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Bio-efficacy of chlorpyriphos 20ec against leaf miner, *Phyllocnistis citrella* Stainton in citrus

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Abstract
Field experiments were conducted to evaluate the bioefficacy of chlorpyriphos 20 EC as foliar application against leaf miner in citrus with two rounds of chlorpyriphos 20 EC @ 250, 500, 750, 1000 ml/ha, Dursban 20 EC (standard check) 500 ml/ha and dimethoate 30 EC @ 500 ml/ha applied at the initiation of new flush followed by the second spray 14 days later. The mean leaf damage was the lowest (9.18%) in plots that received chlorpyriphos 20 EC 1000 ml/ha followed by chlorpyriphos 20 EC 750 ml/ha (9.39%), chlorpyriphos 20 EC 500 ml/ha (9.86%) and Dursban 20 EC 500 ml/ha (11.84%). Reduction in damage over control was maximum due to chlorpyriphos 20 EC 1000 ml/ha (63.21%) and chlorpyriphos 20 EC 750 ml/ha (62.40%).This was followed by chlorpyriphos 20 EC 500 ml/ha (60.47%), Dursban 20 EC 500 ml/ha (58.59%), dimethoate 30 EC 500 ml/ha (52.41%) and chlorpyriphos 20 EC 250 ml/ha (50.54%).

Keywords: Citrus leaf miner, *Phyllocnistis citrella* Stainton, bio-efficacy, Chlorpyriphos 20 EC

Introduction
Leaf miner (*Phyllocnistis citrella* Stainton, Phyllocnistidae: Lepidoptera) is an important citrus pest, native to southern Asia. They are tiny caterpillars of small moths (microlepidoptera). Basically a seedling pest that also invades the grown up orchards during new flush period, epidemically, causing serious damage to vegetative growth of the plant. In India it was first recorded by Stainton in 1856 and is known to be one of the serious pests in Punjab, Tamil Nadu, Madhya Pradesh, Maharashtra, Assam, Uttar Pradesh, Andhra Pradesh, Haryana, Karnataka, and North-Eastern Hilly region (Atwal, 1964) [3].
Its infestation coincides with the new flush periods in citrus. Larvae mine in between epidermal layers of leaf in a zig-zag manner which results in distortion of leaf lamina by ingesting the sap and producing chlorotic leaf patch (Michaud and Grant, 2003) [12].
Leaf miner larval feeding affects photosynthesis and larva consumes a leaf area of 1 - 7 cm^2. Edge of leaves curl upward with silvery mines followed by chlorosis and later by necrotic spots. Serious infestation causes retardation in growth and mines serve as a source for establishment of the bacterium causing citrus canker (Ujiye, 2000; Gottwald *et al*., 2001) [18, 8]. In severe infestation, it may result in delayed fruiting of young trees from 1 to 2 years. Chaudhari *et al*. (2007) [5] registered that average preoviposition, oviposition and post oviposition periods lasted for 0.85, 3.3 and 0.57 days respectively. The duration of egg, larval, prepupal and pupal stages lasted for an average period of 3.3, 12.5, 1.5 and 10.5 days respectively. The larva is apodous and pupates inside the tunnel in silken web. The minute moth having a black spot at tip of fore wings lays along the midrib of tender leaves minute spherical eggs. Moths were short lived and survived for 2.4 to 4.7 days. The male to female sex ratio was 1:1.22. The life cycle from egg laying to death of adult was completed in total period of 26 to 35 days. Kernasa *et al*. (2008) observed that egg eclosion was 3.10±0.46 days. Larva consisted of four instars. Mean durations of larval, pupal, male and female moths were 4.20±0.53, 8.04±0.92, 2.59±0.93 and 4.04±1.26 days, respectively. Broad-spectrum insecticides (pyrethroids, carbamates and organophosphates) are generally used against *P. citrella* (Zhang *et al*., 1994; Farmanullah *et al*., 2005) but they may cause detrimental effects on environment, although, chlorpyriphos has economic viability, environmental acceptability, abundant availability, consumer safety (Khan and Singh, 1985; Anonymous,2000). Chlorpyrifos is an organophosphate insecticide used throughout the world in a wide variety of field crops and vegetables. The primary degradant of chloropyrifos is 3, 5, 6-trichloro-2-pyridinol, a base hydrolysis product (Gotoh *et al*., 2001) [7]. As compared to other organophosphate insecticides, chlorpyrifos is fairly stable and persistent (Baig *et al*., 2009). Ahmad *et al*., (2006) [2] also reported that the cholinesterase tested, chlorpyriphos showed high efficiency in time-oriented mortality.

With this background, the present study was carried out to evaluate the bioefficacy of chlorpyriphos 20 EC against citrus leaf miner.

Materials and Methods

Field experiments were conducted at Kalampalayam (6 years old trees) (Trial I) and Theethipalayam (5 years old tree) (Trial II) in Coimbatore district, Tamil Nadu during Rabi season (November-December 2013) and (February- March 2014) in Rangpur lime in randomized block design to evaluate a new formulation of chlorpyriphos 20 EC against citrus leaf miner, *Phyllocnistis citrella*. Chlorpyriphos 20 EC was used at 250, 500, 750, 1000 ml/ha and compared with Dursban 20 EC at 500 ml/ha, dimethoate 30 EC at 500 ml/ha. Three trees constituted as a single treatment and each treatment was replicated thrice.

The treatments were imposed at the concentrations and control plots were maintained with water spray with a pneumatic knapsack sprayer using 500 litres of spray fluid per hectare. Two rounds of sprays were given. The first spray was given at the initiation of new flush for trial I and II respectively followed by the second spray at 14 days interval. The data from field experiments were scrutinized by RBD analysis of variance (ANOVA) after getting transformed into arcsine percentage values (Gomez and Gomez, 1984) [6].

Method of damage assessment

Leaf miner infestation was recorded prior to insecticide application and 3, 5, 7, 10 and 14 days after spraying, on four directions (north, south, east, west) and top portion, from five terminal shoots (15 cm length of twig) on the basis of infested and total number of leaves.

$$\text{Per cent leaf damage by leaf miner} = \frac{\text{No. of leaves affected/15 cm twig}}{\text{Total no. of leaves observed/15 cm twig}} \times 100$$

The insecticides used in the investigation and their dosages are furnished in Table 1.

Results and Discussion

Pooled mean data of both the field trials revealed that, chlorpyriphos 20 EC was significantly superior at 750, 1000 ml/ha when sprayed twice at 14 days interval in minimizing leaf miner damage. (Table 1). Leaf damage due to leaf miner ranged from 18 to 18.60 per cent before imposing treatments. The lowest leaf damage was recorded on plots sprayed with chlorpyriphos 20 EC 1000 ml/ha (6.80%) followed by chlorpyriphos 20 EC 750 ml/ha (7.20%), with the end of two rounds of application, after 14 days interval which were superior over other treatments at first field trial. Chlorpyriphos 20 EC 500 ml/ha, Dursban 20 EC 500 ml/ha and Dimethoate 30 EC 500 ml/ha were the next best treatments in the order of significant superiority, which resulted in mean per cent leaf damage of 7.57, 8.04 and 10.14 (61.63, 59.79 and 55.60% reduction respectively). However, chlorpyriphos 20 EC 250 ml/ha registered per cent leaf damage of 10.43 (54.60% reduction) as against the per cent leaf damage of 27.20 on untreated plot. Prakash Patil *et al*. (2014) reported that in citrus, profenophos 50 EC (0.1%) recorded 12.1% leaf miner infestation, 14 days after second spray compared to control (54.5%). The reduction over control was maximum due to chlorpyriphos 20 EC 1000 ml/ha (64.38%) and chlorpyriphos 20 EC 750 ml/ha (62.84%). This was followed by chlorpyriphos 20 EC 500 ml/ha (61.63), Dursban 20 EC 500 ml/ha (59.79%), dimethoate 30 EC 500 ml/ha (55.60%) and chlorpyriphos 20 EC 250 ml/ha (54.63%). More than 60 per cent reduction of leaf damage was recorded from chlorpyriphos 100, 150 and 200 g.a.i./ha treated plots. Similar results were also obtained by Narayanwal (1998) [13] who reported that triazophos kept the low level of leaf miner incidence in soybean.

Application of chlorpyriphos 20 EC caused significant reduction in leaf miner damage and the order of efficacy was 62.03, 61.95 and 59.30 per cent respectively at 1000, 750 and 500 ml/ha with 5.74, 5.92, 6.43 per cent leaf damage at second field trial (Table 1).

Dursban 20 EC 500 ml/ha, dimethoate 30 EC 500 ml/ha and chlorpyriphos 20 EC 250 ml/ha accounted for low damage levels of 6.72, 9.38 and 10.10 per cent and registered 57.38, 49.21 and 46.48 per cent reduction respectively as against untreated control 24.32 per cent leaf damage. Valand *et al*. (1992) [19] reported effective control of citrus leaf miner with the application triazophos, dimethoate, monocrotophos, quinalphos, methyl-O-demeton seven days after treatment. Saravanan and Savithri (2005) [16] also observed that, profenophos 50 EC at 0.05% registered 64.05 per cent reduction in citrus leaf miner infestation on acid lime. Karimullah and Sajjad Ahmad (1988) [10] registered that leaf miner infestation decreased from 1.3 to 24 per cent with dimethoate 40 EC at 40 ml per 100 litre of water. Reddy *et al*. (1988) [15] also evaluated the efficacy of monocrotophos 0.03% and 0.05%, causing cent per cent larval mortality of citrus leaf miner after 12 days of application. Similar results were obtained with chlorpyriphos and triazophos against serpentine leaf miner on cotton (Jeyakumar, 1995) [9]. Sharma and Ashu Chandel (2011) [17] observed reduction in live mines count with spinosad 84 g a.i./ha (68.1%) which was on par with chlorpyriphos (66.3%) 3 DAS against serpentine leaf miner, *Liriomyza trifolii* (Burgess) on tomato. Chlorpyriphos 20 EC 1000 ml/ha chlorpyriphos 20 EC 750 ml/ha, chlorpyriphos 20 EC 500 ml/ha, Dursban 20 EC 500 ml/ha, dimethoate 30 EC 500 ml/ha and chlorpyriphos 20 EC 250 ml/ha accounted overall per cent leaf damage of 9.18, 9.39, 9.86, 10.33 11.84 and 12.31 and registered 63.21, 62.40, 60.47, 58.59, 52.41 and 50.54 overall per cent reduction, respectively over untreated check (Table 1). Based on per cent reduction in leaf damage over control the order of relative efficacy was; chlorpyriphos 20 EC 1000 ml/ha > chlorpyriphos 20 EC 750 ml/ha > chlorpyriphos 20 EC 500 ml/ha > Dursban 20 EC 500 ml/ha > dimethoate 30 EC 500 ml/ha >chlorpyriphos 20 EC 250 ml/ha.

Table 1: Efficacy of chlorpyriphos 20 EC against leaf miner on citrus

Insecticide	Dose (ml.ha^{-1})	Trial I			Trial II			Overall mean damage (%) *	Overall mean reduction over control (%)
		Leaf damage per five terminal shoots (%)		Reduction over control (%)	Leaf damage per five terminal shoots		Reduction over control (%)		
		PTC	14 DAS		PTC	14 DAS			
Chlorpyriphos 20 EC	250	18.53	10.43 (18.83)^{c}	54.60	17.96	10.10 (18.28)^{c}	46.48	12.31	50.54
Chlorpyriphos	500	18.10	7.57	61.63	17.34	6.43	59.30	9.86	60.47

20 EC			(15.97)[ab]			(14.31)[ab]			
Chlorpyriphos 20 EC	750	18.00	7.20 (15.55)[a]	62.84	18.00	5.92 (13.87)[a]	61.95	9.39	62.40
Chlorpyriphos 20 EC	1000	18.03	6.80 (15.12)[a]	64.38	17.32	5.74 (13.69)[a]	62.03	9.18	63.21
Dursban 20 EC (standard check)	500	18.33	8.04 (16.46)[b]	59.79	17.66	6.72 (14.77)[b]	57.38	10.33	58.59
Dimethoate 30 EC	500	18.60	10.14 (18.56)[c]	55.60	18.20	9.38 (17.58)[c]	49.21	11.84	52.41
Untreated check	-	19.82 (N.S)	27.20 (31.43)[d]	-	18.50 (N.S)	24.32 (29.28)[d]	-	24.99	-

Mean of damage after two rounds of spray* DAS - Days after spraying PTC- Pre treatment count NS – Not significant.
Values in parentheses are arcsine transformed. Means in a column with same superscripts are not significantly different according to DMRT (P=0.05).

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