Towards Integrated Pest Management for the Citrus Red-Scale and Citrus Whitefly Insects on Orange Trees

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ABSTRACT

A study was carried out towards integrated pest management for the armored scale insect [citrus red-scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae)] and the whitefly [Citrus Whitefly, *Dialeurodes citri* (Ashmead) (Hemiptera: Aleyrodidae] on orange trees at Kafr-Eldwar, El-Beheira Governorate. To achieve this target comparative study using five mineral oils with different purification percentages [Super Mox® 95%, Kemi Oil® 95%, Super Masrona® 95%, Sam Oil® 96.4% and Diver oil® 97%], in addition to an organophosphorus compound [Phenthoate (Cidial®),] an insect growth regulator (IGR) [Pyriproxyfen (Admiral®)] and their binary mixtures, took place against the above mentioned insects in an orchard of orange trees (during fruiting stage). The results indicated an ascending increasable effect with time intervals up to two months against the two tested insects. All treatments were more effective against the citrus whitefly than the citrus red-scale significantly with a different percentages arrangement except Diver oil® alone which was less effective without significant differences in between and Kemi oil® alone with significant differences. Reduction effect caused by mineral oils increased as purification percentages increased. Diver oil® 97% was the most effective mineral oil against the two tested insects but Kemi oil® 95% was the least effective one. The tested insect growth regulator (IGR) Admiral® caused more reduction effect against the whitefly (without significant differences compared with the most effective treatment) than it did against the armored scale insect. Diver oil® 97% could be recommended to be involved in an IPM program for controlling the two insect pests under investigation.

INTRODUCTION

Orange has become the most commonly grown fruit tree in the world. It is an important crop in the Far East, the Union of South Africa, Australia, throughout the Mediterranean area, and subtropical areas of South America and the Caribbean. Major producers are United States, Brazil, Spain, Japan, Mexico, Italy, India, Argentina and Egypt. Large quantities of fresh oranges and orange juice concentrate are exported to the United States and small shipments go to East Germany, Canada and Argentina. However, overproduction has glutted domestic markets and brought down prices and returns to the farmer to such an extent that plantings have declined (Florida Citrus Pest Management Guide, 2007).

The citrus red-scales insect, *Aonidiella aurantii* (Maskell) generally causes yellow chlorotic spots when attacking leaves. Yellow spots may also appear at the feeding sites on fruit. This insect appears to prefer fruit over leaves in the summer and fall therefore, the fruit may be heavily infested, while the adjacent leaves are relatively free of them. Unlike other armored scales on citrus, the insect restrict feeding on foliage and fruit but do not attack twigs or limbs of citrus trees. Large populations of this scale insect may result in severe defoliation and fruit production would be decreased. The insect presents on the fruit will render it as unmarketable fresh fruit because it does not agree with the consumer desire. Heavily infested fruit may be downgraded in the packinghouse and, if population levels are high, serious damage can occur to trees. Severe infestations cause leaf yellowing and drop, dieback of twigs, limbs, and occasionally death of the tree. Tree damage is most likely to occur in late summer and early fall when its population is high and moisture stress on the tree is sever (Kennett *et al.*, 1999)

The whitefly *Dialeurodes citri* (Ashmead) normally lays tiny, oblong eggs on the undersides of leaves. Eggs hatch and young whiteflies gradually increase in size through four nymphal stages called instars. The first nymphal stage (crawler) is barely visible even with a hand lens. The crawlers move around for several hours, then settle and remain immobile. Later nymphal stages are oval and flattened like small scale insects. The legs and antennae are greatly reduced, and older nymphs do not move. The winged adult emerges from the last nymphal stage (for convenience sometimes incorrectly called a pupa). All stages feed by sucking plant juices from leaves and excreting excess liquid as drops of honeydew as they feed and they cause yellowing or death of leaves. Outbreaks often occur when the natural biological control is disrupted and its control management is somehow difficult (Bellows *et al.*, 2002 and Flint, 1998).

Citrus is the most preferable host, to the citrus whitefly [*Dialeurodes citri* (Ashmead)], but the following are also host plants : allamanda, banana shrub, Boston ivy, cape jasmine, chinaberry, laurel cherry, crape myrtle, coffee, English ivy, gardenia, green ash, jasmine, lilac, myrtle, mock olive, pear, privet, osage orange, Portugal cherry, pomegranate, prickly ash, smilax, tree of heaven, trumpet vine, umbrella tree, water oak, persimmon, and devilwood or wild olive (Hamon, 1997 & Fasulo and Brooks, 1997).

Extensive uses of chemical toxicants for pest control caused many problems, such as acute and chronic human and animal toxicity, development of insect resistance to chemicals and environmental pollution.

So, alternative effective and environmental safe insecticides such as IGRs and mineral oils are urgently needed (Abdel Salam, 1993 and Anonymous, 1997).

Insect growth regulators (IGRs) showed good effect against scale insects and white flies on cotton, citrus, fruit trees and vegetables. Their effects have been observed in embryonic; larvae and nymphal development, metamorphosis, reproduction in males and females, behavior and several forms of diapauses (Ware, 2000). They also affect development, maturation and survival of the immature (Pawar *et al.*, 1995). Pyriproxyfen (IGR) is an environmentally safe and non-toxic compound to animals and human where the mode of action of pyriproxyfen reveled that it mimics the action of natural insect juvenile hormone, (Palma and Meola, 1993 and Dhadialla *et al.,* 1998). Insect treated with pyriproxyfen cannot reproduce normally (Shiotsuki *et al.,* 1999).

Local sprays of mineral oils are used for years against the scale insects, mealy bugs, thrips, aphids and mites on different crops and fruit trees, [El-Deeb *et al.*, 2002 and Moursi, 1996]. Oil sprays are used most commonly in horticulture to control scale insects and mites (Chapman *et al.*, 1952). Micks and Berlin (1970) and El Sebae *et al.* (1976) stated that resistance was not recorded for mineral oils which still have the advantage of being effective against the insect resistant strains.

The present work aimed to study the efficacy of different types of compounds: an organophosphorus insecticide; mineral oils; an insect growth regulator (IGR) and their binary combinations against two insects which have different physiology, histology, behavior and ecology but they have the same feeding and injury effect to the orange trees, leaves and fruits; namely the citrus whitefly [*Dialeurodes citri* (Ashmead)] and the citrus red-scale, [*Aonidiella aurantii* (Maskell)] infesting orange trees. Also, to find out the most effective compound (s), that could control the two insects successfully and synchronizely by the same application and can be used in an IPM program for the both insects.

MATERIALS AND METHODS

Field experiment was carried out in early summer and autumn of 2006 in an orchard of orange trees (during fruiting stage) at Kafr-Eldwar, El-Beheira Governorate to evaluate the efficacy of certain compounds: five mineral oils with different purification percentages [Super Mox oil® 95%, Kemi Oil® 95%, Super Masrona oil® 95%, Sam Oil® 96.4% and Diver oil® 97%], an organophosphorus insecticide [Phenthoate (Cidial®)], an insect growth regulator (IGR) [Pyriproxyfen (Admiral®)] and their binary mixtures against the armored scale insect [citrus red-scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae)] and the whitefly [citrus whitefly, *Dialeurodes citri* (Ashmead) (Hemiptera: Aleyrodidae]. Orange trees were 15 years old and have similar uniformity in shape and size. Experiment was designed as a complete randomized block. Spraying was accomplished by means of a conventional knapsack sprayer with a capacity of 20 liters/tank; at rate of 10-12 liters per tree to ensure complete coverage of all parts of the tree.

Thirteen treatments as well as the untreated check (control) were replicated five times with three trees per replicate and randomly distributed over 210 trees. Random samples of thirty leaves from each replicate were selected for laboratory counts (0, 2, 4, 6 and 8 weeks) before and after spraying. Picked samples were put in labeled cloth bags and transferred to the laboratory for counting using the stereoscopic binocular microscope. The reduction of the inspection of both insects numbers was expressed as reduction percentages which have been calculated according to Henderson and Tilton (1955). Statistical analysis of variance and LSD value for comparing the mean effects of each treatment were adopted according to Snedecor (1961). The tested compounds and their type of treatments, rate of application, type of formulation and their source are shown in Table (1).

Table (1) The tested compounds and their mixtures, their rate of applications and sources.

compounds	Rate %	Source (Company)
Cidial® 50% E.C (Phenthoate)	0.15	Zeneca Agrochemical Company
Sam Oil® 96.4% E.C	1.5	
Super Mox oil® 95% E.C	1.5	Alexandria company for Chemicals (KEMEX)
Kemi Oil® 95% E.C	1.5	
Super Masrona oil® 95% E.C	1.5	Misr Petrolium Co.
Diver oil® 97% E.C	1.5	
Admiral® 10% E.W (Pyriproxyfen)	0.05	Sumitomo Chemical Co., Ltd
Cidial® + Sam Oil®		
Cidial® + Super Mox oil®		
Cidial® + Kemi Oil®	0.5 fold for each	
Cidial® + Super Masrona oil®		
Cidial® + Diver oil®		
Cidial® + Admiral®		

RESULTS AND DISCUSSION

Tested orange trees were infested with several insects belonging to different species. Two insects only were having the major numbers on trees (the citrus whitefly and the citrus red-scale), so this work was concerned for those insects.

Figures (1 and 2) illustrate the effect of the tested compounds against the two tested insects. All tested compounds and their mixtures showed an ascending increasable effect with time intervals against the two tested insects. It seems that all compounds were more effective against the citrus whitefly than the citrus red-scale significantly with a different percentages arrangement except Diver oil® alone which was less effective without significant differences and Kemi oil® alone with significant differences.

Also, it was observed that the reduction of the tested insects populations caused by the tested mineral oils increased as the purification percentages increased. Diver oil® 97% caused most effective influence against the two tested insects but Kemi oil® was the least effective one.

The tested insect growth regulator (IGR) Admiral® caused more reduction effect against the whitefly (without significant differences with the most effective compound) than it did against the armored scale insect.

The efficacy against the citrus red-scale

Generally, after eight weeks post- application, Diver oil® alone was the most effective compound through the experiment period where it caused an average mean reduction effect of 71.9% followed by its mixture with phenthoate (67.6%); Sam oil® alone (66.5%); mixture of Sam oil® and phenthoate (64.8%); (IGR) Admiral® alone (64.0%); mixture of phenthoate with Kemi Oil® (62.5%); Super Mox oil® alone (61.7%); the mixture of phenthoate with Super Masrona oil® (61.3%); the organophosphorus insecticide phenthoate alone (58.3%); the mixture of phenthoate with Super Mox oil® (56.4%); Super Masrona oil® alone (53.8%); the mixture of phenthoate with Admiral® (52.6%); and the least effective tested compound was Kemi Oil® when it was applied alone (48.9%) Figure (1).

Reduction effect caused by the tested mineral oils differ with their purification percentages, where Sam oil® 96.4% caused reduction percentage of 66.5% and Diver oil® 97% caused reduction percentage of 71.9%, but Kemi oil® 95%; Super masrona oil® 95% and Super mox oil®

95% caused reduction percentages of 48.9%; 53.8% and 61.7%, respectively.

There were no significant differences between Diver oil® alone and its mixture with phenthoate, Sam oil® alone and its mixture with phenthoate and so Super masrona oil® alone and its mixture with phenthoate, also, Super mox oil® alone and its mixture with phenthoate. Therefore, mineral oils can be applied alone since they gain the same effect as their mixture with the O.P insecticide and that will reduce the costs and hazards.

There were significant differences between Admiral® and its mixture with phenthoate and so Kemi oil® alone and its mixture with phenthoate.

Phenthoate (as an organophosphorus insecticide) caused an average mean reduction effect of 58.3% when it was applied alone, and that effect increased without significant differences when it was mixed with Sam oil® (64.8%); Kemi oil® (62.5%) and Super masrona oil® (61.3%) and increased significantly when mixed with Diver oil® (67.6%), but it decreased with no significant differences when mixed with Admiral® (52.6%) and Super mox oil® (56.4%). The admixture of phenthoate and admiral® would not be recommended.

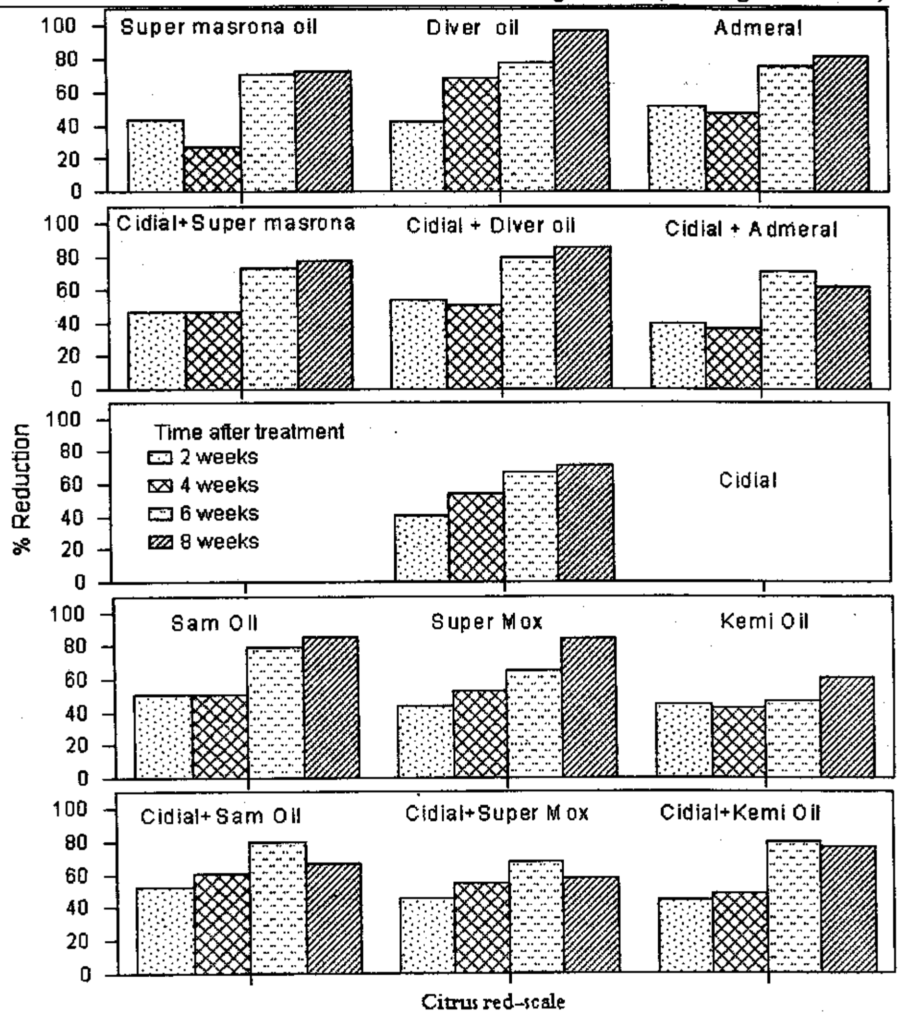

Fig. (1): Efficacy of an organophosphorus insecticide; five mineral oils; an insect growth regulator and their binary combinations against the citrus red-scale insect *Aonidiella aurantii* (Maskell) infesting orange trees, at Kafr-Eldwar, El-Beheira Governorate (2006).

The efficacy against the citrus whitefly

Generally, Fig.2 show that the mixture of phenthoate with Diver oil® was the most effective treatment where it caused an average mean reduction effect of 80.3% followed by the insect growth regulator (IGR) Admiral® alone (78.1%); the mixture of Sam oil® and phenthoate (77.4%); Sam oil® alone (77.2%); Diver oil® (76.3%); phenthoate alone (76.0%); the

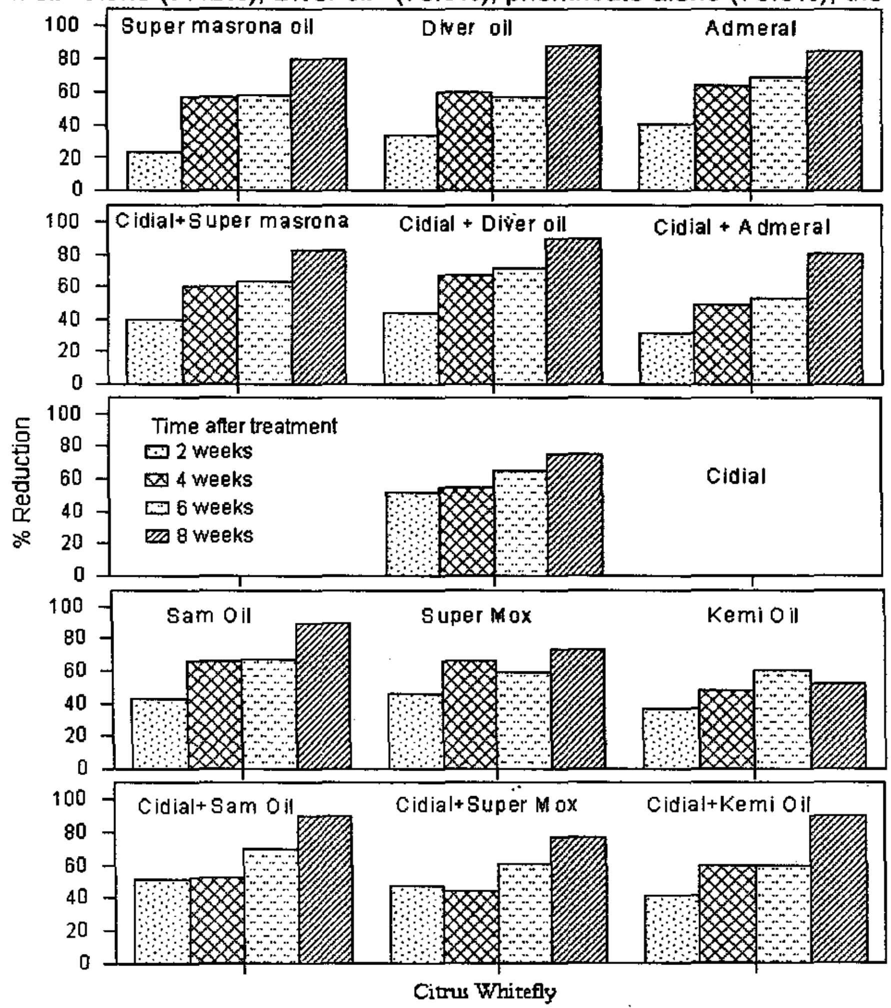

Fig. (2) : Efficacy of an organophosphorus insecticide; five mineral oils; an insect growth regulator and their binary combinations against the citrus whitefly, *Dialeurodes citri* (Ashmead) infesting orange trees, at Kafr-Eldwar, El-Beheira Governorate (2006).

mixture of phenthoate with Super Masrona oil® (75.2%); Super Mox oil® (74.7%); the mixture of phenthoate with Kemi Oil® (74.6%); the mixture of phenthoate with Admiral® (70.6%); the mixture of phenthoate with Super Mox oil® (70.3%); Super Masrona oil® alone (67.2%); and the least effective treatment was Kemi Oil® alone (43.6%) .

Phenthoate alone caused reduction percentage of 76.0% which increased when it was mixed with Sam oil® (77.4%) and Diver oil® (80.3%) without significant differences, but its effect decreased without significant differences when mixed with Super masrona oil® (75.2%); Kemi oil® (74.6%); Admiral® (70.6%) and Super mox oil® (70.3%).

It could be recommended that, Diver oil® alone give successful control against both armored red-scale insect and the citrus whitefly infesting the orange trees.

Those results are in agreement with those of Helmy *et al.* (1992), Moursi (1996), El-Deeb (1999), Abdel-Rhaman (2002) El-Deeb *et al.* (2002) and Abo-Shanab (2005).

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الملخص العربي

نحو مكافحة متكاملة لحشرتى الموالح القشرية الحمراء وذباب الموالح الابيض على اشجار الموالح

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أُجريت هذه الدراسة تجاه مكافحة متكاملة لحشرتى الموالح القشرية الحمراء *Aonidiella aurantii* (Maskell) وذباب الموالح الابيض *Dialeurodes citri* (Ashmead) على أشجار الموالح بمنطقة كفر الدوار بمحافظة البحيرة. ولتحقيق هذا الهدف تم إجراء دراسة مقارنة بإستخدام ثلاثة عشر معاملة [خمسة زيوت معدنية مختلفة فى نسبة نقاوتها (سام اويل، سوبر موكس، كيمى اويل ٩٥%، سوبر مصرونا ٩٥%، والدايفر اويل ٩٧%) والمبيد الفوسفورى الفنثيويت (السيديال) ومنظم النمو الحشرى البيريبروكسيفين (ادميرال) وخلائط المبيد الفوسفورى مع كلا من الزيوت المعدنية ومنظم النمو الحشرى خلال مرحلة إثمار اشجار الموالح. وقد أظهرت النتائج أن جميع المعاملات أعطت زيادة فى خفض تعداد الحشرتين مع مرور الوقت حتى شهرين من المعاملة. وكانت جميع المعاملات أكثر فاعلية ضد ذباب الموالح الأبيض عن حشرة الموالح القشرية الحمراء فيما عدا زيت الدايفر وزيت كيمى اويل.

وقد تسببت الزيوت المعدنية المختبرة فى خفض تعداد الحشرات المختبرة وإزدادت نسبة الخفض فى تعداد الحشرات بزيادة نسبة نقاوة الزيت المعدنى، وكان أكثر هذه الزيوت المعدنية تأثيراً ضد الحشرات

المختبرة هو زيت الدايفر ٩٧% وكان أقلهم تأثيراً زيت كيمى اويل ٩٥%. وقد أظهر منظم النمو الحشرى (أدميرال) كفاءة إبادية ضد ذباب الموالح الأبيض أكثر من حشرة الموالح القشرية الحمراء، كما أن تأثيره لم يختلف معنوياً مع أكثر المعاملات المختبرة كفاءة ضد حشرة الموالح القشرية. هذه النتائج تـدعو إلــى التوصية بإستعمال الزيوت المعدنية كمواد منفردة بدون خلط مع مركبات أخرى لمكافحة حشرتى المــوالح القشرية الحمراء وذباب الموالح الأبيض ضمن برامج المكافحة المتكاملة لتلك الحشرتين وذلكيــؤدى إلــى تقليل التكلفة المادية وتجنب خطورة المواد الأخرى المستخدمة فى مكافحة هذه الحشرات التى قد تــسبب تلوث البيئة وتلوث ثمار الموالح بمتبقيات المبيدات.