Bangladesh J. Environ. Sci. Vol. 9, 9-14, 2003 @BAED ISSN 1561-9206

BIO-EFFICACY AND RESIDUAL EFFECT OF SIX INSECTICIDES AGAINST CITRUS LEAF MINER, *Phyllocnistis citrella* Stainton

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ABSTRACT

Six insecticides were evaluated for their effectiveness against citrus leaf miner, *Phyllocnistis citrella* Stainton (Gracillaridae : Lepidoptera), on one year old pumello, *Citrus grandis* saplings in a citrus nursery. The tested insecticides with the concentration were Cypermethrin @ 0.01%, Deltamethrin @ 0.0025%, Profenofos 40% + Cypermethrin 2.5% (Sobicron 425 EC) @ 0.425%, Diazinon @ 1.0 g ai/plant, Quinalphos @ 1.0 g ai/plant and Carbofuran @ 1.0 g ai/plant. The efficacy was determined based on survival of leaf miner larva and leaf area infestation after the application of insecticide. No further infestation and larval survival was found Carbofuran treated saplings after one day of application but other insecticides treated saplings had few survived larvae. All insecticides were equally effective up to three weeks showing no further infestation and larval survival. The residual effect was determined in days required for further infestation. Carbofuran treated plants required 46.2 days for further infestation while Quinalphos treated plants showed infestation after 26.6 days. Thus, carbofuran was found to be superior both in respect of larval mortality and residual effect against the pest citrus leaf miner.

Keywords: Citrus, *Phyllocnistis citrella*, Insecticides, Efficacy and Residual effect.

Introduction

Insect pests are considered as one of the major factors responsible for low fruit quality and production of citrus in Bangladesh. More than 250 insect pests have been reported to attack citrus plant (Nayer *et al.*, 1976 and Rajput and Haribabu, 1985). Of these, citrus leaf miner, *Phyllocnistis citrella* is the most destructive microlepidopteran pest (Patel and Patel, 2001). It attacks the citrus plants both in the nurseries and young plantations and causes considerable economic damage to various citrus plants (Pandey and Pandey, 1964; Hill, 1987; and Batra *et al.*, 1998). Citrus leaf miner feeds on epidermal tissues of young leaves through serpentine tunnel both in abaxial and adaxial leaf surface, causing in crumbling of leaf and reduction in plant vigour. In addition, it has been reported to encourage incidence of 'citrus canker' (Ando *et al.* 1985, Prodhan, 1992 and Muller, 1995).

Although, the control of citrus leaf miner is difficult as it is an internal leaf feeder, application of insecticide is the principal method of its control in Bangladesh. The efficacy of different insecticides has not been evaluated against the pest in Bangladesh. Insecticides of contact action may not be effective against the pest (Divender *et al.*, 1997). Without testing, spraying of different insecticides may not provide successful control. As information on the effectiveness of different insecticides is not available, the citrus growers use the chemicals indiscriminately, which may cause several adverse effects in the agro-ecosystem. Therefore, the present study on testing six insecticides was undertaken to determine the bio-efficacy against *P. citrella* in a citrus nursery.

Materials and Methods

This experiment was conducted in a citrus nursery under 'Fruit Tree Improvement Project' (FTIP) located at Madhukhali, Faridpur during July to August, 2002. Pummelo (*Citrus grandis* L.), the most susceptible citrus species to citrus leaf miner (Singh, *et al.* 1988) was used for this study as host plant. One-year old saplings of uniform growth were used for the experiment and five saplings were selected for each treatment. Six insecticides including three Emulsifiable Concentrates (EC) and three Granular

(G) formulations were evaluated for their efficacy against leaf miner using recommended dose. The Emulsifiable Concentrate insecticides were Agromethrin (Cypermethrin) 10 EC @ 0.01%, Decis (Deltamethrin) 2.5 EC @ 0.0025% and Sobicron (Profenofos 40% + Cypermethrin 2.5%) 425 EC @ 0.425%. The granular insecticides were Basudin (Diazinon) 10 G @ 1.0 g ai/plant, Ekalux (Quinalphos) 5G @ 1.0 g ai plant and Furadan (Carbofuran) 5 G @ 1.0 g ai/plant. The emulsifiable concentrates were sprayed with continuous hand sprayer (Hudson commet continuous sprayer, Model no. 431A). The granular insecticides were applied by digging the ground area of the saplings followed by mixing the granules with the soil properly. Water was applied thereafter to moisten the soil for easy uptake of the chemicals by the saplings. The control plants were sprayed with water only. All necessary precautions were taken during application of insecticides. Data were recorded prior and after 1 day, 1 week, 2 weeks, 3 weeks, 4 weeks, 5 weeks, 6 weeks and 7 weeks of insecticide application. Observation was made on the following:

a) Survival of larva per infested plant

Larvae of different instar(s) were observed carefully, by using magnifying glass. All individuals including the pre-pupal stage per infested plant were counted.

b) Percentage leaf area infestation

The percentage of leaf area infestation was measured using transparent graph paper considering a single leaf as 100% area. The investigation was made with the infested leaves only.

c) Residual effect

The days required for further infestation was recorded to determine the residual effect of different insecticides.

The lay out of the experiment was designed in Randomized Complete Block Design (RCBD. The data were analyzed statistically after appropriate transformation and mean values were separated using Duncan's Multiple Range Test (DMRT).

Results and Discussion

The comparative study on efficacy of some insecticides applied as soil and foliar treatments against leaf miner, *P. citrella* infesting pummelo *C. grandis* L., revealed significant superiority of Carbofuran (1.0 g ai plant) to rest of insecticides. The efficacy was determined on the basis of number of larvae survived per infested plant, leaf area infestation, and residual effect of the insecticides.

Survival of Larvae

To determine the efficacy of insecticides on the basis of number of larva per plant, observations were made prior and after 1 day, 1 week, 2 weeks, 3 weeks, 4 weeks, 5 weeks, 6 weeks and 7 weeks of insecticide application. The data regarding efficacy of insecticides on the basis of number of larva survived per plant are presented in Table 1.

All the insecticides caused significant mortality of citrus leaf miner larva. After one day of carbofuran application no leaf miner larva was found to survive. Sobicron (Profenofos 40% + Cypermethrin 2.5%) @ 0.425%, Deltamethrin @ 0.0025% and Cypermethrin @ 0.01% showed less effectiveness against the pest than carbofuran. Survival of the pest was very low in all the insecticide treated plants after one day of application. Bhumannavar (1987) found the best control of citrus leaf miner with Cypermethrin @ 0.01% and Deltamethrin @ 0.005%.

After 1, 2 and 3 weeks of treatment, all foliar and soil insecticides became equally effective and no larva survived in any insecticides treated plant, although there was available new flush in the saplings. This indicates that all the six insecticides can control 100% of the leaf miner population upto 3 weeks of application. However, Sobicron, Diazinon and Quinalphos were found to be less effective from 4th weeks of application when the occurrence of larval population was noticed again. Alrubei *et al.* (1997) and Seraj (1999) found least effectiveness in larval mortality of citrus leaf miner with Diazinon. Further infestation in the saplings treated with Cypermethrin and Deltamethrin was observed after 5th week. While Carbofuran treated plants had no infestation up to five weeks. After seven weeks, all the treated plants were found to be infested by the leaf miner and the trend was similar to that of pre-treatment. From the foregoing discussion, it is concluded that Carbofuran (1.0 g ai/plant) is the most efficacious insecticide in controlling larvae of *P. citrella* and the effectiveness can be graded as:

Curbofuran > Cypermethrin > Deltamethrin > Quinalphos > Sobicron > Diazinon.

Table 1. Bio-efficacy and residual effect of different insecticides against citrus leaf miner, *P. citrella* infesting pummelo, based on larval survival

Insecticides	Average no. of leaf miner larva survived per plant at different interval								
	Before Application	After Application							
		1 DAT	1 WAT	2 WAT	3 WAT	4 WAT	5WAT	6 WAT	7 WAT
Cypermethrin 0.01%	4.80 (2.40)	1.80^{bc} (1.66)	0.00^{b} (1.00)	0.00^{b} (1.00)	0.00^{b} (1.00)	0.00^{c} (1.00)	0.40^{cd} (1.17)	1.20^{bc} (1.46)	3.80^{ab} (2.18)
Deltamethrin 0.0025%	4.47 (2.32)	2.00^{bc} (1.72)	0.00^{b} (1.00)	0.00^{b} (1.00)	0.00^{b} (1.00)	0.00^{c} (1.00)	0.80^{cd} (1.31)	2.00^{b} (1.71)	3.40^{b} (2.09)
Sobicron 0.425%	4.60 (2.36)	1.20^{c} (1.45)	0.00^{b} (1.00)	0.00^{b} (1.00)	0.20^{b} (1.08)	0.60^{bc} (1.25)	1.80^{bc} (1.63)	2.60^{ab} (1.89)	3.40^{b} (2.09)
Diazinon 1.0 g ai/plant	4.47 (2.31)	3.00^{ab} (1.99)	0.00^{b} (1.00)	0.00^{b} (1.00)	0.40^{b} (1.17)	0.80^{bc} (1.31)	2.80^{ab} (1.94)	4.20^{a} (2.27)	5.00^{ab} (2.44)
Quinalphos 1.0 g ai/plant	4.80 (2.40)	2.80^{ab} (1.94)	0.00^{b} (1.00)	0.00^{b} (1.00)	0.60^{b} (1.23)	1.20^{b} (1.46)	2.60^{ab} (1.88)	4.00^{a} (2.23)	5.00^{ab} (2.44)
Carbofuran 1.0 g ai/plant	4.80 (2.39)	0.00^{d} (1.00)	0.00^{b} (1.00)	0.00^{b} (1.00)	0.00^{b} (1.00)	0.00^{c} (1.00)	0.00^{d} (1.00)	0.40^{c} (1.17)	1.80^{c} (1.66)
Control (Water)	4.60 (2.35)	4.40^{a} (2.31)	3.80^{a} (2.18)	3.20^{a} (2.34)	2.80^{a} (1.94)	3.40^{a} (2.08)	4.00^{a} (2.23)	4.60^{a} (2.36)	5.40^{a} (2.52)
SE ±	-	0.103	0.031	0.035	0.087	0.098	0.125	0.111	0.092
LSD	-	0.407	0.125	0.137	0.345	0.388	0.494	0.440	0.367
P <	NS	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Figures in the parentheses are $\sqrt{(X+1)}$ transformed value

DAT = Day(s) after treatment; WAT = Week(s) after treatment

Figures having different letter(s) in the superscript in same column are significantly different (as per DMRT)

Table 2. Bio-efficacy and residual effect of different insecticides against citrus leaf miner, P. citrella infesting pummelo, based on leaf area infestation

Insecticides	Percentage of leaf area infestation								
	Before Application	After Application							
		1 DAT	1 WAT	2 WAT	3 WAT	4 WAT	5WAT	6 WAT	7 WAT
Cypermethrin 0.01%	70.42^{a} (57.06)	4.80^{c} (12.53)	0.00^{b} (2.56)	0.00^{b} (2.56)	0.00^{b} (2.56)	0.00^{c} (2.56)	2.52^{cd} (7.19)	10.74^{c} (17.45)	50.82^{c} (45.46)
Deltamethrin 0.0025%	69.76^{a} (56.64)	5.60^{c} (13.59)	0.00^{b} (2.56)	0.00^{b} (2.56)	0.00^{b} (2.56)	0.00^{c} (2.56)	4.08^{cd} (9.88)	25.24^{b} (29.84)	57.12^{bc} (49.10)
Sobicron 0.425%	71.50^{a} (57.78)	1.28^{d} (7.91)	0.00^{b} (2.56)	0.00^{b} (2.56)	0.76^{b} (4.04)	2.88^{bc} (8.50)	6.24^{c} (13.30)	52.18^{a} (46.26)	68.26^{ab} (55.90)
Diazinon 1.0 g ai/plant	71.02^{a} (57.53)	7.20^{bc} (15.46)	0.00^{b} (2.56)	0.00^{b} (2.56)	1.72^{b} (6.11)	4.48^{bc} (10.30)	29.66^{b} (32.84)	67.52^{a} (55.27)	80.36^{a} (63.75)
Quinalphos 1.0 g ai/plant	70.00^{a} (56.80)	10.00^{b} (18.16)	0.00^{b} (2.56)	0.00^{b} (2.56)	3.12^{b} (7.80)	9.04^{b} (15.89)	33.52^{b} (35.17)	61.50^{a} (51.69)	69.20^{ab} (56.33)
Carrbofuran 1.0 g ai/plant	73.82^{a} (59.24)	0.00^{c} (2.56)	0.00^{b} (2.56)	0.00^{b} (2.56)	0.20^{b} (2.56)	0.00^{c} (2.56)	0.00^{d} (2.56)	3.12^{d} (6.71)	12.00^{d} (19.82)
Control (Water)	66.26^{a} (54.69)	68.38^{a} (15.83)	51.54^{a} (45.87)	42.54^{a} (40.67)	49.22^{a} (44.53)	62.24^{a} (52.12)	60.50^{a} (51.06)	66.88^{a} (54.94)	76.76^{a} (61.23)
SE ±	-	1.106	0.251	0.620	1.757	2.201	2.465	2.645	1.964
LSD	-	4.38	0.99	2.45	6.95	8.71	9.751	10.46	7.768
P =	NS	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Figures in the parentheses are $\sqrt{(X+1)}$ transformed value

DAT = Day(s) after treatment; WAT = Week(s) after treatment

Figures having different letter(s) in the superscript in same column are significantly different (as per DMRT)

Leaf infestation

The data on leaf infestation after insecticide applications in respect of percentage of area at different intervals are presented in the Table 2. There was a significant ($P<0.01$) effect of different insecticides of leaf damage by the pest after one day of treatment. Carbofuran treated plants had no leaf infestation while, Sobicron treated plants had minimum (1.28% area) infestation. The rest of insecticides were more or less equal in their effectiveness. After 1 week, 2 weeks, 3 weeks of application no further infestation was found in all insecticide treated plants although the autumn flushes are available in the saplings. Infestation of leaf miner was again noticed in the saplings treated with Quinalphos, Diazinon and Sobicron after four weeks of application. Valand *et al.* (1992) found intermediate effect with Quinalphos (0.05%). But the saplings treated with Carbofuran, Cypermethrin and Deltamethrin remained free from infestation. The Carbofuran treated plants were unaffected until 5th weeks of application but the saplings treated with other insecticides started to have further infestation. Here, Cypermethrin, Delthamethrin and Sobicron treated saplings were least infested for the leaf miner. Borad *et al.* (2001) found effective control with Cypermethrin (0.04%) for the reduction of leaf miner infestation. Thus Carbofuran had the higher residual effect and kept the saplings free from leaf miner attack upto 5 weeks. A few infestation was noticed at the beginning of 6 weeks in the Carbofuran treated Saplings. The most effective insecticide at 6 WAT was Carbofuran followed by Cypermethrin and Deltamethrin. But the rest of the insecticides had lost their toxicity and allowed the leaf miner for further infestation.

The infestation levels of all insecticidal treatment except Carbofuran at 7 WAT were more or less similar to pre treatment used. On the basis of percentage area of infestation it is concluded that Carbofuran (1.0 g ai/plant) is the most efficacious insecticide to control leaf miner infestation. A remarkable reduction of *Phyllocnistis citrella* infestation with Cypermethrin and Deltamethrin was reported by Bathia and Joshi (1991) and Wu and Wu (2000). Observation at different interval revealed the following sequence of effectiveness

Carbofuran > Cypermethrin >,Delthamethrin > Sobicron > Diazinon > Qunalphos

Residual Effect

A regular observation was made to determine the time interval required for further infestation in the treated saplings. It was also noted that the treated saplings had available autumn flush for infestation during the experimental period. The data on days required for further infestation after application of insecticides are presented in Fig. 1.

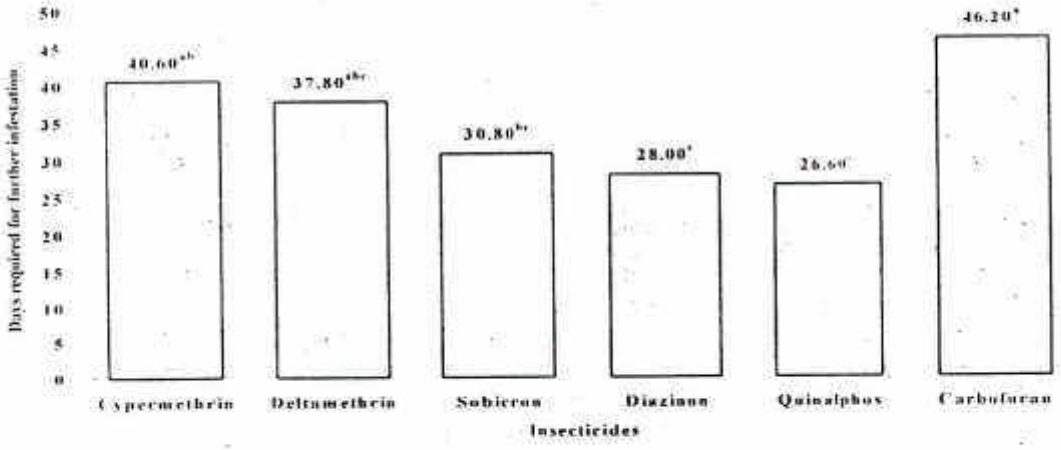

Fig. 1. Days required for further infestation by *P. citerella* in the saplings treated with different insecticides.

Bars having different letter(s) are significantly different

On an average the Saplings treated with Carbofuran showed the highest (46.2 days) duration for further infestation, but it was statistically similar to Cypermethrin (40.6 days) and Deltamethrin (37.8 days), indicating their longer persistence in the plants. The lowest (26.6 days) duration for further infestation was found in Quinalphos treated plant but it was identical to Deltamethrin, Sobieron and Diazinon treated plant, indicating as less persistence insecticides. Thus, from the study, it can be revealed that Carbofuron has the high residual activities against leaf miner in the treated saplings. The result of the present investigation reveals that Carbofuran @ 1.0 g a.i. per sapling is the most efficacious and long persistent insecticide against citrus leaf miner followed by Cypermethrin @ 0.01% and Deltamethrin 0.0025%. Since Carbofuran has systemic action and is applied as soil insecticide in the form of granules, it causes less harm to the environment and beneficial organisms. Therefore, it could be suggested here that citrus growers should prefer Carbofuran as one of the most effective insecticides in managing the citrus leaf miner in the nursery.

Acknowledgements

The authors are grateful to the authority of Fruit Tree Improvement Project (FTIP) and Village and Farm Forestry Programme (VFFP) funded by Swiss-Agency for Development and Cooperation (SDC) for providing financial support for the research work.

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