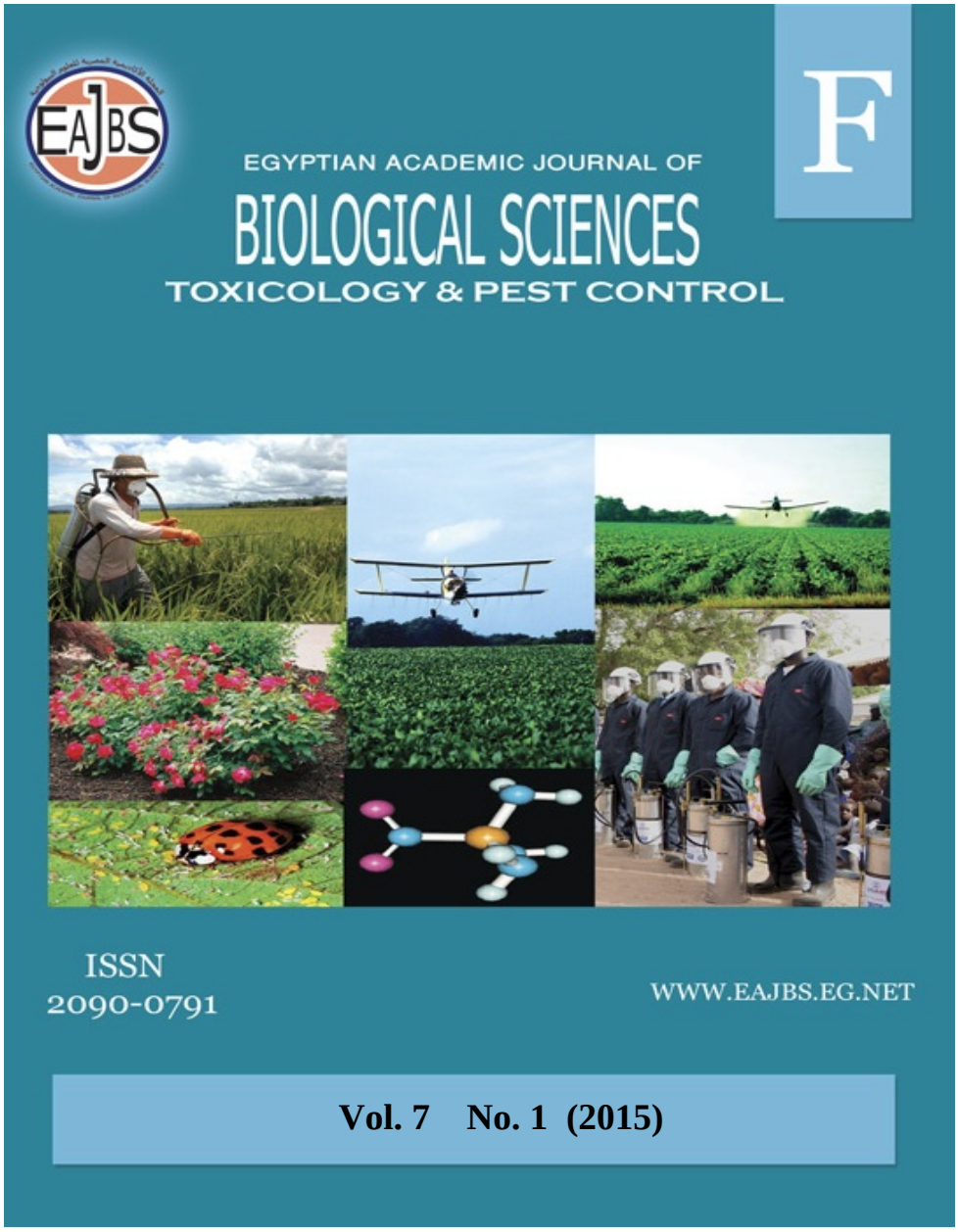

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Effectiveness of Selective Insecticides to Control Citrus Leafminer on Mandarin Trees.

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ABSTRACT

The efficacies of four insecticides Viz., imidacloprid (Confidor 20% OD), abamectin (Vertimec 1.8% E.C), a mineral oil (KZ oil 95% EC), and a mixture of Vertimec and KZ oil (1 : 10 V/V) to control the larvae of citrus leafminer (CLM) in mandarin orchard located in Sharkia Governorate during 2013 – 14 and 2014 – 15 were evaluated. Experiment was laid out in randomized complete block design with four replicates (each contains 5 trees) for each chemical treatment. At each studied year, two foliar insecticidal sprays were applied on early September and late May. CLM larval mortality was recorded at 3, 5, 7, 10, 14 and 21 days after treatment (DAT). Results showed that, regardless the studied year and the time of insecticidal application, nearly complete reduction in number of CLM larvae compared to control was observed with all treatments 7 DAT. At 21 DAT, the insecticidal activities of all chemicals were declined. However, imidacloprid exhibited the highest residual activity. Mixing abamectin with KZ oil increased its insecticidal activity at all inspection times. Thus, Confidor and a mixture of Vertimec with KZ oil gave the higher foliar insecticidal activity and persistence against CLM infestation on mandarin trees.

INTRODUCTION

The citrus leafminer (CLM), *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae), is an important pest of commercial citrus production and other species of Rutaceae family and some related ornamental plants. (Heppner, 1993 and Abbas *et al*., 2013). Larvae damage leaves by creating serpentine feeding mines and leaf wounds which facilitate the infection by citrus bacterial canker, *Xanthomonas axonopodis* pv. citri, which results in blemished fruit, premature fruit drop, leaf drop, and finally reduce yield (Pen˜a *et al*., 2000; Graham *et al*., 2004).

To combat this pest damage and for qualitative and quantitative increase of yield, sustainable approaches for pest management are very much essential. Various control methods have been proposed for the management of citrus leaf miner, these include cultural practices, chemical control, biological control, etc. (Muthaiah *et al.,*1998 ; Shivankar *et al.,* 2002).

The effect of insecticides in citrus orchards against the CLM is difficult to achieve the maximum CLM larval mortality and it is not very sufficient, because several generations of CLM are usually overlapping and the CLM larvae are protected by a cuticular layer of the leaves in the serpentine mine and the pupal stage is also protected by the rolled leaf margins (Raga *et al*., 2001). Moreover, it is necessary to be aware of the effect of these insecticides on beneficial insects including parasitoid and predators (Besheli, 2007). In this regard, higher costs involved for insecticides multiple applications and development of resistance to these insecticides should be considered (Yumruktepe *et al*., 1996).

In spite of the above problems which associated with insecticidal control, Michaud and Grant (2003) recommended that pesticides could be applied to protect new flushes of growth when the leaves are most susceptible to CLM damage.

Mineral oils are currently regarded as more environmentally friendly than synthetic pesticides. Such oils are becoming an essential part of many Integrated Pest Management (IPM) programs for agricultural crops worldwide. The integration of mineral oils is mainly because they are effectively non-toxic to vertebrates and beneficial insects (Beattie and Smith, 1996), degrade relatively quickly in the environment (Davidson *et al*., 1991; Beattie *et al*., 1995), and have never been associated with resistance or outbreaks of secondary pests (Beattie 1990; Beattie and Smith, 1993). According to Kim *et al*. (2010), mineral oils can control a range of pests and can replace synthetic pesticides in organic orchards. The effectiveness of mineral oils for the control of *P. citrella* has also been demonstrated in Australia (Beattie *et al*., 1995) and China (Rae *et al*., 1996).

The present investigation was conducted to evaluate the efficiency of two insecticides (Confidor 20% OD, Vertimec 1.8% E.C.), one mineral oil (K.Z. oil 95%E.C.) and one mixture of insecticide and mineral oil (Vertimec + K.Z. oil) for controlling CLM infestation under field conditions.

MATERIALS AND METHODS

The experiments were conducted in mandarin (5 years old) orchard located in Sharkia Governorate during two successive seasons of 2013-14 and 2014-15 to evaluate the effectiveness of four insecticides against citrus leaf miner. That orchard did not receive any insecticidal treatments throughout the last two years. A randomized complete block design was used where each chemical treatment was carried out on 20 trees (represents 4 replicates, 5trees each replicate). The other trees were left as borders between treatments. In the first year (2013-14) two sprays were applied on September 4 and May24 whereas in the second year (2014-15) they were run at September 12 and May 22.

All rates of insecticidal application were recommended by Plant Protection Researches Institute, Ministry of Agriculture Egypt. Specifications of insecticides used are shown in Table (1).

Table 1: Specifications of the mineral oils and pesticides that were used.

NO.	Trade name	Active ingredient	Formulation	Rate mL of formulated product / 20 L of water
1	Confidor	Imidacloprid	20% OD	20 mL
2	Vertimec	Abamectin	1.8% EC	5 mL
3	KZ Oil	mineral oil	95% EC	300 mL
4	Vertimec + KZ Oil	abamectin + mineral oil		5 mL+50 mL oil

OD: Oil Dispersion. ; EC: Emulsifiable Concentrate.

Confidor, Vertimec and KZ Oil were purchased from Bayer Crop Science, Syngenta Crop Protection formulations and Kafr El Zayat Pesticides & Chemicals Co., respectively.

Spraying was accomplished by means of motor sprayer with a 20 L tank capacity, as foliar treatment, at the rate of ca. 2 L of spray solution / tree to insure complete coverage of all parts of the tree. The control treatment was sprayed with water only.

Samples of 15cm length twigs of new flushes were randomly collected from the trees one day before insecticidal application and at 3,5,7,10,14 and 21 days after treatments (DAT). Five twigs (contain 50 leaves) were collected from each replicate (one twig /tree) and placed in a plastic bag, transported to a laboratory and examined under a microscope to record the number of survived larvae. The mortality percentages, (% Reduction) were corrected according to Henderson and Tilton equation (1955).

% Reduction = [1-(A×C/B×D)] 100

A= No. of alive larvae in treatment after spraying.

B= No. of alive larvae in treatment before spraying.

C= No. of alive larvae in control before spraying.

D= No. of alive larvae in control after spraying.

Data collected on numbers of live larvae per twig were subjected to statistical analysis (one way analysis of variance ANOVA); means were separated using Duncan's Multiple Range Test (Cohrt Software, 2004).

RESULTS AND DISCUSSION

Results of Tables 2&3 indicate that all insecticidal treatments gave the maximum reduction of CLM larvae after 7 DAT. In general, regardless the year of study and the time of insecticidal foliar application (1st or 2nd spray), Confidor and a mixture of Vertimec + KZ oil treatments achieved more than 98% reduction of CLM larvae after 7, 10 and 14 days of treatment. These results are in agreement with those obtained by Anonymous, (1995); Salas *et al*. (2006) and GOA (2007) who reported that Confidor which is a systemic neonicotinoid insecticide achieved 90% reduction of CLM larvae.

Abbas *et al*. (2013) reported that Confidor (imidacloprid 20SL) gave significant control, 85.30% reduction, to CLM with maximum persistence of 9.3 days in citrus orchard. Results of Tables 2 & 3 indicate that Confidor significantly control CLM for 14 days with more than 98% reduction. This difference may be due to many factors such as insecticide formulation, temperature, relative humidity …. etc. On the other hand, Hoy *et al*. (2007) found that the length and number of shoots on trees treated with Confidor were significantly shorter and fewer than that on untreated citrus trees, raising concerns that Confidor might affect growth of citrus flush. These authors cited that the mortality observed in the Confidor treated trees was probably due to predation, because the mines were empty and no pupal chambers were present.

Vertimec (abamectin) has demonstrated nematicidal, acaricidal and insecticidal activity (Lasota and Dybas, 1991). Data presented in Tables 2 & 3 indicate that abamectin gave satisfactory control of CLM and its insecticidal activity declined 10 DAT. Clark *et al*. (1995) reported that abamectin breaks down rapidly when exposed to sunlight or when presented as a thin film. However, Patil (2013) evaluated the insecticidal activity of six novel groups of insecticides for the management of CLM on acid lime during 2010-11 and 2011 – 12. He found that abamectin 1.9 E.C. at the rate of 0.0007 percent

recorded minimum infestation of leave and gave maximum yield of acid lime.

Data listed in Tables 2&3 show that mixing of abamectin with mineral oil (KZ oil) increased its insecticidal activity and persistence especially 10 DAT. This piece of result is in accordance with that obtained by Lasota and Dybas (1991) and Wang *et al*. (2005). While, Wang *et al*. (2005) reported that the application of abamectin in combination with petroleum oil provides the most synergistic effect to control CLM, Lasota and Dybas (1991) cited that reservoirs of abamectin can remain within the mesophyll layer of leaves, particularly when it is applied with oil.

Taple2: Mean number of live (CLM) larvae per twig and reduction percentage in mandarin trees after two foliar sprays of insecticides during 2013-14.

Time of application / Treatment		1st spray (4th of September, 2013)							2nd spray (24th of May,2014)						
		Pre Treat	DAT						pre Treat	DAT					
			3 days	5 days	7 days	10 days	14 days	21 days		3 days	5 days	7 days	10 days	14 days	21 days
Confidor	Mean	1.4 b	0.2 a	0.1 b	0.0 b	0.0 b	0.1 c	1.1 b	1.5 a	0.1 c	0.1 b	0.0 b	0.0 b	0.1 c	0.7 c
	%Reduction	----	68.6	95.1	100.0	100.0	97.8	64.0	----	95.4	94.1	100.0	100.0	96.3	74.3
Vertimec	Mean	1.5 b	0.3 a	0.2 b	0.1 b	0.4 b	1.9 b	2.3 ab	2.1 a	0.6 bc	0.5b	0.3 b	0.3b	1.6 b	2.2 ab
	%Reduction	----	56.0	90.8	97.4	82.8	61.3	29.7	----	80.1	78.8	93.1	88.0	58.0	42.2
KZ OIL	Mean	2.7 a	0.3 a	0.3 b	0.0 b	1.4 a	2.6 b	3.3 a	1.6 a	0.7 b	0.4 b	0.0 b	0.4 b	1.4 b	2.5 a
	%Reduction	----	75.6	92.4	100.0	66.5	70.6	44.0	----	69.6	77.8	100.0	78.9	51.7	13.8
Vertimec +oil	Mean	1.3b	0.1 a	0.2 b	0.0 b	0.0 b	0.1 c	1.3 b	1.8 a	0.2 bc	0.1 b	0.0 b	0.0 b	0.1 c	1.1 bc
	%Reduction	----	83.1	89.4	100.0	100.0	97.7	54.2	----	92.3	95.1	100.0	100.0	96.9	66.3
CONTROL	Mean	1.1b	0.5 a	1.6 a	2.8 a	1.7 a	3.6 a	2.4 ab	1.6 a	2.3 a	1.8 a	3.3 a	1.9 a	2.9 a	2.9 a

DAT= days after treatment
Means in each column followed by the same small letter (s) are no significant at P<0.05 according to Duncan's multiple range tests.

Taple3: Mean number of live (CLM) larvae per twig and reduction percentage in mandarin trees after two foliar sprays of insecticides during 2014-15.

Time of application / Treatment		1st spray (12th of September,2014)							2nd spray (22nd of May,2015)						
		pre Treat	DAT						Pre Treat	DAT					
			3 days	5 days	7 days	10 days	14 days	21 days		3 days	5 days	7 days	10 days	14 days	21 days
Confidor	Mean	1.3b	0.2 c	0.0 b	0.0 b	0.0 c	0.0 b	0.4 c	2.4 b	0.1 b	0.0 b	0.0 b	0.0b	0.0 b	1.2 b
	%Reduction	----	86.0	100.0	100.0	100.0	100.0	78.9	-----	89.9	100.0	100.0	100.0	100.0	55.6
Vertimec	Mean	2.6 a	0.6bc	0.5 b	0.4 b	0.3bc	1.2 b	2.1ab	3.9 a	0.4 b	0.5 b	0.1 b	0.1ab	0.4 b	2.3 a
	%Reduction	----	79.0	80.8	84.6	82.3	73.6	44.3	-----	72.7	93.0	96.7	79.5	75.4	47.6
KZ OIL	Mean	1.7 ab	0.7 b	0.4 b	0.2 b	0.4 b	1.3 b	2.1 ab	2.6 b	0.4 b	0.3 b	0.0 b	0.0 b	0.3 b	2.3 a
	%Reduction	-----	62.6	76.5	88.2	63.8	56.1	14.8	-----	59.0	93.7	100.0	100.0	72.3	21.4
Vertimec +oil	Mean	2.4ab	0.3 c	0.1 b	0.0 b	0.0 c	0.1 b	1.1bc	2.2 b	0.2 b	0.2 b	0.0 b	0.0 b	0.0 b	1.0 b
	%Reduction	-----	88.6	95.8	100.0	100.0	98.8	68.4	-----	75.8	95.0	100.0	100.0	100.0	59.6
CONTROL	Mean	2.0ab	2.2 a	2.0 a	2.0 a	1.3 a	3.4 a	2.9 a	2.4 b	0.9 a	4.4 a	1.9 a	0.3 a	1.0 a	2.7a

DAT= days after treatment
Means in each column followed by the same small letter (s) are no significant at P<0.05 according to Duncan's multiple range tests.

Thus, abamectin becomes much more accessible to pests such as CLM than to their predators or parasites. Morse *et al*. (1987) found that field-weathered residues of abamectin did not cause residual mortality to three selected beneficial arthropods of citrus. These characteristics indicate that abamectin could be used for IPM in citrus. In contrast, Metcalf and Luckmann (1994) reported that abamectin was ranked as a very dangerous pesticide and it should be recommended only in very urgent cases. Keetch (1968) added that the use of

abamectin, Confidor and Dursban led to eliminate the predatory mite.

Mineral spray oil has been used traditionally to control small, relatively immobile insects. The oil is said to suffocate the insects (Ebeling, 1950; Davidson *et al*., 1991). Najar-Rodriguez *et al*. (2008) observed no signs of oil accumulation within the trachea. They believed that rapid penetration of oil through the insect's body and accumulation in the nerve ganglia has the direct effect of suppressing synaptic transmission in the insect's ganglia. Frequent applications of oil during the growing season may be an option to reduce both pests and insecticide use (Mc Coy, 1985). Mineral oil caused a significant reduction in CLM damage by acting as an ovipositional deterrent to the pest (Beatti *et al*., 1995; Liu *et al*., 2001).

Results listed in Tables 2 & 3 showed that foliar spray with mineral oil gave reasonable CLM control regardless the time of spraying. This piece of result is in agreement with that obtained by Damavandian and Moosavi (2014) who reported that in citrus orchards, a 0.65% concentration of mineral oil provided appropriate control to CLM, and cost the least compared to Confidor, Dursban and abamectin. They added that, the oil / water emulsion should be thoroughly agitated so that all the foliage is covered, and the temperature should be less than 35^{o}C and relative humidity more than 20%.

Thus, by using chemicals such as Confidor which give maximum larval mortality with highest persistence not only protects the natural enemies but also the environment by reducing the number of sprays. For further understanding in future and for better management of CLM, it is necessary to rationalize insecticides in combination with mineral oil, in the field and semi field condition to obtain acceptable results.

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ARABIC SUMMERY

كفاءة بعض المبيدات الحشرية المختارة لمكافحة صانعة أنفاق أوراق الموالح على أشجار اليوسفي.

أحمد محيي غريب – وائل محمد سمير – محمد محمد محمد مجاهد -– فؤاد أحمد فهمي على
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تم تقييم كفاءة أربعة من المبيدات الحشرية إيميداكلوبريد (كونفيدور20% OD)، أبامكتين (فيرتميك 1,8% EC)، الزيت المعدنى (95% EC) وخليط من الأبامكتين والزيت المعدنى بنسبة 1:10حجم/حجم لمكافحة يرقات صانعة أنفاق أوراق الموالح في بستان اليوسفي الذى يقع في محافظة الشرقية خلال عامى 2013-14 و 2014-15. صممت التجربة على هيئة قطاعات كاملة العشوائية كل معاملة تحتوى على 4مكررات وكل مكررة تحتوى على 5 أشجار وذلك فى كل عام من عامى الدراسة . عوملت هذه الأشجار رشا مرتين فى العام (أوائل سبتمبر وأواخر مايو) .وتم تسجيل أعداد اليرقات قبل الرش وبعد 3، 5، 7، 10، 14 و 21 يوما من المعاملة. أظهرت النتائج - وبغض النظر عن عام الدراسة ووقت تطبيق المبيدات - أن أعلى معدلات المكافحة ظهرت بعد سبعة أيام من المعاملة (تراوحت مابين 100% لمعظم المعاملات و84% فى حالة مبيد الفيرتميك فى الموسم الثانى فقط). لوحظ أن هناك انخفاض فى معدلات المكافحة بدءا من اليوم الحادى والعشرون بعد المعاملة. أظهر مبيد الكونفيدور فاعلية لوقت أطول بعد الرش (High residual activity). بينما أوضحت النتائج أن خلط مبيد الفيرتميك مع الزيت المعدنى زاد من فعالية المبيد وذلك عند جميع أوقات الفحص . وعلى ضوء النتائج السابقة فإنه ينصح باستخدام مبيدى الكونفيدور أو مخلوط من الفيرتميك والزيت المعدنى للحصول على أعلى نسبة مكافحة لحشرة صانعة أنفاق أوراق الموالح على أشجار اليوسفى.