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Efficiency of Some Biorational Insecticides on Leafminer, *Liriomyza Sativae* Blanchard (Diptera: Agromyzidae)

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Research Article

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ABSTRACT

The leafminer, *Liriomyza sativae* is the major leaf pest of tomato and cucumber fields. It reduces economically yield in outbreak conditions. The farmers use insecticides more times per season against the pest. It is necessary to register new insecticides with different mode of action and low-risks. In this investigation, thiocyclam as a new and biorational insecticide was studied against leafminer. This research carried out in West Azarbaijan province in 2011. Results showed that all treatments had acceptable efficacy in tested location. The mean efficacy of abamectin (0.15 ml/L), cyromazine (0.3 g/L) and thiocyclam (0.75 and 0.5 g/L) were 77%, 70.5%, 82.25% and 76.25%, respectively. Due to same efficacy of both thiocyclam treatments, it can be applied with low concentration (0.5 g/L). The most decreasing of large and small mines were observed in thiocyclam 0.75 treatment (34.97% and 38% respectively). But the lowest were noticed in cyromazine 0.3 treatment (15.59% and 13% respectively). Results indicated that thiocyclam had larvicide activity and adult toxicity.

INTRODUCTION

The leaf miner, *Liriomyza sativae* (Diptera: Agromyzidae) is regarded as a major pest of many crops due to serious economic damage to leaves [1]. Liriomyza genus includes about 300 species distributed worldwide with 23 species being considered economically important [2, 3]. *L. sativae* was native to tropical regions of the world and originally were reported from Mexico and parts of central and South America but expanded quickly in other countries in Europe, Africa and Asia. In Iran the pest was first reported in 2000. This species and *Liriomyza trifolii* Burgess have considerable damage to products such as peas, beans, vegetables, tomatoes and cucumber in the provinces of Khuzestan, Kerman, Hormozgan and Tehran [4-6]. *L. sativae* is a polyphagous pest that attacks to many plants including agricultural crops and all associated weeds. Flowering and ornamental plants such as gerbera and chrysanthemum are infected with this pest quickly and transfer to different parts of the world. In addition, there are other host plants specially compositae family [7]. Leaf miners have a relatively short life cycle; they are able to complete their development in 21-28 days from egg deposition to emergence of adults. Although leaf miner females during the process of feeding and egg-laying provide many pores on the surface of a host plant foliage, especially final young leaves and their margins, the original damage is creating leaf mines by larvae that lead to the destruction of leaf mesophilic. These actions will reduce plant growth and yield [8]. The management of agromyzid leaf miners has been an important subject for the last three decades. Most studies have been focused on using synthetic and natural insecticides, which are commonly used.

However, the effectiveness of these pesticides is reduced greatly due to adverse effects on natural enemies, environment, human health and development of pest resistance. Other control techniques such as using yellow sticky traps or resistant host plants, currently have high limited usage in some countries [9].

In IPM strategy, application of chemical pesticides is considered as a last management tool, so it is recommended that select the method that have the least adverse effects on biological control agents with affecting on target pest [9]. In general, fresh consumption of vegetables and importance of pesticide residues in these products it causes pest management with natural products.

In comparison of the insecticides such as abamectin and cyromazine with conventional pesticides to control *L. huidobrensis* were performed in cultured celery found that in experimental plots with conventional pesticides due to the reduction of parasitoids, pest population increase, but the plots of abamectin and cyromazine good control of pests can be seen [10]. Saito *et al* reported cyromazine, amamectyn benzoate, fipronil, spinosad, chlorfenapyr, azoksation pesticides were effective against *Chromatomyia horticola* in hortocola culture in japan [11]. Mujica surveyed effectiveness of abamectin alone or in combination with vegetable oil on the eggs and larvae of *L. huidobrensis in vitro* and *in vivo* [12]. They founded that 1% addition vegetable oil could decrease insecticide dose (50% to 75%). Their results showed that mortality rate of larvae in laboratory is more than greenhouse. Shashan noted that abamectin and spinosad were the most effective against *L. trifolii* larvae [13]. Cyromazine and azadirachtin were less effective than abamectin and spinosad. Abamectin provided effective control of *L. trifolii* in vegetable crops such as celery [14-17]. Seal found that the abamectin and spinosad provided better control of *L. trifolii* than the untreated control plants [18]. Ferguson found that cyromazine and abamectin resulted in relatively few cases of resistance and have been the most effective insecticides for *L. trifolii* control in vegetable and ornamentals.

Thiocyclam is a broad-spectrum nereistoxin analogue insecticide that is provided *Lubriconereis heteropoda* (Annelida). The only disadvantage of this insecticide, being sensitive to sunlight, so it should be kept in opaque containers and dark cellar [19]. In recent years there has been good researches in chemical control of leaf miner in Iran, that can be noted spinosad efficiency in controlling of leaf miner [20]. Leaf miner is sensitive to cyromazyne, abamectin and spinosad and the role of oils in improving the efficiency of these insecticides is regarded [21, 22]. Fassihi showed that there was no signification different within using abamectin, cyromazine and thiocyclam for controlling *L. sativae* [23]. Predict the effects of new pesticides such as thiocyclam with field information, enabling us to expand the use of selective insecticides that causes the least damage on the biological control agents. So, efficiency of new insecticides and determine their effective dose against this pest in order to reduce pesticide use and prevent environmental pollution is essential as one of the most effective approaches in managing this pest.

MATERIALS AND METHODS

This experiment was carried out during August and September of 2012 in a tomato field that was infected with tomato leaf miner (Naghadeh, Balikhchi village). Geographical location: the test site with latitude 36°56′17″, longitude 45°22′05″ is at an altitude of 1318 meters above sea level. Average annual temperature, precipitation and evaporation were 10.5°C, 391.8 mm, 1600 mm respectively.

Treatment plots were arranged in randomized complete block design with 4 replications. Plot size were 10 × 20 m^2 and 2.5-5 m margine for each plot and block **(Table 1)**. The conditions of planting, harvesting and harvesting were carried out according to the current method of the region, in the same way for the tested area and farm with wooden beams were blocking. After repeated visits, sampling was done before spraying twenty-second of August, and on August 23 was sprayed. Spraying carried out at least 30% of leaves were infested with leaf miner. Spraying was done as foliar application according to the concentration with solution consumption 400 liters per hectare [24].

Table 1. The list of tested insecticides with their intake of vegetable *Liriomyza sativae.*

The list of tested insecticides with their intake of vegetables on Liriomyza sativae				
Common name	**Registered trade name**	**Type of formulation and percentage of effective ingredient**	**Manufacturer**	**Amount of consumed concentration (G or ml per liter) ***
Thiocyclam	Evisect	SP 50%	Arista life science	0.7
Thiocyclam	Evisect	SP 50%	Arista life science	0.5
Cyromazine	Trigard	WP 10%	syngenta	0.3
Abamectin	Agri-Mek	EC 1.8%	syngenta	0.15
Control	-	-	-	-

For sampling, 10 infected plants from each plot selected and marked and a complete leaf from third middle each plant was selected. Closed plastic bag, brought back to the laboratory and kept at 24 ± 1.5°C, 60 ± 10% RH and 14:10 h L: D photoperiod. To evaluate the treatments, number of small and large mines and larvae were recorded for each 10-leaflet sample which was monitoring daily. Sampling were continued one day before spraying, five and ten days after application. The results were converted to efficiency percentage by Henderson and Tilton formula [25]:

Efficiency percentage = $1-(\frac{TaCb}{CaTb})\times 100$

Ca and Cb=Contamination rate in control plots pre and post spraying

Ta and Tb=Contamination rate in treated plots pre and post spraying

In order to determine LC50 values, the data were analyzed using the probit procedures with SPSS for Windows ® released 19. The means were separated by using the Tukey test. Skewness and kurtosis of data were calculated to ensure normal distribution of small and large mines under Naghadeh conditions. Results showed that data were normally distributed and had no significant difference with Student's test ($p \le 0.05$) **(Table 2)**.

RESULTS

Anova analysis showed that trait of large mines was significantly differ between date of sampling and interaction between them ($p \le 0.01$). For trait of small mines, only date of sampling was significantly differing between pesticides ($p \le 0.01$) **(Table 2)**.

Table 2. Skewness and kurtosis of *Liriomyza sativae* under Nagadeh location in 2011-12 seasons.

Trait	Skewness	T-Student Value	Probability	Kurtosis	T-Student Value	Probability
Small mines	0.601	1.949	0.062	-0.145	-0.238	0.406
Large mines	0.698	2.262	0.073	0.0872	0.143	0.443

Efficiency of pesticides spray date 5 showed significantly difference but there was no significant difference between pesticides spray date 10 **(Table 3)**.

Table 3. Table of analysis of variance of small and large mines of different insecticide treatments on *Liriomyza sativae* in West Azarbaijan province.

Variations		Mean squares	
Source of variation	**df**	**Small channel**	**Large channel**
Replication	3	0.035	0.008
Pesticide	4	0.015^{ns}	0.043^{*}
Date of sampling	2	0.209^{**}	0.320^{**}
Pesticide× Date of sampling	8	0.032^{ns}	0.031^{*}
Error	42	0.020	0.016
Coefficient of variation (%)		15.38	13.62
Ns, * and **: was not significant difference and significant at 0.05 and 0.01 probability levels, respectively.			

Regardless of the type of pesticide, there was significant difference between spray date 5 and 10 of pesticides in the number of small mine (0.926 versus 0.812). The mean number of small mines in spray date 5 was lower than spray date 10. Therefore, pesticide effect on the number of small mines was the highest in spray date 10. There was no significant difference between the number of large mines five (0.8435) and ten (0.8650) days after application. Therefore, efficacy of pesticides in number of large mines were similar for both sampling times.

Furthermore, there was no significant simple correlation for small (0.208^{ns}) and large (0.217^{ns}) mines in sampling times **(Table 4)**.

Table 4. Analysis of variance table Efficiency of different insecticide treatments on *Liriomyza sativae* in West Azarbaijan province.

Days after application	Source of variation	DF	MS	F	Pr
5+	Block	3	189.5	8.53	0.005
	Treatment	3	92.5	4.16*	0.04*
	Error	9	22.2	-	-
	Total	15		CV=6.1	
10+	Block	3	131.06	0.87	0.49
	Treatment	3	126.06	0.83	0.5
	Error	9	128.56	-	-
	Total	15		CV=15.6	

Pesticide Efficiency

Comparison between pesticides showed that thiocyclam 0.75 g/L had the best efficiency (82.25 ± 1.88). The lowest value was allocated for cyromazine 0.3 with amount of 70.5 ± 2.96. Thiocyclam 0.5 and abamectin 0.15 had in the same group and amount of them were 76.25 ± 3.96 to 77 ± 6.19. **(Figure 1)**.

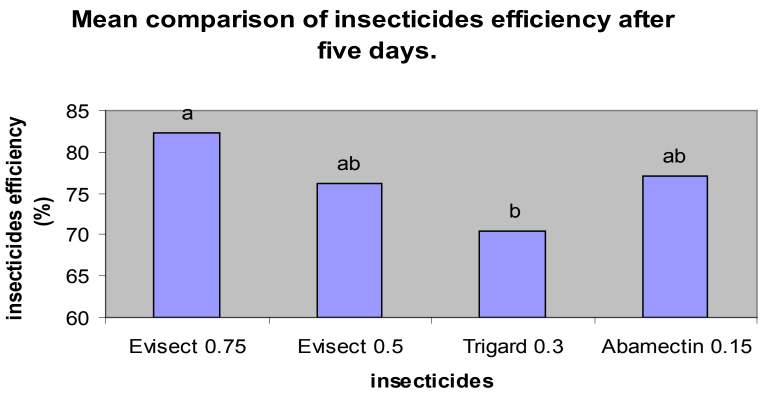

Figure 1. Mean comparison of insecticides efficiency after five days.

Number of Small Mines

There was no significant difference between the number of small mines before and five days after application. Therefore, both of them were the same group (group a). But there were significant differences between the number of mines ten days after application and previous sampling (group b) **(Figure 2)**. Therefore, spray date ten showed the most decrease in the number of small mines.

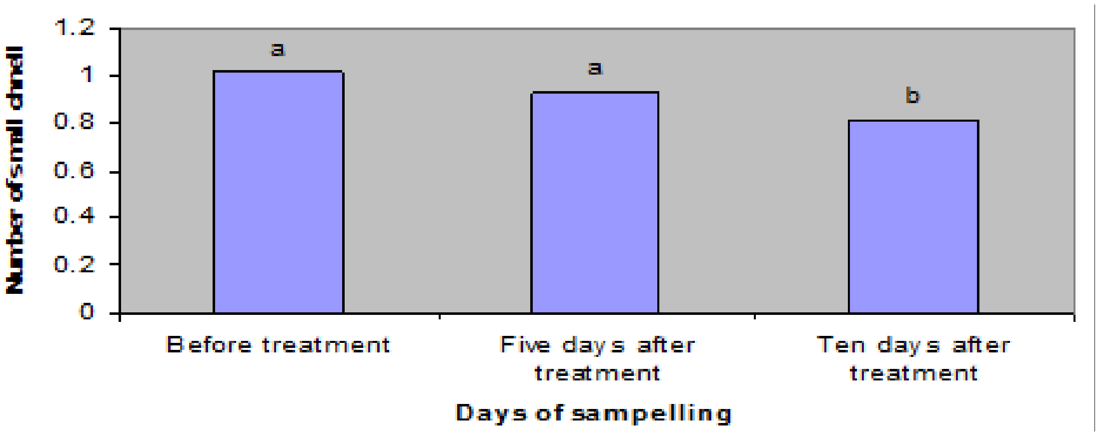

Figure 2. Number of small mines in different days of sampling.

Number of Large Mines

Spray date five and ten were seen the highest decrease in number of thiocyclam 0.7 large mines. Thiocyclam 0.5 and abamectin 0.15 showed decrease in the number of large mines spray date five and ten, but this reduction was lower than Thiocyclam 0.75. The number of large mines in cyromazine 0.3 decreased in different times of sampling but large mine reduction was the lowest **(Figure 3)**.

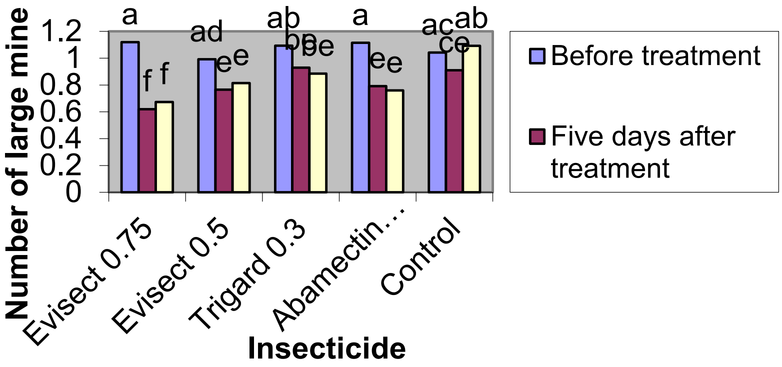

Figure 3. Number of large mine in different days of sampling.

Range of Variations for Small Mines

Based on **Table 4**, the most decreasing of small mines was observed in thiocyclam 0.75 (38%) treatment but the lowest was distinguished in cyromazine 0.3 (13%). All pesticides spray date ten had the lowest value of small mines Thiocyclam 0.75 had the most effect on small mines of *L. sativae*. Thiocyclam 0.5 had the most efficacy on the number of small mines after five days in comparison with the other treatments. Cyromazine 0.3 had the lowest effect spray date 5 **(Table 5)**.

Table 5. Statistical parameters of *Liriomyza sativae* for small mine under Nagadeh on-farm conditions in 2011-12 seasons.

Pesticide	Minimum	Maximum	Sum	Mean	Variance	Standard error	Standard deviation
One time 1	0.91	1.36	4.53	1.132	0.0338	0.183	0.183
One time 2	0.94	1.04	3.86	0.965	0.002	0.044	0.05
One time 3	0.7	0.7	2.8	0.7	0.00	0.00	0.00
Two time 1	0.81	1.17	4.07	1.017	0.023	0.151	0.151
Two time 2	0.83	1.03	3.63	0.907	0.009.	0.094	0.096
Two time 3	0.70	0.86	3.18	0.795	0.005	0.070	0.071
Three time 1	0.78	1.28	3.8	0.95	0.051	0.225	0.226
Three time 2	0.70	1.22	3.69	0.922	0.0480	0.219	0.221
Three time 3	0.70	0.75	3.30	0.765	0.001	0.04	0.045
Four time 1	0.89	1.14	4.07	1.01	0.010	0.100	0.0102
Four time 2	0.83	1.04	3.72	0.93	0.007	0.083	0.086
Four time 3	0.7	0.81	3.48	0.87	0.037	0.192	0.194
Five time 1	0.83	1.12	3.85	0.962	0.0142	0.119	0.1192
Five time 2	0.70	1.04	3.62	0.905	0.0209	0.144	0.144
Five time 3	0.80	1.3	3.93	0.982	0.048	0.219	0.219

Range of Variations for Large Mines

Based on **Table 3**, the most decreasing of large mine was observed in thiocyclam 0.75 treatment (34.97%). But the lowest was noticed in cyromazine 0.3 treatment (15.59%). All pesticides (except thiocyclam 0.5) spray date ten had the lowest value of large mines. Thiocyclam 0.7 had the best effect on large mines of *L. sativae.* Thiocyclam 0.5 had the best efficacy on the number of small mines after five days in comparison with the other treatments. Cyromazine 0. 3 had the lowest effect spray date 5 **(Table 6)**.

Table 6. Statistical parameters of *Liriomyza sativae* for large channel under Nagadeh on-farm conditions in 2011-12 seasons.

Pesticide	Minimum	Maximum	Sum	Mean	Variance	Standard error	Standard deviation
One time 1	0.96	1.42	4.46	1.11	0.043	0.207	0.207
One time 2	0.7	0.94	3.17	0.79	0.013	0.114	0.115
One time 3	0.68	0.81	2.9	0.72	0.001	0.011	0.02
Two time 1	0.78	1.28	3.97	0.99	0.044	0.209	0.211
Two time 2	0.70	0.83	3.06	0.76	0.005	0.07	0.075
Two time 3	0.78	0.86	3.26	0.81	0.001	0.031	0.041
Three time 1	1.00	1.18	4.37	1.09	0.005	0.07	0.076
Three time 2	0.70	1.14	3.72	0.93	0.032	0.178	0.18
Three time 3	0.70	0.85	3.14	0.92	0.01	0.11	0.095
Four time 1	0.94	1.32	4.48	1.12	0.032	0.17	0.179
Four time 2	0.7	0.94	3.28	0.89	0.009	0.097	0.065
Four time 3	0.8	0.92	3.49	0.87	0.003	0.054	0.055
Five time 1	0.94	1.16	4.17	1.04	0.011	0.104	0.109
Five time 2	0.83	1.04	3.64	0.91	0.0102	0.1	0.1
Five time 3	1.00	1.18	4.37	1.09	0.006	0.077	0.082

DISCUSSION

Data analysis showed that the tested insecticides had acceptable performance in West Azarbaijan. Comparison of the efficacy of treatments showed that thiocyclam insecticide had the same efficiency in both concentrations of 0.75 and 0.5/1000, spray date ten with abamectin and cyromazie insecticides. Therefore, thiocyclam can be used at concentration of 0.5-0.75 per thousand for control of *L. sativae*. Boulahia found that confidor, thiocyclam and mineral oil oleostec significantly reduced the pest population as compared to untreated plants. Also, Garjan reported efficiency of thiocyclam 1 and 0.75 per 1000 on *Tuta absoluta* Meyrick control in Boushehr were 83.33% and 78.33%, respectively and in Jiroft were 94.5% and 87.75% that tally with our results [26]. Also, Grafius and Haydan noted that application of thiocyclam (0.17-0.84 kg ai/ha) were effective in controlling all larval instars of *L. trifolii* in field- gran celery [27]. In addition, Saito reported that *L. trifolii* larvae in bean that were sprayed with cartap 50 s, thiocyclam 50 w and bensultap 50 w, thiocyclam and cartap had better efficiency (100% mortality) than bensultap (71% mortality 8 days post treatment [28]. Esmaeeli and Hatami also reported in controlling *T. absoluta* after using Muyan to control the pest, recommend thiocyclam spraying with a dose of 1 per 1000 [29]. Soltani surveyed efficiency of abamectin, chlorpyrifos, thiocyclam and B.T against *T. absoluta* [30]. He reported that thiocyclam exhibited the lowest number of live larvae and large mines. Albeit, abamectin and thiocyclam had a significant effect on reducing the number of live larvae and large mines in comparison with other pesticides. In a laboratory study with cyromazine, abamectin and stamyprid on *Liriomyza trifolii*, in the first and second year of sampling, abamectin was the most effective in comparison with other tested insecticides, these results are accordance with findings of Saberfar and Sheikhi [31]. Javadzadeh and Bani-Ameri found that abamectin's performance was between 70% to 90%, which is similar to the results of this study. According to Sheikhi's report, the average efficiency of spray date five against *L. trifolii* are abamectin 82.83%, thiocyclam 0.75 and 0.5, 83.53% and 76.13% and cyromazine 80.68%, which is consistent with our results (except cyromazine) [32]. Fasihi investigated efficacy of thiocyclam, cyromazine and abamectin in control of *liriomyza sativae* in Bushehr. He showed that there was no significant difference between treatments. Therefore, it can be used for the control of this pest in rotation with other insecticide groups. The results of Fassihi research are contradictory to the present study. However, the results of this researcher in Jiroft showed that although abamectin had the greatest effect on pest control and thiocyclam was in the second group, however, its effectiveness in reducing the number of live larvae and the number of mines is optimal, effect of thiocyclam in reducing number of live larvae and mines is similar to the results of this study, however, in the present study, abamectin is in the second group in terms of efficiency and reduction of mines, This may be due to different weather condition differences of the tested pest population in different areas. Weintraub and Horowitz and Weintraub reported that abamectin, deltametrin, imidaclopride and stamyprid insecticides reduced the numer of leaf mines [33]. The effect of abamectin on reducing the number of mines confirms the results of our investigation. Treatment this leaf miner by azadirachtin and comparing it with conventional pesticides, showed that abamectin insecticide has the highest efficiency in samples of 1.3, 7 and 14 days after spraying.

Richardo reported when *L. trifolii* densities were lower, abamectin reduced leaf miner density after application and appeared effective [34]. Also among 54 insecticides tested by spraying on one-day-old larvae, isoxathion, thiocyclam, cartap, cyromazine and flufenoxuron gave high mortality [35]. Results of effects of cyromazine and abamectin on *Liriomyza huiobrensis* showed that application of cyromazine by drip irrigation system had minor effects on larval leaf miner, which also confirms the results of this study [36]. These results support the findings of Shashan who reported treatment with cyromazine led to significantly more *L. trifolii* mines after spray date 3 than after all other spray dates. In turn, cyromazine spray date 5 had significantly fewer mines than spray dates 2, 3, 4. This condition is probably due to the strong resistance to cyromazien, so that Liebee and Capinera [37] also reported leaf miner resistance to this pesticide. Cyromazine and abamectin were the most efficacious insecticides for *L. trifolii* control on potted- and cut-chrysanthemums. This was probably due to their toxic action on the immature stages [38, 39]. Also, Shashan showed abamectin and spinosad were the most effective products for managing *L. trifolii* population by reducing mines and larvae. Cyromazine and azadirachtin appeared more intermediate and were less effective or more variable than azadirachtin and spinosad. Cyromazine and abamectin appear to be compatible with the leaf miner parasitoid [40]. In fall of 2007, overall efficacy of abamectin was nil. However, in spring of 2008 when leafminer densities were lower, abamectin reduced leafminer density after application and appeared effective [41,42].

CONCLUSION

Results of this study indicated that among tested pesticides, thiocyclam was found to be effective against leaf miner, *L. sativae* and can be used at concentration of 0.5-0.75 per thousand for control it. In view of this efficacy of thiocyclam against lefminer, it can be incorporated in the integrated pest management program.

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