacy was determined by counting the alive scales and then calculating the percentage of mortality (Bobb *et al.,* 1973). The dead scales drop down when probed with a pin and had a light dirty grey color.

Five scales (similar in size) on small pieces of the twig were collected from each treatment in mid-May (2006 and 2007) and kept in a glass vial (3.5 cm diameter, 8 cm high). Each treatment was held inside a beaker (500ml) covered with very fine muslin at 25±3˚C and 75% RH, filled with saturated NaCl. Number of hatched eggs was determined by counting the emerging crawlers (modified after Yarom *et al.* 1988).

To determine if these materials could negatively impact beneficial insects, the exit holes of *Scutellista cyanea* parasitoids on 10 cm shoots in July were counted by carefully examining the scales. To asses the efficacy of different treatments, the number of scales per five leaves in mid-July was recorded. Sooty mold rating of the foliage was taken in August (2006 and 2007). A scale of 1 to 5 was used with 1=0%, 2=1-25%, 3=26-50%, 4=51-75%, 5=76-100% of the leaves affected by sooty mold.

Temperature and R.H. were taken from the nearest Al-Salt and Madaba meteorological stations.

Summer Spray

Two field trials were conducted for two consecutive years in June 8, 2006 and June 15, 2007 to evaluate the effect of three chitin synthesis inhibitors; neonicotinoid, conventional and summer oil against immature stages (1^{st} and 2^{nd} nymphal stages) of fig wax scale. Ten heavily infested trees (5x5 m spaced) of equal spread and vigor were chosen (five trees for each year). From each tree, 5 terminal twigs, each about 60 cm long, were selected and tagged as an experimental unit. The individual branches were sprayed to point of run-off. At the time of spraying, 70% of the scale population was in

the 2nd stage nymph.

Tested Pesticides

The pesticides used in summer as commercial formulations were:

1- Dimilin 25W, 12 g/ 20L (Diflubenzuron, Benzoylurea), Uniroyal Chemical.

2- Actara 25, 6 g/20L (thiamethoxam, neonicotinoid),Syngenta.

3- Patron, 12g/20L (diflubenzuron, benzoyl phenylurea), Vapco.

4- Trigard 75WP, 30g/20L (cyromazine, triazine),Syngenta.

5- Cascade 10DC, 15ml/20L (flufenoxuron, chitin synthesis inhibitors), BASF.

6- Dursban EC, 30ml/20L Chlorpyrifos, organophosphate), Dow AG.

7- Samarol, 250ml/20L (Mineral Oil 96%),Vapco.

Insecticide Application and Parameters

Seven treatments with four random replicates each and the untreated control were carried-out. To monitor the scale population, from each replicate five leaves were marked and the population followed over time (Hesselein, 1997). Counting was conducted prior to spraying and numbers of alive and dead nymphs were counted three weeks (21 days) and five weeks (35 days) after spraying. Insecticide efficacy was determined by calculating the percentage mortality of scales.

FWS fecundity was taken by counting the number of eggs / 5 gravid scales in mid-August (2006 and 2007). Sooty mold rating was taken for the whole sprayed branch on August 27, 2007. A scale of 1 to 5 was used with 1=0%, 2=1-25%, 3=26-50%, 4=51-75%, 5=76-100% of the leaves affected by sooty mold. To test the effect of different treatments on the parasitoids *S.cyanea*, 50 scales were taken from the sprayed branches and examined under the stereomicroscope for parasitism in mid-August, 2006 and 2007.

Pesticide Screening in a Plastic House

One year old fig transplants in plastic pots were artificially infested with FWS by placing one gravid scale per plant. The insects were allowed to establish for four weeks prior to treatment. Foliar sprays of ten different pesticides were evaluated against 1st and 2nd nymphal stages. Pre-treatment counts of nymphs on each transplant were recorded before spraying. The transplants were sprayed to point of run-off, to be sure that they are completely covered, on June 20, 2007. At the time of spraying, 70% of the scale population was in the early second stage nymph. The experiment was set in a randomized complete block design with five replications.

The soybean oil treatment was used by mixing the oil with water at 2.5% and adding 10 g of commercial detergent / 20 L water. The mixed formulation was agitated continually in the spray tank (Record ®) to prevent rapid separation of the emulsion. Sodium nitrate was used at 4%. To monitor the pesticide efficacy, mortality percentage was calculated twice after spraying. FWS fecundity was taken by counting number of eggs / 5 gravid scales in mid-August. Sooty mold rating was taken on August 27, 2007. A scale of 1 to 5 was used with 1=0%, 2=1-25%, 3=26-50%, 4=51-75%, 5=76-100% of the leaves affected by sooty mold. To test the effect of different treatments on the parasitoids *S. cyanea*, 50 scales were examined under the stereomicroscope for parasitism in mid-September.

The pesticides used in pesticide screening of the plastic house as commercial formulations were:

1-Potassium nitrate 800 g / 20L.

2-Trigard 75WP, 35 g/20L (cyromazine, triazine) Syngenta.

3-Patron, 12 g/20L (diflubenzuron, benzoylurea)

Vapco.

4-Actara 25WP, 8g/20L (thiamethoxam, Neonicotinoid) Syngenta.

5-Match50 EC, 200 ml/20L (Lufenuron, Chitin synthesis inhibitor) Syngenta.

6-Samarol, 250ml/20L (mineral Oil 96%EC) Vapco.

7-Cascade 10DC, 15 ml/20 (flufenoxuron, chitin synthesis inhibitor) BASF.

8-Oberon 15 ml/20L (spiromesifen, spirocyclic phenyl-substituted tetronic acids) Bayer.

9- Dursban, 30 ml/20L (chlorpyrifos, organophosphate) Dow AG.

10-Soya bean Oil, 600 ml/20L (vegetable oil).

RESULTS

Dormant Spray

Results of dormant sprays in Al-Salt (2006) and in Madaba (2007) are presented in Table (1) and Table (2). In 2006 and 2007, the percentage mortality means of overwintering scales one week after spraying in February in all tested pesticides were significantly higher than the control. Better results were achieved in 2007 since percentage mortality means were higher (79.4- 98.5%) than those achieved in 2006 (52.8-55%).

In addition, it was found that mean number of crawlers which emerged from 5 gravid scales collected in mid-May in all treatments was significantly lower than the control in the two years. In 2006, the lowest number of crawlers emerged from 'mineral oil alone' and 'mineral oil+ Ultracidin' treatments; while in 2007, the effectiveness of insecticides added to mineral oil appeared clearly when comparing the number of crawlers in mineral oil alone treatment with other combinations.

Mean numbers of exit holes counted on scales on 10 cm treated shoots at the end of July showed that all the chemicals evaluated caused high reduction in *S. cyanea* percentage of parasitism in the two seasons with the highest number of exit holes collected from samples sprayed with 'mineral oil alone treatment'. In both years, five months after the treatments, the number of scales per five leaves was significantly higher in the control compared to other treatments. In 2006, addition of insecticides to 'mineral oil' didn't improve the results compared to 'mineral oil alone' treatment; while in 2007, all the 'mineral oil' and insecticide combination treatments were significantly better than the mineral oil alone treatment. Except for 'mineral oil and Dimilin' treatment, sooty mold rating in August was significantly lower in all treatments compared to the control in the two years.

Table (1): Effect of dormant oil alone and other insecticide combinations on fig wax scale, sooty mold and parasitism in Al-Salt in 2006.

Treatments	% Mortality±SE	No. of crawlers / 5 scales ± SE	% Parasitism/ 10 cm shoot± SE	No. of scales / 5 leaves in mid June± SE	Sooty mold rating ±SE
Mineral oil	52.8 ± 7.9 a	192 ±40.0 d	8.4 ±0.9 b	225.2 ±31.6 bc	3.0 ±0.3 bc
Mineral oil+ Dimilin	51.6 ± 5.4 a	320 ±51.5 bc	6.0 ±0.5 c	279.4 ±42.9 bc	3.4 ±0.2 ab
Mineral oil+ Dursban	55.0 ± 6.0 a	398.4 ±29.4 b	1.6 ±0.5 d	331.8 ±70.9 b	2.8 ±0.5 bc
Mineral oil+ Ultracidin	53.8 ± 2.1 a	215.4 ±47.3 cd	1.8 ±0.6 d	250.4 ±31.6 c	2.4 ±0.4 c
Control	0.0 ± 0.0 b	618 ±55.0 a	12 ±0.5 a	564.6 ±51.4 a	3.8 ±0.2 a

Means in the same columns having the same letters are not significantly different at P= 0.05.

Table (2): Effect of dormant oil alone and other insecticide combinations on fig wax scale, sooty mold and parasitism in Al-Mushaqar (Madaba) in 2007.

Treatments	% Mortality ±SE	No. of crawlers / 5 scales ±SE	% Parasitism/10 cm shoot ±SE	No. of scales / 5 leaves in mid – June ±SE	Sooty mold rating ±SE
Mineral oil	79.4 ± 5.5 b	220 ± 25.5 b	16.9 ± 6.4 a	227.8 ± 45.3 b	1.0 ± 0.3 b
Mineral oil+ Confidor	92.2 ± 3.3 a	2 ± 16.0 c	0.0 ± 0.0 b	13.0 ± 3.0 c	1.0 ± 0.3 b
Mineral oil+ Dursban	87.7 ± 4.1 ab	61 ± 18.8 c	0.0 ± 0.0 b	38.2 ± 16.5 c	1.0 ± 0.3 b
Mineral oil+ Ultracidin	98.5 ± 1.5 a	48.8 ± 2.0 c	0.0 ± 0.0 b	28.0 ± 6.4 c	1.0 ± 0.3 b
Control	8.8 ± 3.4 c	476 ± 47 a	24.4 ± 2.8 a	500 ± 83.7 a	3.4 ± 0.5 a

Means in the same columns having the same letters are not significantly different at P= 0.05.

Summer Spray

In both years, percentage mortality means of FWS on five fig leaves in Al-Salt (Table 3) revealed that three and five weeks after spraying, Actara Patron and Dursban

treatments were the most effective ones but with no significant differences between them. Dimilin, Trigard, Cascade and mineral oil were the least effective treatments. Moreover, Actara, Patron, Dursban and summer oil showed a progressive increase in insect mortality on subsequent intervals. In 2006, summer oil treatment appeared to perform better than Dimilin, Trigard and Cascade with 77.9 % of mortality. However, in 2007 the percentage of mortality in 'summer oil' treatment decreased (53.0%) but with no significant differences when compared to Dimilin, Trigard and Cascade treatments. Scale insects mortality in the control treatment in the two years might be associated with natural or environmental causes. Evidence of high mortality in Actara, Patron and Dursban treatments is confirmed by low sooty mold rating and scale fecundity. Mean number of eggs in five gravid scales collected in the beginning of August was lowest in Actara, Patron and Dursban.

Percentage of parasitism in 50 scales inspected under the stereomicroscope on 15 August in the two years showed that all the treatments were significantly lower than the control. The lowest numbers of *S. cyanea* was in Actara, Patron and Dursban (Table 4).

Table (3):Toxic effects of seven pesticides treated as summer spray on fig wax in Al-Salt in 2006 and 2007.

Treatments	% Mortality± SE			
	2006		2007	
	After three weeks	After five weeks	After three weeks	After five weeks
Dimilin	30.9 ± 6.6 c	40.1 ± 10.7 c	34.3 ± 6.1 c	39.1 ± 7.8 c
Actara	86.3 ± 5.3 a	99.4 ± 0.6 a	89.9 ± 0.6 a	92.8 ± 1.6 a
Patron	84.0 ± 5.3 ab	91.3 ± 3.2 ab	82.4 ± 4.1 a	86.2 ± 5.3 a
Trigard	29.4 ± 9.6 c	31.6 ± 10.3 cd	49.6 ± 9.4 b	56.2 ± 11.0 bc
Cascade	27.7 ± 10.0 c	27.8 ± 8.0 cd	49.8 ± 5.8 b	59.7 ± 6.4 b
Dursban	80.3 ± 6.7 ab	84.3 ± 2.5 ab	90.8 ± 1.3 a	98.2 ± 1.1 a
Summer oil	64.4 ± 6.0 b	77.9 ± 5.0 b	53.0 ± 1.7 b	56.7 ± 2.9 bc
Control	0.8 ± 0.8 d	18.4 ± 4.5 d	7.5 ± 0.9 d	13.7 ± 2.4 d

Means in the same columns having the same letters are not significantly different at P= 0.05.

Table (4): Effects of seven pesticides treated as summer spray on fig wax scale, sooty mold and parasitism in Al-Salt in 2006 and 2007.

Treatments	Mean of eggs ± SE	Sooty mold rating ±SE	% Parasitism ± SE	Mean of eggs ± SE	Sooty mold rating ±SE	% parasitism ± SE
	2006			2007		
Dimilin	388.8± 11.3c	2.8 ± 0.3b	10 ± 0.8cd	380 ± 27c	2.5 ± 0.3b	13.5 ± 2.4c
Actara	190 ± 10ef	0.3 ± 0.3d	0.0 ± 0.0e	137.5± 37.5de	0.8± 0.3de	0.0 ± 0.0d
Patron	160 ± 10f	0.5 ±0.5cd	0.0 ± 0.0e	220 ± 50.6de	0.3 ± 0.3e	0.0 ± 0.6d
Trigard	270 ± 23.8d	2.3 ± 0.3b	8.0 ± 1.6d	262.6 ± 12.5d	1.5± 0.3cd	20.5± 1.3ab
Cascade	512 ± 31.4b	2.8 ± 0.3b	14.0 ±2.6bc	463.5 ±23.1bc	1.3 ± 0.3d	14.5 ±2.1bc
Dursban	225 ±14.4 de	1.0 ± 0.4c	1.0 ± 1.0e	210 ± 10de	0.0 ± 0.0e	2.0 d± 2.0d
Summer oil	515 ±15b	2.3±0.3b	17.5±3.0b	472.5±24.9b	2.6± 0.3bc	24.5 ± 2.9a
Control	631 ± 23.6a	4.0 ± 0.0a	27.5 ± 4.8a	652.2 ± 30.4a	3.5 ± 0.3a	21.5 ± 3.8a

Means in the same columns having the same letters are not significantly different at P= 0.05.

Plastic House Pesticide Screening

Results of plastic house pesticide screening experiment are presented in Table (5). Four weeks after spraying, all the insecticides tested had significantly higher % of mortality of 1st and 2nd nymphal stages compared to the control treatment. Actara, Summer oil, Oberon and Dursban recorded the highest mortalities but with no significant differences between them. Spraying 2.5% of soybean oil resulted in 77.1 % of mortality; while Match gave 66.2%, but with no significant differences between them. On the other hand, the lowest mortalities were significantly recorded in potassium nitrate, Trigard, Patron and Cascade.

Table (5): Effects of the tested chemical treatments on fig wax scale in plastic house in Al-Mushqar-Madaba, 2007.

Treatments	% Mortality after 4 weeks ± SE	Mean number of eggs/ 5 scales ± SE	Sooty mold rating ± SE
Potassium nitrate	31.4 ± 8.1c	850 ± 52a	1.8 ± 0.2bc
Trigard 75WP	36.1 ± 10.6c	705.8 ± 49.1d	2.2 ± 0.2b
Patron	30.8 ± 3.2c	815 ± 35.5ab	1.6 ± 0.2bcd
Actara 25WP	92.5 ± 2.9a	238 ± 37.3h	0.8 ± 0.2e
Match50 EC	66.2 ± 10b	370 ± 55.1f	1.8 ± 0.2bc
Summer oil	93.5 ± 3.6a	480 ± 34.1e	0.8 ± 0.2e
Cascade 10DC	43.8 ± 4.1c	412.2 ± 55f	1.6 ± 0.24bcd
Oberon	89.4 ± 6.4a	232 ± 42.6h	1.0 ± 0.0de
Dursban4	88.6 ± 6.1a	298.2 ± 23g	0.8 ± 0.2e
Soya bean oil	77.1 ± 11.0b	762.2 ± 60c	1.2 ± 0.4cde
Control	5.6 ± 78.4 d	780 ± 78.4bc	3.0 ± 0.3a

Means in the same columns having the same letters are not significantly different at P= 0.05.

DISCUSSION

In both years 2006 and 2007, dormant oil alone reduced the number of overwintered fig wax scales and set as a baseline for insect control for the up-coming growing seasons. The efficacy of dormant oil was clearly improved by the addition of insecticides in moderately infested trees in 2007. The percentages of mortalities in 2007 after one week of spraying were better compared to those obtained in 2006 which reached approximately 100% in 'mineral oil + Confidor' treatment.

The effect of horticultural mineral oils against scale insect is well documented in literature (Salama and Amin, 1983; Rebek and Sadof, 2003) although several factors cause control of FWS in the dormant season to be difficult. It seemed that the success of dormant spray might be reduced by high population density. Erkilic and Uygun (1997) reported that the effectiveness of pesticides might be reduced by high population densities of white peach scale since crawlers were placed under old scales. But in fig wax scale situation, the crowded overwintering scales protect each other from the oil or even the insecticide by making a united crust that encrusted the twig without any spaces between the scales leading to poor contact of scales with the pesticides. Because of that, the application of dormant oil sprays to runoff is necessary for the management of scales with oil since it is important that the scales be entirely covered to become dead when using insecticides and by suffocation when using oil.

In Madaba experiment, the results were better than in Al-Salt experiment, because the infestation density was lower and most of the scales were in the 3rd nymphal stage and were pre-adult. In Al-Salt experiment, the scales were mostly pre-adult and adult having more dense wax on their backs that might enable them to withstand the pesticide treatment.

In spite of the fact that using mineral oil alone gave intermediate results in the two years when compared to all treatments, winter spraying with mineral oil alone would appear to be more suitable, because the parasites and predators were not actively present in the orchards and because there was a longer period in which spraying could be conducted.

Most of the insecticides used in summer spray had consistent results in both years except for Trigard and Cascade. Observations suggest that some of these differences in results were contributed to the level of infestation and to the insect behavior. Most previous reports follow up the counts of scale insects three or more times after spraying upon different intervals, but in case of this insect, it was better not to take more than two readings to calculate the percentage of mortality because the nymphs moved from the leaves to fruits and twigs. This behavior might give a false reading of mortalities. Actara, Dursban and Patron had the highest percentage mortality means with no significant differences between them. The three insecticides belong separately to three different groups. Actara 25WG (summer spray) and Confidor 200SL (dormant spray) belong to a new pesticide group known as Neonicotinoid. Current studies establish the superiority of Actara and Confidor over other insecticides. Actara and Confidor have the benefit of being systemic insecticides so that the plant does not need to be overturned to achieve effective coverage. Many reports showed the efficacy of Actara against scale insects, but it has not yet been recommended on fig to be considered an effective insecticide for the control of FWS. Ahmed (2007) reported that the total number and percentage of mortality of adult and immature stages of green date palm pit scale insect *Asterolecanium phoenicis* Rao (Homoptera: Asterolecaniidae) were significantly higher than for the untreated control when Actara is used as soil application and trunk injection.

Demonstrated effectiveness of Dursban (Organophosphates) agreed with the findings of Benfatto (1994) who reported high mortalities by using two formulations of chlorpyrifos (Dursban) compared with paraffin oil which was less effective against FWS on orange. Also, Ismail and Abdalla (2001) got 84.3% mortality by spraying chlopyrifos against FWS.

Patron which showed good percentage mortality means in summer spray is a chitin synthesis inhibitor insecticide. This group of insect growth regulator insecticides (IGR) is larvicide interfering with the insect chitin deposition and preventing the insect moulting (Tunaz and Uygun, 2004). Treatment with Patron in summer spray arrested the development of the insect and recorded 91.3 and 86.2% in 2006 and 2007, respectively. Staal (1975) stated a rather lengthy development of Coccidae, and for this reason IGR effects become apparent only after a long time of treatment. In addition, lack of synchronization in development tends to make this group a difficult target for IGR. But most recent researches that tested IGR against Coccidae reported good results (Wakgari and Giliomee, 2001; Ishaaya *et al.*, 1989). However, timing of application appears to be important for these products. This was obvious in 2007 summer trial and greenhouse testing in which there was a great decrease in the percentage of mortality compared to 2006 when the spray time was delayed by one week.

Sometimes controlling with IGR might not give the highest reduction in the population of the scale insect compared to other conventional insecticides (Wakgari and Giliomee, 2001; Peleg and Gothilf, 1981). This information is potentially the same as what we obtained with Cascade and Trigard in which the two recorded the lowest percentage mortality means. The dosage concentration and mode of action might explain the failure of Cascade and Trigard in summer spray since there is no labeled rate for any IGR for control of FWS scale. Boboye and Carman (1975) found that increasing dosages of IGRs had a uniformly greater suppressing effect of male and female development of California red scale.

Mean numbers of eggs obtained from IGR treatments in summer spray in 2006 and 2007 were consistent with other reports that emphasized that IGR chemicals affect the fecundity of scale insect. Eisa *et al.* (1991) found that there were significant differences between the numbers of eggs laid by females in the IGR treatments and the control and also between treatments within the different growth regulators used.

S. cyanea was the dominant parasitoid species in the trial area. The results showed that the number of *S. cyanea* decreased greatly in dormant and summer spray treatments. This could be interpreted by the fact that the parasitoid *S. cyanea* overwinters the cold season as larvae under the pre-adult scale. So, the effect of dormant spray including the dormant oil on the parasitoid will be as much as or more than its effect on the scale (Cox, 1942). During summer spray, the emergence of *S. cyanea* coincided with the presence of the second nymphal stage which was our spraying target. But according to our observations, the differences of *S. cyanea* emergence worked in preference of the parasitoid. Because of the delay of the parasitoid appearance, less insecticides residue on the leaves.

In summer spray, Actara, Patron and Dursban treatments were significantly the most harmful ones. The effects of Actara (Neonicotinoid), Patron (IGR) and Dursban (Organophosphate) were nearly identical. Other IGR used (Dimilin, Trigard and Cascade) had less detrimental effects on *S. cyanea*. There are wide discrepancies on what is written about the effect of IGR on natural enemies. However, most of the reports emphasize that these products are harmless to parasitoids and predators (Ishaaya *et al.*, 1989; Peleg, 1982; Olson

and Oetting, 1996; Pless *et al*., 1995, 1996; Erkilic and Uygun, 1997) and quite selective in their mode of action and act potentially only on target species (Tunaz and Uygun, 2004). In this study, the highly reduction in *S. cyanea* population in some IGR and Neonicotinoid treatments might be due to the high decrease in the fig wax scale populations. On the other hand, others reported that some IGR had a detrimental effect on natural enemies (Mendel *et al.*, 1994).

Plastic house screening insecticides provided additional results that partially confirmed summer field trials. In contrast to results of field summer trials, IGR recorded low percentage mortality means. These differences in the results might be due to environmental differences, especially plastic house temperature. Oberon (spiromesifen) which is a novel non-systemic insecticide-acaricide belonging to the new chemical class of spirocyclic phenyl-substituted tetronic acids had a good result, since it achieved 89.4% of mortality, but it still needs to be tested in the field.

Potassium nitrate alone or in combination with summer oil have been reported by Yardeni and Shapira (1995) to control Florida wax scale *Ceroplastes floridensis* on citrus. Comparable to our results, potassium nitrate recorded 31.4 % of mortality which was a discouraging result. However, using potassium nitrate was illogical because it was an expensive chemical to be used by fig growers and it was not sold without governmental permission.

The results obtained from dormant and summer sprays revealed that dormant spray alone or summer spray alone might not be enough to control the insect. Because of this difficulty, effective control of fig wax scale was obtained with dormant oil spray and a late summer spray aimed at the immature nymphs (1^{st} and 2^{nd}). Dormant oil was sprayed in order to reduce the initial densities of overwintering scales at the beginning. Summer sprays should be timed about 10 days after the first crawlers' emergence. Oender and Soydanbay (1984) reported that the spraying should be applied following hatching of more than 90% of the eggs. This was suggested to prevent the buildup of damaging populations and to minimize crop losses.

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تقييم فعالية بعض المبيدات الحشرية التقليدية وغير التقليدية على قشرية التين الشمعية *Ceroplastes rusci* L. وتأثيرها على خروج المتطفل *Scutellista cyanea* Motsch

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ملخـص

تمت دراسة فعالية إضافة الزيت الشتوي والصيفي إلى بعض المبيدات الحشرية التقليدية وغير التقليدية على قشرية التين الشمعية *Ceroplastes rusci* L. في الحقل والبيت البلاستيكي.لم تتحسن معنوياً فعالية الزيت المعدني عند إضافة المبيدات إليه في عام 2006. وقد أظهرت النتائج فعالية الرش بالزيت الشتوي مع التراسيدين أو الكونفدور أو الدورسبان حيث حققت نسبة موت بلغت 98.5 و 92.2 و 78.7%. أما في الرش الصيفي (الربيعي) فكانت المبيدات أكتارا ودورسبان وبانترون أكثرها فعالية. بينت الدراسة أن للمبيدات المستعملة تأثيراً ذا دلالة إحصائية على متوسط عدد البيض لكل أنثى. كما تمت دراسة تأثير هذه المبيدات على العدو الحيوي *Scutellista cyanea* Motsch.ولقد كانت نسبة التطفل أقل معنوياً في معاملات المبيدات مقارنة بالشاهد. وقد كانت أقل الأعداد في معاملة مبيدات أكتارا، وبانترون، ودورسبان.

الكلمات الدالة: قشرية التين الشمعية، *Ceroplastes rusci* L.، *Scutellista cyanea* Motsch.، مبيدات منظمات النمو، الرش الشتوي، الرش الصيفي، مبيدات غير تقليدية.

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تاريخ استلام البحث 2007/12/31 وتاريخ قبوله 2008/10/12.