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ROLE OF INSECTICIDES IN THE CONTROL OF LEAF MINER, *Liriomyza sativae*, DAMAGE IN TOMATO

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ABSTRACT

In early 1990s for the first time in Sri Lanka leaf miner damage was observed in several vegetable crops and farmers attempted to control the pest using insecticides. A survey conducted during 1994/1995 *maha* season in vegetable growing areas of the mid-country showed that insecticides that were available to the farmers had no effect on leaf miners or their damage in tomato. However, results of the survey showed that with fewer insecticide applications the damage was less. Also, leaf miner larval parasitoids were more in fields, which received few insecticide applications than in fields, which received more applications. Two field studies carried out during 1995 *yala* and 1995/1996 *maha* to evaluate three readily available conventional insecticides, two new insecticides (abamectin and cyromazine), a chitin inhibitor (chlofluazuron), a commercial formulation of entomopathogenic bacterium (*Bacillus thuringiensis*), neem seed kernel water extract, farmers' practice and an untreated control revealed that the untreated control had the least leaf miner damage either significantly lower or not different to the other treatments. The highest damage was observed in farmer fields when different insecticides were used alternatively. Further, this study showed that even when the damage was significantly high the total yield was not significantly different suggesting that the leaf miner damage had no direct effect on yield. Another study carried out to evaluate eleven tomato varieties for leaf miner resistance revealed that none of the varieties were resistant/tolerant. This study highlights the finding that the most effective method of controlling leaf miner damage is to avoid insecticides and thereby allow parasites to build up.

KEYWORDS: Insecticides, Leaf miner, Parasites, Tomato, Yield Control

INTRODUCTION

Leaf miners are worldwide pests of numerous vegetable and ornamental crops (Lindquist, 1983). However damage by *Liriomyza sativae* was not recorded in Sri Lanka until the early 1990s. Damage symptoms started appearing in several important vegetable crops mainly in areas where gherkins were extensively grown. Pyrethroid insecticides were used liberally on gherkins to control insect pests. The sudden appearance of the leaf miner in Sri Lanka may either have been due to a secondary pest out break caused by excessive use of pyrethroid insecticides or an introduction through planting material. As soon as leaf miner damage appeared on crops such as gherkin, tomato, and beans, farmers tried to control it by spraying insecticides available to them with no avail. When the pest rapidly spread over to the other areas with an expanded host range including ornamentals, it became a national problem. Since the Department of Agriculture, at that time was not in possession of much research information several studies were undertaken by entomologists to develop an economically viable management package. This paper report the results of a survey conducted on the insecticides used by farmers to control leaf miner in tomato, and their effects on the parasitoid population. The paper also reports the effects of new and conventional insecticides on leaf miner and information on leaf miner resistance/tolerance of eleven tomato varieties commonly grown in the mid country and few varieties that are due to release shortly.

MATERIALS AND METHODS

Survey of insecticide use in the control of leaf miner in tomato

The survey was conducted in *maha* 1994/1995. Leaf samples from leaf miner infested tomatoes were collected from several farmers' fields in Marassana, Nalanda and Gannoruwa areas with a history of insecticide applications. These samples were brought into the laboratory and the number of leaf mines on them was counted. Leaf samples were kept in insect rearing cages and number of adult leaf miners and parasitoids that emerged were counted. Each sample consisted of twenty-five randomly collected compound leaves.

Screening of insecticides during *yala* 1995 with greased yellow polythene treatment.

A Randomized Complete Block Design experiment was laid out at the research field of Horticulture Research and Development Institute (HORDI) with five treatments replicated four times. The plot size for each treatment was 3m x 3.5m and the spacing between and within rows was 60 cm and 50 cm respectively. Seeds of tomato variety, T245 were sown in a nursery pre-treated with captan to control damping off disease. Three and half weeks old healthy, vigorous seedlings were transplanted in the plots. Fertilizer was applied at the rate of 225kg N, 275 kg $P_2O_5$and 125 kg K_2O per ha as basal and 225kg N per ha at three weeks and six weeks after transplanting as top dressings. N, P and K were given as urea, triple super phosphate and muriate of potash, respectively. The crop was rain fed with supplementary sprinkler irrigation. Weeding was done manually.

Table 1. Details of insecticide and other treatments used in the study.

Treatment	*Formulation of Insecticide*	*Dilution (ml/L water*	*Application Interval(Days)*	*No. of Application*
Imidocloprid	20 SL	1.0	12	3
Carbosulfan	20 EC	2.5	12	3
Profenophos	20 EC	2.0	12	3
Covering the soil space between tomato rows with greased, yellow polythene	-	-	-	-
Untreated control	-	-	-	-

Covering of soil space between rows with greased yellow polythene was done immediately after transplanting of the tomato seedlings. The stickiness of the greased polythene was maintained throughout the experiment by applying grease at regular intervals.

First application of insecticides was made when symptoms of damage started to appear. The damage was observed 3 weeks after transplanting of seedlings. Application of insecticides was stopped two weeks before first harvest. A hand operated knapsack sprayer was used for spraying. Data were recorded on number of new mines made by leaf miners in 10 randomly plucked compound leaves per plot immediately before first harvest and total number of fruits and weight of total fruits per plot at harvests.

Screening of insecticides during *maha* 1995/1996.

The experimental design and cultural practices followed in this experiment were the same as for the previous experiment. The same tomato variety T 245 was used. In this experiment five non-conventional insecticides (*Bacillus thuringiensis*, abamectin, cyromazine, chlofluazuronn and neem seed water extract) and the farmers' practice of applying different conventional insecticides alternatively were evaluated with an untreated control to observe the efficacy of those treatments in controlling the leaf miner.

Application of insecticide was started with first sign of damage symptoms. The symptoms were observed eighteen days after transplanting. Insecticide application was stopped two weeks before first harvest. In a sample of 30 compound leaves, plucked randomly from each plot at flowering and at first harvest, following data were collected.

1. Total number of leaflets/compound leaf
2. Number of severely leaf miner damaged leaflets/ compound leaf (50-100% leaf area is damaged)
3. Number of moderately leaf miner damaged leaflets/ compound leaf (25-50% leaf area is damaged)
4. Number of slightly damaged leaflets/ compound leaf (0-25% leaf area damaged)

Using above data percentage damage at flowering/first harvest was calculated. At each harvest the total number of fruits and the total fruit weight per plot were also recorded.

Table 2. Details of non-conventional insecticides used in the study.

Treatment	*Formulation of insecticide*	*Dilution/ rate per application*	*Application Interval (Days)*	*Number of Applications*
Bacillus thuringiensis (An entomopathogenic bacterium)-	-	1kg/ha	12	3
Abamectin (A natural derivative from *Strptomyces avermetilis*, a soil micro organism)	1.8% EC	0.6ml/ l water	12	3
Cyromazine (An insect growth regulator)	75% WP	0.25 g/l water	12	3
Chlofluazuron (A chitin inhibitor)	5 % EC	0.1ml/l water	12	3
Azadirachtin	5 % EC	0.2ml/l water	12	3
Alternative spraying of two insecticides				
Chlorpyriphos	40% EC	2.5ml/l water	07	4
Dimethoate	40% EC	2.5ml/l water	07	-
untreated control	-	-	-	-
(Farmers' practice)	-	-	-	-

Effect of tomato varieties on leaf miner damage

Eleven varieties of tomato (CLN 457, B2, BL 355; CLN 65, BL 350, T245, KWR, Caraibe, B1, Menik and B 13) were evaluated in a Randomized Complete Block Design experiment replicated three times. Out of these varieties except T245, KWR and Caraibe, other varieties were promising breeding lines received from the plant breeder at HORDI. Plot size was 2.4mx 3.5m. Between row and within row spacing was 80cm and 50 cm respectively. Similar cultural practices were followed as in the previous experiments. During the experiment all the varieties received one application of imidochloprid and three applications of dimethoate. For assessment of leaf miner damage, data were recorded as in the second experiment described above.

RESULTS AND DISCUSSION

Survey of insecticide use in the control of leaf miner

Data presented in tables 3, 4 and 5 show that insecticides that were available to farmers in different areas were not effective in reducing leaf miner damage. At Kahambiliyawa in Marassana the mean number of mines / compound leaf was four times more in the sample which received three endosulfan applications than in the sample which received two applications of the same insecticide. Even the parasitism (Hymenoptera: Braconidae; *Opuis* sp.) in that location was reduced to nearly half in the crop, which received three applications of endosulfan (table 3). The same trend was observed at the HORDI research fields. The plot that did not receive insecticide applications, showed three times more parasitism compared to the plot that received two applications of dimethoate insecticide. Further,. the mean number of mines found in the compound leaves in those two plots (table 4) showed an increasing number of leaf mines with increased insecticide applications. The number of leaf miner adults that emerged from the samples collected from different areas showed an increase of leaf miner incidence with increased number of insecticide applications revealing that more applications of insecticides appear to aggravate the problem. (tables 3, 4 and 5). The overall analysis of the survey indicated that insecticides, which were available to farmers, did not control the damage but had increased it. This can be attributed to the fact that application of insecticides could have adversely affected the parasitoides of the leaf miner and that had lowered the natural mortality of the pest. The natural mortality of the leaf miner caused by parasites would have been much higher than what had been observed (3.8% – 33.8%) if no insecticides were applied. The survey also, showed that all the popular varieties grown by farmers were prone to damage without much difference (tables 3, 4 and 5).

Screening of insecticides during *yala* 1995.

The leaf miner infestation in untreated control was not significantly different from rest of the treatments (table 6). However, the leaf miner infestation was significantly higher in the profenophos treatment than in the imidacloprid treatment (table 6). This suggested that different insecticides act differently on leaf miner infestation. Even though, there was significant difference in leaf miner damage between certain treatments, the mean number of fruits and mean fruit weight were not significantly different among the treatments. This suggests that certain levels of leaf miner damage has no adverse effect on yield parameters of tomato (table 6).

Means followed by the same letter are not significantly different at P = 0.05.

Covering the soil space in between rows with yellow, sticky polythene to trap the adults also had no effect in reducing the leaf miner population over the other treatments (table 6). This may have been due to the flying behavior of the leaf miner, which prevented it flying close to the ground. Always, new mines were observed on leaves, which were at half mature stage (Leaves which were in between mature and tender stages).

Screening of insecticides during *maha* 1995/1996

Leaf miner damage at flowering

Untreated control and cyromazine gave high levels of undamaged leaflets. These levels (71.9/ and 69.1/ respectively) were significantly higher than under farmer practices and chlorfluazuron treatment. Farmer practices gave the lowest percentage of undamaged leaflets and this was significantly lower than the percentages given by neemazal F, cyromazine, *Bt* and untreated control treatments (table 7). Moderately damaged leaflets were lowest in the untreated control and this was significantly lower than under farmer practices and chlorfluazuron treatments (table 7). Lesser number of severely damaged leaflets were observed in neemazal F, cyromazine, and untreated control treatments , but these values were not significantly different from abamectin and *Bt* treatments (table 7). Farmer practices gave the highest number of severely damaged leaflets in comparison to all other treatments (table 7).

Table 3. Effect of insecticides on leaf miner damage and their parasitoides in Marassana in tomato (variety Caraibe).

Location	Age of the crop (days)	*Insecticides sprayed*	*Number of sprays*	*Mean number of mines/compound leaf*	*Number of adults emerged/sample*	*Number of parasitoid (Hymenoptera: Braconidae,* Opuis sp?) emerged /sample	*% Parasitism*
Kahambiliyawa	45	Endosulfan	2	37.4	60	19	24.05
Kahambiliyawa	60	Endosulfan	3	155.0	50	7	12.28
Neelawala	60	Dimethoate,	2				
		Chlorfluazuron	8	96.4	40	7	14.89
Nawanaliya	30	Endosulfan	1	91.5	55	7	11.29
Mailagaha	21	Formothion	1	83.7	43	2	4.44
Neelawala	35	Chlorpyriphos	1	26.92	72	4	5.26
Marassana	60	Methamidophos	1	49.6	72	9	11.11
Neelawala	45	Chlorpyriphos	1	71.8	182	22	10.78
Neelawala	30	Thianex	1	66.2	234	8	3:31
Neelawala	30	Thianex	1	58.2	53	8	13.11

Table 4. Effect of insecticides on leaf miners, their parasitoides and damage in HORDI field, Gannoruwa.

Crop and Variety	*Age of the crop (Days)*	*Insecticides sprayed*	*Number of sprays*	*Mean mines/compound leaf*	*Number of adults emerged/sample*	*Number of parasites emerged/sample*	*% parasitism*
Tomato T245	50	None	-	30	29	10	25.64
Tomato KWR	45	Dimethoate	2	110.2	111	11	9.91

Table 5. Effect of insecticides on leaf miners, their parasitoides and damage in Marassana.

Crop and Variety	*Location*	*Age of the crop (days)*	*Insecticides sprayed*	*Number of sprays*	*Mean mines/compound leaf*	*Number of adults emerged/sample*	*Number of parasites emerged/sample*	*% parasitism*
Tomato KWR	Bogaspalalla	30	Endosulfan	1	35.6	76	9	10.59
Tomato KWR	Walmoruwa	35	Dimethoate Methamidophos	1 1	47.2	101	8	7.34
Tomato KWR	Walmoruwa	35days	Dimethoate Methamidophos	1 1	49.1	47	24	33.80
Tomato Local selection	Walmoruwa	35days	Dimethoate Methamidophos	1 1	66.3	49	17	25.76
Tomato Local selection	Walmoruwa	35days	Dimethoate Methamidophos	1 1	55.5	59	30	33.71

Table 6. Effect of insecticides on leaf miner damage and tomato yield.

Treatment	*Mean number of mines/compound leaf*	*Mean total number of fruits/7m²*	*Mean weight of total fruits k/m²*
Imidocloprid	18.1 b	485.0 a	25.2 a
Carbosulfan	22.1 ab	531.5 a	27.3 a
Profenophos	23.0 a	497.5	25.6 a
Yellow polythene	19.4 ab	508.3 a	27.0 a
Untreated control	22.8 ab	511.3 a	26.6 a
LSD	4.8	77.2	53.0
CV%	14.9	9.9	13.1

Leaf miner damage at harvest

Undamaged leaflets were significantly higher in abamectin treatment than under farmer practices and chlorfluazuron treatments. However, undamaged leaflets under neemazal F, cyromazine, Bt and untreated control were not significantly different from abamectin treatment. Slightly damaged leaflets were not significantly different among abamectin, cyromazine and neemazal F treatments (table 8).

Severely damaged leaflets were significantly higher under farmer practices. Neemazal F; Chlorfluazuron and *Bt* treatments. It was significantly lower in abamectin treatment compared to the above treatments. Severely damaged leaflets observed in untreated control were, however, not significantly different from abamectin treatment (table 8).

Effect of leaf miner damage on yield

Even though significant differences in severity of leaf miner damage was observed between different treatments, the yield parameters shown in table 9 revealed that the intensity of leaf damage had not affected the yield.

The results of the survey and the two field trials were in agreement with published data on leaf miner by others. It has been recorded that regular usage of conventional insecticides against leaf miners and other insect species that infest tomatoes intensify leaf miner damage owing to reduction of natural enemies (Hayslip, 1961; Poe *et al.*, 1978, Jonson *et al.*, 1980 a,b). In many field situations, a complex of hymenopterous parasitoids may maintain leaf miners below economically damaging level. In USA at least 14 parasitoid species (Families Braconidae, Pteramalidae, Eulophidae and Cynipidae) have been reared from the larvae and pupae of *L. sativae* (Musgrave *et al.*, 1975).

Survey by chrysanthemum growers in California (Newmen and Paralella, 1986) revealed that, growers spent an average of nearly US$ 14,800 per hectare per year on insecticides for leaf miner control between 1982 and 1985 and still lost 23% of the crop. Hence, the ability of *Liriomyza* spp. to develop resistance to insecticides must be taken into consideration when a management strategy for the pest is developed for crops where it is a major problem.

Table 7. Effect of insecticides on severity of leaf miner damage at flowering.

Insecticide (Treatment)	*Severity of damage*			
	Mean % undamaged leaflets	*Mean % slightly damaged leaflets*	*Mean % moderately damaged leaflets*	*Mean %s severely damaged leaflets*
Farmer practices	38.5 a	32.3 a	19.4 a	10.0 a
Neemazal F	59.0 ab	25.5 a	10.4 abc	3.0 c
Chlorofluazuron	49.4 bc	26.8 a	13.9 ab	9.8 ab
Cyromazine	69.1 a	22.4 a	6.7 bc	1.8 c
Abamectin	56.5 abc	31.7 a	7.8 bc	3.9 bc
Bt	62.4 ab	25.5 a	8.3 bc	3.8 bc
Untreated control	71.9 a	21.9 a	4.4 c	2.1 c
CV%	15.5	16.9	28.4	39.7

Analysis of variance is done on arc sine transformed data. Means followed by the same letter are not significantly different at P=0.05.

Table 8. Effect of insecticides on severity of leaf miner damage at first harvest.

Insecticide (Treatment)	*Mean % undamaged leaflets*	*Severity of damage*		
		Mean % slightly damaged leaflets	*Mean % moderately damaged leaflets*	*Mean %s severely damaged leaflets*
Neemazal F	9.7ab	27.6ab	9.5a	51.5a
Chlorofluazuron	6.1b	6.4b	8.7a	58.5a
Cyromazine	20.7a	19.4ab	23.8a	37.5ab
Abamectin	25.3ab	23.8a	23.4a	27.4b
Bt	8.7ab	39.0b	25.7a	25.0a
Untreated control	8.3ab	17.3b	18.8a	33.5ab
CV%	85.1	59.6	50.7	44.4

Analysis of variance was done on arc sine transformed data. Means followed by the same letter are not significantly different at P=0.05.

Effect of tomato varieties on leaf miner damage

Leaf samples taken randomly revealed that all leaflets in the tested varieties were damaged. Percentage of severely damaged leaflets were not significantly different among the varieties (P=0.05) and in all the varieties tested, it was above 50% (table 10). Percentage moderately damaged leaflets was significantly lower in BL 350 than in KWR. Percentage of slightly damaged leaflets was significantly higher in BL 355 (P=0.05) than in rest of the varieties.

Table 9: Effect of insecticide treatments on yield of tomato.

Insecticide (Treatment)	*Mean total number of fruits/11.2m²*	*Mean wt. Of total fruits kg/11.2m²*
Farmer practices	323.0a	16.2a
Neemazal F	272.8a	15.1a
Chlorfluazuron	313.5a	16.0a
Cyromazine	320.0a	16.3a
Abamectin	319.3a	16.3a
Bt	344.8a	17.2a
Untreated control	284.3a	15.3a
CV%	19.5	19.6

Variety BL 350 gave the lowest % of slightly damaged leaflets (table 10). Even though, there were significant differences in moderately damaged leaflets and slightly damaged leaflets between some tested varieties, it was evident that they were neither resistant nor tolerant to leaf miners as over 50% of leaflets were severely damaged (table 10).

Host resistance to leaf miners has not yet been fully explored in the wild relatives and cultivars of tomatoes. More research is needed, at least for relatively low levels of resistance in tomato because that will be sufficient to prevent any economic losses, as high level of damage is needed to affect yield reduction. This fact was evident from the results of insecticides screening trial (tables 6,7and 8). These findings are in agreement with that of Woenbarger and Wofenbarger (1966). Webb *et al.*, (1971) reported that several breeding lines of tomato have genes contributing to larval antibiosis, adult non-preference or both. They further reported that *Lycospersicon hirsutum* is a potential parent that could be included in breeding programmes for leaf miner resistance. However, incorporation of resistant genes into lines, while concurrently maintaining desirable horticultural characters, is likely to be difficult.

With presently available information it is apparent that strategies for management of leaf miner species on tomatoes should incorporate cultural and biological methods. Destruction of alternative hosts, particularly broad-leaved weeds, near tomato fields at least one month prior to establishment may delay leaf miner appearance. Removal or turning under host residues prior to planting had prevented the emergence of nearly 100% of the viable larvae and pupae (Musgrave *et al.*, 1975).

Table 10. Effect of tomato varieties on leaf miner damage.

Variety	*% Severely damaged leaflets*	*% Moderately damaged leaflets*	*% Slightly damaged leaflets*
CLN457	50.1 a	16.1 abc	5.8 bc
KWR	63.5 a	25.7 a	7.1 bc
B2	62.1 a	15.9 abc	6.2 bc
CARAIBO	61.3 a	20.9 abc	7.6 bc
BL355	58.5 a	21.7 ab	19.8 a
B1	55.2 a	7.2 bc	6.6 bc
CKLN65	69.9 a	11.0 abc	4.2 bc
MANIK	73.7 a	12.0 abc	2.6 bc
BL350	61.7 a	4.8 c	1.8 c
B13	57.9 a	14.5 abc	9.7 b
T245	68.0 a	11.5abc	3.8 bc
CV%	38.3	66.0	64.4

Means followed by the same letter are not significantly different at P=0.05.

CONCLUSIONS

Results of the survey of farmer fields and the first two field studies showed that the available insecticides as well as non-conventional, new insecticides are not effective in reducing leaf miner damage in tomato. It was evident from the survey results that even with insecticide applications there is a certain level of parasitism and if no insecticides are applied against this pest, parasitism could be increased and effectively used to keep the pest below injurious level. Further, the findings revealed that the damage observed in the two field studies had no effect on yield suggesting that except under severe infestation no economic loss in yield would occur. The available varieties as well as the breeding lines about to be released did not show resistance or tolerance to leaf miner damage (table 10). Therefore, it can be concluded that, the most effective way of overcoming leaf miner problem is to avoid unnecessary insecticide applications and there by help to increase the parasitism level, bringing about natural control of the pest, along with practicing desirable cultural practices.

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REFERENCES

Hayslip, N.C. 1961. Leafminer control on tomatoes in the Indian River area Proc. Fla State Hort. Soc. 74: 134-137.

Jonson, M.W., E.R.Oatman and J.A. Yyman 1980a. Effects of insecticides on population of the vegetable leaf miner and associated parasites on summer pole tomatoes. J. Econ. Entomol. 73: 61-66.

Jonson, M.W., E.R. and Oatman, J. A.Wyman 1980b. Effects of insecticides on population of the vegetable leaf miner and associated parasites on fall pole tomatoes. J.econ. Entomol. 73:67-71.

Lindquist, R.K. 1983. New greenhouse pests, with particular reference to the leafminer, *Liriomyza trifolli* (Burgess). Proc. 10th Int.Congr. Plant Prot., Brighton, England 3:1087-1094.

Musgrave, C. A., S.L. Poe and H.V. Weems. 1975. The vegetable leaf miner, Liriomyza sativae Blanchard in Florida, Entomol. Circ. Fla Dept. Agric. Lonsum.Serv., No.162.

Newman, J.P. and M.P.Parella. 1986. A licence to kill. Green House Manager. 5(3):86-92.

Poe, S.L., R.H. Everret, D.J. Shuster and C.A. Musgrave. 1978. Insecticidal effects on *Liriomyza sativae* larvae and their parasiteson tomato. J. Ga. Entomol. Soc. 13:322-327.

Wolfenbarger, P.A. and D.O. Wolfenbarger. 1966. Tomato yields and leaf miner infestations and a sequential sampling plan for determining need for control treatments. J. Econ. Entomol. 59:279-283.

Webb, R.E., A.K. Stoner and A.G. Gentile. 1971. Resistance to leaf miner in *Lycospersicon* accessions. J. Am. Soc. Hort. Sci., 96: 65-67.