Egypt. J. Plant Prot. Res. Inst. (2023), 6 (2): 133 –142

Egyptian Journal of Plant Protection Research Institute

www.ejppri.eg.net

Population density of leafminer *Liriomyza trifollii* (Diptera: Agromyzidae) on early tomato season as influenced by seed treatments and spraying plants

El-Fakharany, S. K. M. and Samy, M. A.

Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

ARTICLE INFO

Article History

Received: 7/ 4/2023

Accepted: 22/6/2023

Keywords

Liriomyza trifolii, tomato, population density, seed treatments and insecticides.

Abstract

Liriomyza trifolii (Burgess) (Diptera: Agromyzidae) is one of the most important pests in which host range causing serious losses in several economically important crops. Thus, greenhouse and field experiments were conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate in the two plantations (March and July), season 2022 to study the population density of *L. trifolii* on tomatoes as affected by tomato varietal preference and to determine, efficiency to certain compounds through tomato seed treatments and spraying plants. The number of leafminer larvae appeared in the first week of May in Angham, Thurayia and Elissa cultivars tomato in plantations, and then it increased gradually to reach the highest peak in the second week of May. Also, it started at low density in the second week of August in July plantation and the highest peak of pest was recorded in the fourth week of August in the three cultivars. The population densities of *L. trifollii* larvae were higher on Elissa cultivar than on Angham and Thurayia in April and July plantations. Thus, it should differ significantly between Elissa C.V. and Angham ($p \leq 0.05$). This pest was lower in the first plantation than in the second one. Difenoconazole 2.2%+ fludioxonil 2.2% + thiamethoxam 22.6% (I) and fludioxonil 2% +thiamethoxam 20% (Π) compounds induced a fast initial effect where the reduction in population was 100% on all verities in the two plantations, while the effect decreased gradually to reach zero% reduction after 5 weeks. Significant differences were found among treatments and control on the mean number of *L. trifollii* larvae on all cultivars ($p \leq 0.05$). The general mean of reduction in insect population throughout the scouting period, (1) and (Π) compounds significantly induced the highest reduction in the two plantations. Thus, it did not differ significantly in the two compounds with cultivars as tomato seed treatments against leafminer ($p \geq 0.05$). Cyromazine and abamectin were the most potent compounds in reducing the population density of leafminer in tomato plants in the two plantations. It was followed by thiocyclam hydrogen oxalate, while fipronil was the least in this pest control.

Introduction

Tomato (*Lycopersicon esculentum* L.) is important vegetable crop grown in Egypt. There is a number of insect pests attacking tomato crop from the emergence of seeds to fruit harvesting. Tomato leafminer is one of the main insect pests of tomatoes in different tomato-growing countries. Almost twenty-four different host plants were identified infested by leafminers i.e., *Liriomyza* spp. on tomato (89% infestation) (Hamza *et al.*, 2023).

Worldwide, there are more than 330 leafminer species that belong to genus Liriomyza which are important insect pests of many vegetables and ornamental plants (Gao *et al*., 2017). Leafminer *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) in its immature stage lives inside and consumes the leaf tissues of host plants. It is a major insect pest of vegetables and ornamentals, especially tomato crop in the Mediterranean countries and worldwide (Spencer, 1990; Seal *et al.,* 2002 and Hamza *et al.*, 2023). This pest can cause major production and economic losses in host crops also larvae feed on the mesophyll layer of leaves, which reduces the photosynthetic area, leaf chlorophyll content and water losses in the plants (Bueno *et al.,* 2007; Yıldırım *et al.,* 2010 and Thorat *et al.,* 2017).

Regarding the management of agromyzid leafminers, there had been an extensive debate among researchers. Farmers commonly used synthetic and natural insecticides for the control of this pest for better production of vegetables especially tomatoes. Due to the use of these insecticides in a disorganized way, the effectiveness of these insecticides is reduced. These include abamectin, cyromazine, thiocyclam hydrogen oxylate and bensultap insecticides (Weintraub, 2001; Civelek and Weintraub, 2003; Ibrahim *et al.*, 2008; Hernández *et al.*, 2011; Reitz *et al*., 2013; Morsy *et al.*, 2019; Chang *et al*., 2022 and Hamza *et al.*, 2023) significantly reduced *L. trifollii* larvae on plants. To the best of our knowledge, few works have been reported regarding tomato seed treatments, tomato varietal preference of leafminer and efficacy of different insecticides for management strategies.

These findings will provide some basic information and management options to reduce the pest population.

Materials and methods

1. Population density of *Liriomyza trifollii***:**

The population for *L. trifollii* infestation tomato (*L. esculentum* L. var. Angham, Thurayia and Elissa,) crop was conducted at the farm of Sakha Agricultural Research Station, Kafr El-Sheikh governorate, during 2022 season in the two plantations. An area of 400 m^2 was assigned for each tomato variety. On April 15 (The first plantation) and on July 26 (The second plantation) tomato seedlings were transplanted. The inspection started 15 days after transplanting and continued weekly till six weeks. The experimental area was divided into four plots, each variety was represented by four replicates arranged in a complete randomized block design and ten tomato plants were weekly inspected randomly from every replicate. Thus, 40 tomato plants were sampled for every variety at every sampling date.

2. The tested compounds:

The study was carried out to evaluate six compounds; two were applied as seed treatment and the field performance of four insecticides in their respective commercial formulations available on the market. Difenoconazole 2.2%+ fludioxonil 2.2% + thiamethoxam 22.6% (I) (Corner Plus 27% FS), fludioxonil 2% +thiamethoxam 20% (Π) (Assure Extra 22% FS, Starchem Industrial Chemicals, Egypt) for seeds treatment; abamectin (Vapcomic1.8% EC, Vapco), thiocyclam hydrogen oxalate (Evisects 50% SP, Nippon Kayaku; Arysta), cyromazine

(Cymax 50% SP, Shandong, Sino- Agri United Biotechnology Co., Ltd) and fipronil (Ekiw Safe 50% FS, BASF), for plant treatments. The pesticide generic and chemical information is given in Table (1). The concentrations used were based on the recommendations of the Egyptian Ministry of Agriculture for each pesticide to control sucking pest insects and leafminers under field conditions.

Table (1): Common and trade names of tested compounds, their chemical classes and application.

Common name	Trade name	Chemical classes	Application rate /Kg
Seeds treatment			
Difenoconazole 2.2%+ fludioxonil 2.2% + thiamethoxam 22.6% (I)	Corner Plus 27% FS	Triazole+phenylpyrrole neonicotinoid	4 ml
Fludioxonil 2% +thiamethoxam 20% (Π)	Assure Extra 22% FS	Phenylpyrrole +neonicotinoid	3 ml
Plants treatment			/100L
Abamectin	Vapcomic1.8% EC	Avermectin	40 ml
Thiocyclam hydrogen oxalate	Evisects 50% SP	Nereistoxin analogue	250 g
Cyromazine	Cymax 50% SP	Cyromazine	20 g
Fipronil	Ekiw Safe 50% FS	Phenylpyrazole	15 g

3. Seed treatments:

The study was conducted on tomato seeds to evaluate the effect of different treatments against *L. trifolii*. Tomato seeds varieties: Angham, Thurayia and Elissa were spread on clean plastic sheets moistened, then mixed thoroughly with the tested compounds (I) and (Π) as shown in Table (1). The treated seeds and control were left to dry, then directly planted in the trays in greenhouse. The planting was carried out in the last week of March (in the first plantation) and the first week of July (in the second plantation) in trays greenhouse (3 trays each variety) in 2022 season. The inspection started 15 days after planting (The appearance of two true leaves) and continued for two weeks, then tomato plants were transplanted in the last week of April (In the first plantation) and the first week of August (In the second plantation) in the open field. The experimental area was divided into four plots, each variety was represented by four replicates arranged in a completely randomized block design and 25 tomato plants were weekly inspected randomly from every replicate. This area did not receive any insecticidal treatments during the experimental period extending about 7 weeks after planting. The reduction percentage in leafminer population was calculated according to Abbott's Formula (1925).

4. Field assessments:

Field experiments were conducted during June and August 2022 season at the experimental farm of Sakha Agricultural Research Station, Kafr El-Sheikh governorate. An area of 1000 m^2 planted with tomato (*L. esculentum* L. var. Elissa) was divided into plots 200 m^2 for each treatment and infested with *L. trifollii*. This area did not receive any insecticidal treatments before the start of the experiment. Four insecticides + control was tested in arranged and complete randomized blocks designed with four replicates. The tested compounds were applied at recommended rates using a motor knapsack sprayer, tap water was used for dilutions. Ten tomato leaves were randomly chosen from each replication to count the leafminer population. The chosen plants were examined before spraying and 3, 5 and10 days post spray. The mean number of *L. trifollii* per 40 tomato leaves (10 leaves/ replicate) was recorded. The percentage of infestation reductions in leafminer population among treatments in relation to control was calculated according to Flemings and Ratnataran (1985) equation.

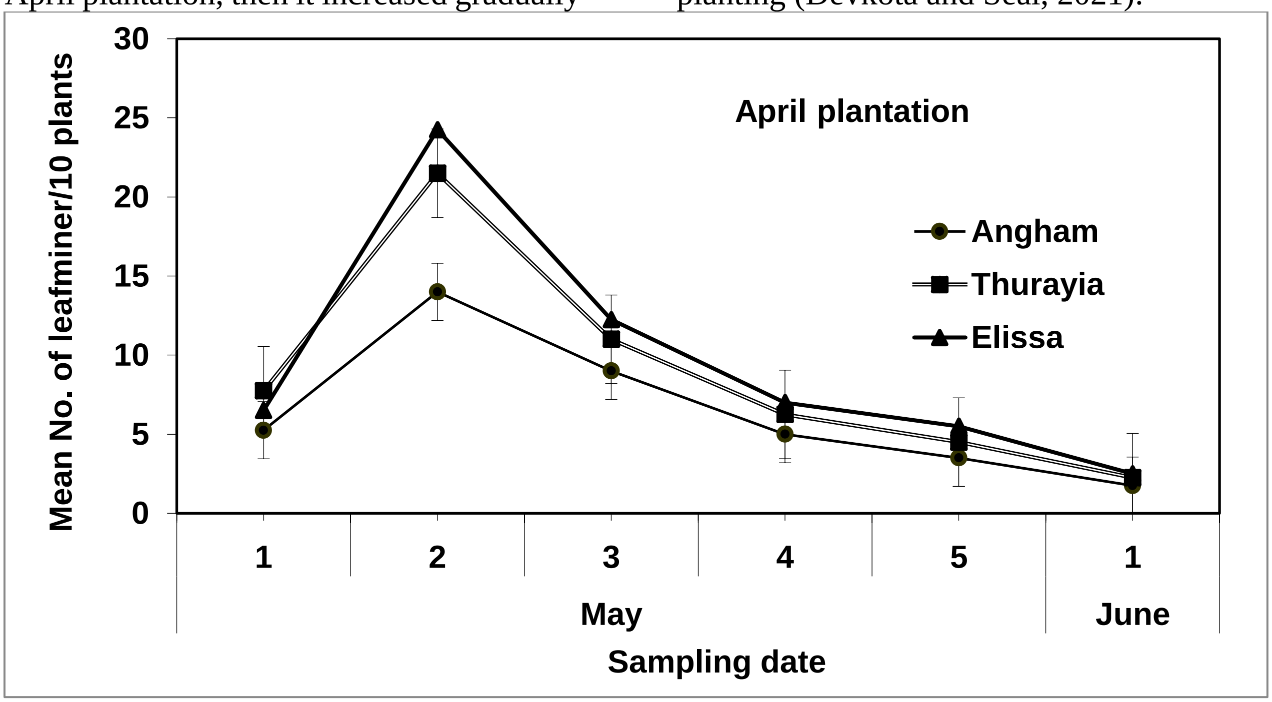
5. Statistical analysis:

Analysis of variance (ANOVA) was calculated, and significant differences between the means of these treatments by Dancan's Multiple Rang Test (Duncan, 1955) using the SPSS statistical software package 16.0 (SPSS, 2016).

Results and discussion

1. Population density of *Liriomyza trifollii*:

Population densities of *L. trifollii* larvae on tomato plants at the farm of Sakha Agricultural Research Station, Kafr El-Sheikh 2022 season are shown in (Figure 1) the numbers of leafminer larvae appeared in the first week of May in Angham, Thurayia and Elissa cultivars tomato in April plantation, then it increased gradually to reach the highest peak in the second week of May. Also, in Figure (1) *L. trifollii* larvae were started at low density in the second week of August in July plantation. The population increased gradually, and the highest peak of pest was recorded in the fourth week of August in the three cultivars. The present results are in parallel with Abou-Attia *et al.* (2004) who observed the peak of leafminer larvae on tomatoes in May at Kafr El-Sheikh, while Saradhi and Fatniar (2004) in India, recorded the highest infestation of leafminer in the second and third weeks in February on tomato. Tran *et al.* (2007) found that the abundance of leafminer was high at the beginning of the growing season (Cucumber) in July until late August after which the population decreased until the last season. The mean numbers of mines, larvae, and pupae were highest at 2 weeks on snap beans and 3 weeks on squash after planting (Devkota and Seal, 2021).



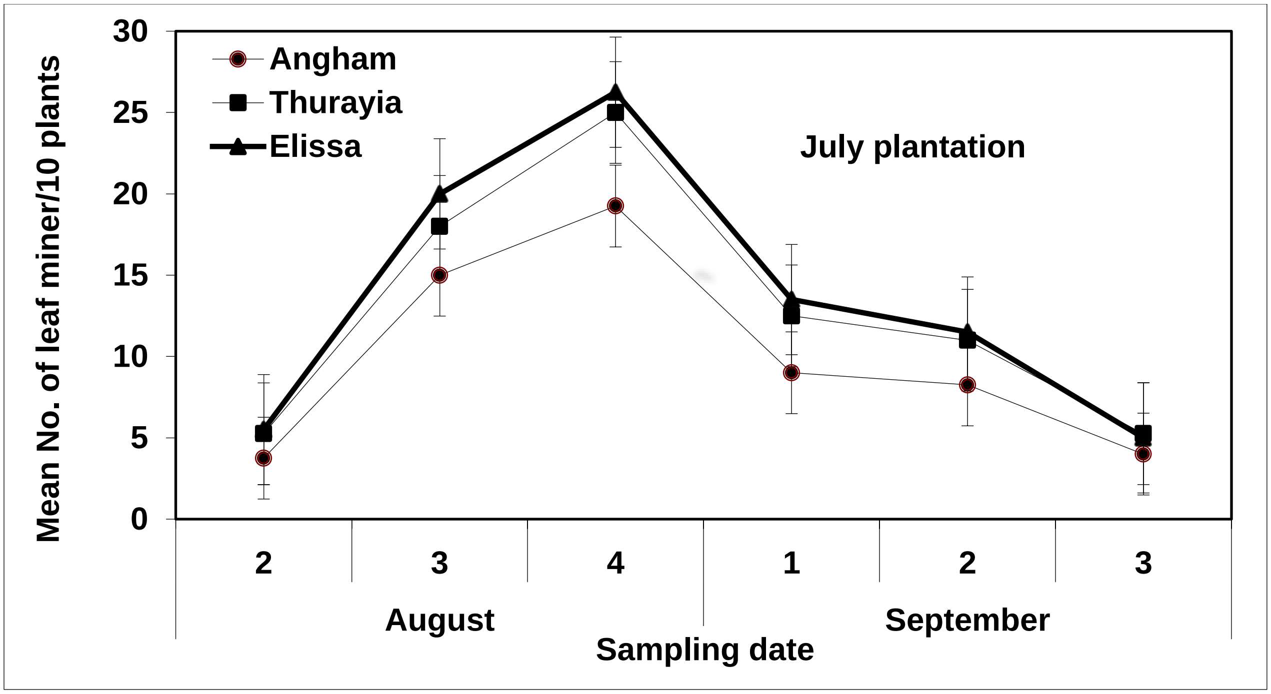


Figure (1): Population densities of *Liriomyza trifollii* larvae on tomato plants at Sakha Agricultural Research Station farm in 2022 season.

2. Tomato varietal preference of leafminer:

The population densities of *L. trifollii* larvae were higher on Elissa cultivar (9.67 and 13.63) than on Angham (6.42 and 9.88) and Thurayia (8.88 and 12.83) in April and July plantations respectively. Thus, it should differ significantly between Elissa c.v. and Angham ($p \leq 0.05$) (Table 2). Leafminer larvae were lower in the first plantation than in the second one. The mine numbers in each tomato leaflet varied from 1 to 9, but the leaflets with 2 mines were the most frequent case (Lee *et al.*, 2004). Also, Lee *et al.* (2005) found that the mean number of leafmines per leaf ranged from 1.02 to 11.04 in the first season, while it was from 0.16 to 9.97 in the second. Lalruatsangi and Chatterjee (2022) found that the highest leafminer infestation was recorded on cultivar Mahy Gotya, while it least was recorded on cultivar MT-2 and Selection-1. Hamza *et al.* (2023) showed that Baby red variety of tomato crop was the most preferred by leafminer (*Liriomyza* spp.), and comparatively Sehar was the least preferred variety.

Table (2): Tomato varietal preference of leafminer in 2022 season at Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate.

Plantation	Seasonal mean of *Liriomyza trifollii* larvae /10 tomato plants ±SE		
	Angham	Thurayia	Elissa
April	6.42^{b}±0.71	8.88^{ab}±1.08	9.67^{a}±1.08
July	9.88^{b}±0.82	12.83^{ab}±1.22	13.63^{a}±1.22

In a row, means followed by the same letter are not significantly different at the 5% level by Duncan (1955)

3. Seed treatments:

The data presented in Table (3) showed the mean number of *L. trifollii* larvae on tomato plants and reduction percentage as influenced by (I) and (Π) compounds applied as tomato seed treatments on three tomato cultivars (At recommended) in the two plantations, 2022 season. It was apparent that (I) and (Π) compounds induced a fast initial effect where the reduction in population was 100% on all verities; Angham, Thurayia and Elissa in the two plantations, while the effect decreased gradually to reach zero% reduction after 5 weeks. Significant differences were found among treatments and control on a mean number of *L. trifollii* larvae on all cultivars (p≤0.05) (Table 3).

Table (3): Mean number and percentage reduction of *Liriomyza trifollii* larvae on tomato plants in different periods from appearance two true leaves in 2022 season.

Compound	Variety	Average No. of leafminer/25 tomato plants ±SE and reduction % after indicated weeks					Grand average reduction%
		In trays ()		In field			
		One	2	3	4	5	
March plantation							
(I)	Angham	0.0^{b}±0	0.25^{b}±0.48	1.0^{b}±0.41	2.0^{b}±0.41	13.0^{a}±1.08	
		(100)	(90)	(71.43)	(46.67)	(0.0)	61.62
(Π)		0.0^{b}±0	0.5^{b}±0.29	1.5^{b}±029	2.5^{ab}±0.29	16.0^{a}±1.08	
		(100)	(80.0)	(64.29)	(33.33)	(0.0)	55.53
Untreated		1.0^{a}±0.41	2.5^{a}±0.29	3.5^{a}±0.29	3.75^{a}±0.48	13.0^{a}±1.08	-
(I)	Thurayia	0.0^{b}±0	0.5^{b}±0.29	1.25^{b}±0.48	2.75^{b}±0.25	16.0^{a}±1.08	
		(100)	(86.67)	(68.75)	(38.89)	(0.0)	58.86
(Π)		0.0^{b}±0	1.0^{b}±0.41	1.5^{b}±0.29	3.0^{b}±0.41	17.0^{a}±2.16	
		(100)	(73.33)	(62.5)	(33.33)	(0.0)	53.83
Untreated		1.0^{a}±0.41	3.75^{a}±0.48	4.0^{a}±0.41	4.5^{a}±0.65	16.0^{a}±1.08	-
(I)	Elissa	0.0^{b}±0	0.5^{b}±0.29	1.25^{b}±0.25	3.0^{b}±0.41	18.0^{a}±1.47	
		(100)	(87.5)	(68.75)	(36.84)	(0.0)	58.62
(Π)		0.0^{b}±0	1.0^{b}±0.41	1.75^{b}±0.25	3.25^{b}±0.25	19.0^{a}±1.08	
		(100)	(75.0)	(56.25)	(31.58)	(0.0)	52.57
Untreated		1.25^{a}±0.41	4.0^{a}±0.41	4.0^{a}±0.41	4.75^{a}±0.48	18.0^{a}±1.47	-
July plantation							
(I)	Angham	0.0^{b}±0	0.5^{b}±0.14	1.5^{b}±0.29	2.75^{b}±0.14	9.0^{a}±1.15	
		(100)	(83.33)	(73.91)	(54.17)	(0.0)	62.28
(Π)		0.0^{b}±0	0.75^{b}±0.14	1.75^{b}±0.14	3.0^{b}±0.58	10.25^{a}±0.58	
		(100)	(75.0)	(69.57)	(50.0)	(0.0)	58.91
Untreated		1.25^{a}±0.14	3.0^{a}±0.58	5.75^{a}±0.58	6.0^{a}±0.58	9.0^{a}±1.15	-
(I)	Thurayia	0.0^{b}±0	0.75^{b}±0.14	2.0^{b}±0.29	4.0^{b}±0.58	11.25^{a}±0.58	
		(100)	(81.25)	(71.43)	(46.67)	(0.0)	59.87
(Π)		0.0^{b}±0	1.0^{b}±0.14	2.5^{b}±0.29	4.25^{b}±0.58	11.5^{a}±1.15	
		(100)	(75.0)	(64.29)	(43.33)	(0.0)	56.52
Untreated		1.5^{a}±0.29	4$^{.0a}$±0.58	7.0^{a}±0.58	7.5^{a}±0.87	11.0^{a}±1.15	-
(I)	**Elissa**	0.0^{b}±0	0.75^{b}±0.14	2.75^{b}±0.29	4.25^{b}±0.58	13.5^{a}±0.58	
		(100)	(82.35)	(65.63)	(48.48)	(0.0)	59.29
(Π)		0.0^{b}±0	1.0^{b}±0.14	3.0^{b}±0.58	4.5^{b}±0.58	14.0^{a}±1.15	
		(100)	(76.47)	(62.5)	(45.45)	(0.0)	56.88
Untreated		1.5^{a}±0.29	4.25^{a}±0.43	8.0^{a}±0.58	8.25^{a}±0.58	13.0^{a}±1.15	-

In a column, means followed by the same letter are not significantly different at the 5% level by Duncan (1955).

Based on the general mean of reduction in insect population throughout the scouting period, (I) and (Π) compounds significantly induced the highest reduction 62.28 to 52.57% in the two plantations. Thus, it did not differ significantly in the two compounds with cultivars as tomato seed treatments against leafminer (p≥0.05) (Table 4).

Table (4): General means of reduction of *Liriomyza trifollii* larvae as tomato seed treatments.

Compound	Grand average reduction% ± SE		
	Angham	Thurayia	Elissa
March plantation			
(1)	61.62^{a} ±3.46	58.86^{a} ±2.89	58.62^{a} ±3.46
(II)	55.53^{a} ±2.31	53.83^{a} ±2.89	52.57^{a} ±1.73
July plantation			
(1)	62.28^{a} ±3.46	59.87^{a} ±4.04	59.29^{a} ±2.31
(II)	58.91^{a} ±3.46	56.52^{a} ±2.89	56.88^{a} ±2.31

In a row, means followed by the same letter are not significantly different at the 5% level by Duncan (1955).

Hamid *et al*. (2003), El-Dewy (2006) and El-Naggar (2006) revealed that imidacloprid and thiamethoxam as seed treatment had relatively fast initial effects against thrips on cotton and the residual efficiency lasted for 7 weeks after planting.

The insecticide efficacy of four compounds, from different chemical groups presented in Table (5) was evaluated under field conditions for their efficacy against *L. trifollii* infesting tomato plants at Sakha, Kafr El-Sheikh Governorate during two plantations, 2022 season. It is obvious that cyromazine (91.94 and 91.89%) and abamectin (89.43 and 89.94%) were the most potent compounds in reducing the population density of leafminer in tomato plants in the two plantations. It was followed by thiocyclam hydrogen oxalate, while fipronil was the least in this pest control. Significant differences were found among treatments (Cyromazine, abamectin and thiocyclam hydrogen oxalate) and fipronil in reduction of *L. trifollii* larvae ($p \leq 0.05$) (Table 5).

Results were in accordance with that reported by Weintraub (1999 and 2001) who found that abamectin and cyromazine significantly reduced leafminer as compared to non-treated control; however, cyromazine was significantly more effective than abamectin. Civelek and Weintraub (2003) also mentioned cyromazine and bensultap significantly reduced *L. trifollii* larvae on tomato plants as compared to non-treated control; however, bensultap at 3.0 kg/ha was significantly more effective than at 2.5 kg/ha. Ibrahim *et al.* (2008) found that profenofos was the most potent chemical used against *L. trifollii,* while thiocyclam hydrogen oxylate was the lowest effective in this pest. Hernández *et al.* (2011) found the plants pepper treated with abamectin had lower leafminer density than those in the untreated control. Morsy *et al.* (2019) found the highest reduction in *L. trifolii* population occurred with cyromazine followed by abamectin, while it was low by bemistop. Chang *et al.* (2022) found that the genes related to *L. trifollii* hormones were significantly expressed after treatment with cyromazine. Hamza *et al.* (2023) found that the highest reduction was observed for spinetoram, whereas bifenthrin. Deltaphos was the least toxic insecticide against *Liriomyza* spp.

Table (5): Potency of tested compounds in reducing *Liriomyza trifollii* larvae on tomato plants in 2022 season at Sakha, Kafr El-Sheikh Governorate.

Compound	Used* conc. [mg a.i.l^{-1}]	Aver. No. pre- treat. /10 leaves	% Reduction				
			Initial effect % (3)	Residual effect after indicated days		Residual effect average	Grand Average
				5	10		
March plantation							
Abamectin	7.20	7.25	$83.48^{a}\pm2.89$	$89.77^{a}\pm2.31$	$95.04^{a}\pm1.73$	$92.41^{a}\pm2.31$	$89.43^{a}\pm2.31$
Thiocyclam hydrogen oxalate	1250	9.75	$68.06^{b}\pm1.73$	$88.5^{a}\pm2.89$	$94.95^{a}\pm1.73$	$91.73^{a}\pm1.73$	$83.84^{a}\pm3.46$
Cyromazine	100	5.25	$86.31^{a}\pm2.31$	$92.93^{a}\pm1.73$	$96.58^{a}\pm1.15$	$94.76^{a}\pm2.31$	$91.94^{a}\pm2.31$
Fipronil	75	10.5	$45.24^{c}\pm2.89$	$71.74^{b}\pm2.31$	$82.89^{b}\pm2.31$	$77.32^{b}\pm2.89$	$66.62^{b}\pm1.73$
Control (No.)	-	5.75	6.0	7.75	8.0	-	-
July plantation							
Abamectin	7.20	8.75	$79.22^{ab}\pm2.31$	$92.86^{a}\pm2.89$	$97.74^{a}\pm1.15$	$95.30^{a}\pm2.31$	$89.94^{a}\pm2.89$
Thiocyclam hydrogen oxalate	1250	8.25	$72.45^{b}\pm2.89$	$89.89^{a}\pm2.89$	$95.22^{a}\pm2.31$	$92.56^{a}\pm2.31$	$85.85^{a}\pm2.31$
Cyromazine	100	10.0	$81.82^{a}\pm2.31$	$95.83^{a}\pm1.73$	$98.03^{a}\pm0.58$	$96.93^{a}\pm1.73$	$91.89^{a}\pm2.89$
Fipronil	75	9.0	$54.55^{c}\pm2.31$	$74.54^{b}\pm2.31$	$84.65^{b}\pm2.89$	$79.60^{b}\pm4.61$	$71.25^{b}\pm2.89$
Control (No.)	-	7.5	8.25	9.0	9.5	-	-

*** The used concentrations were determined based on the recommendations of Egyptian Ministry of Agriculture**
In a column, means followed by the same letter are not significantly different at the 5% level by Duncan (1955).

Almost the mean numbers of larvae were highest at 2 to 3 weeks on tomato after planting. Difenoconazole 2.2%+ fludioxonil 2.2% + thiamethoxam 22.6% (I) and fludioxonil 2% +thiamethoxam 20% (Π) as seed treatment had relatively initial effects against leafminer on tomato and the residual efficiency lasted for 5weeks after planting. Tomato varieties tested almost all were found susceptible to leafminer attack, however Angham, a variety of tomatoes showed relatively less attack than other varieties i.e., Thurayia and Elissa. Cyromazine and abamectin proved to be more effective against *L. trifollii* than other insecticides tested.

References

Abbott,W.S. (1925): A method of computing the effectiveness of an insecticide. J. Economic Entomol., 18: 265-267.

Abou-Attia, F.A.; Sharshir, F.A.; Tadros, M. S. and El-Shafei, G. M. A. (2004): Relative abundance and spatial distribution of *Liriomyza trifolii* (Burgess), *Thrips tabaci* (Lind) and *Tetranychus urticae* (Koch.) populations attacking cucumber and tomato grown under green houses. Agric. Tanta Univ., 30(2):342-357.

Abou-Attia, F.A.; Sharshir, F.A.; Tadros, M.S. and El-Shafei, G.M.A. (2004): Relative abundance and spatial distribution of *Liriomyza trifolii* (Burgess), *Thrips tabaci* (Lind.) and *Tetranychus urticae* Koch populations attacking cucumber and tomato grown under green houses at Kafr El-Sheikh. J. Agric. Res. Tanta Univ., 30 (2): 342-357.

Bueno, A. de F.; Zechmann, B.; Hoback, W. W.; de F. Bueno, R. C. O. and Fernandes, O. A. (2007): Serpentine leafminer (*Liriomyza trifolii*) on potato (*Solanum tuberosum*): field observations and plant photosynthetic responses to injury. Ciência Rural, Santa Maria, 37(6):1510-1517.

Chang, Y.W.; Wanga, Y.C.; Yan, Y.Q.; Wub, C.D.; Xie, H.F.; Gong, W.R. and Du,Y.Z. (2022): Insect hormones affect the toxicity of the insecticidal growth regulator cyromazine in *Liriomyza trifolii* (Diptera: Agromyzidae). Pesticide Biochemistry and Physiology 188,105263.

Civelek, H.S. and Weintraub, P.G. (2003): Effects of bensultap on larval serpentine leafminers, *Liriomyza tirfolii* (Burgess) (Diptera: Agromyzidae), in tomatoes. Crop Protection, 22: 479–483.

Devkota, S. and Seal, D. R. (2021): Seasonal abundance and spatial pattern of distribution of *Liriomyza trifolii* (Diptera: Agromyzidae) and its parasitoid on bean and squash in South Florida. Turkish Journal of Agriculture - Food Science and Technology, 9(12):2094-2105.

Duncan, B. D. (1955): Multiple range and multiple F test. Biometrics 11:1-42.

El-Dewy, M.E. H. (2006): Toxicological studies on some pests attacking cotton. Ph. D. Thesis, Fac. Agric. Kafr El-Sheikh University.

El-Naggar, J.B. (2006): Population density of certain early cotton season insects and associated predators as influenced by seed treatments. J. Agric. Sci. Mansoura Univ., 31(11):7434-7434.

Flemings, R. and Ratnataran, A. (1985): Evaluating single treatment data using Abbot's formula with modification. J. Econ. Entomol., 78: 1179.

Gao, Y.; Reitz, S.; Xing, Z.; Ferguson, S. and Lei, Z. (2017). A decade of leafminer invasion in China: Lessons learned. Pest Manag. Sci., 73: 1775–1779.

Hamid, A. M.; El-Basyouni, S. A.; Sharf, F. H. and Korkor, A.A (2003): Efficiency of Gaucho and Cruiser applied as cotton seed treatment on sucking pests and associated predators as long acting effect. J. Agric. Sci. Mansoura Univ., 28(4):3083-3091.

Hamza, M.A.; Ishtiaq, M.; Mehmood, M.A.; Majid, M.A.; Gohar, M.; Radicetti, E.; Mancinelli, R.; Iqbal, N. and Civolani, S. (2023): Management of vegetable leafminer , *Liriomyza* spp., (Diptera: Agromyzidae) in vegetable crops. Horticulturae, 9(2), 255. https://doi.org/10.3390/ horticulturae 9020255

Hernández, R.; Harris, M. and Liu T-X. (2011): Impact of insecticides on parasitoids of the leafminer, *Liriomyza trifolii*, in pepper in south Texas. Journal of Insect Science 11:61 available online: insectscience.org/11.61.

Ibrahim, E. G.; Abd El-Latif, M. E. and Barakat, A.S.T. (2008): Efficacy of certain insecticides on leafminer *Liriomyza trifolii* (Burgess) (Diptera:Agromyzidae) infesting green bean (*Phaseolus Vulgaris* L.) and its parasitoid *Digiyphus Isaea* (Hymenoptera: Eulophidae) at Alexandria, Egypt. Alexandria Science Exchange Journal, 29(2): April-June.

Lalruatsangi, K. and Chatterjee, M. L. (2022): Screening of tomato cultivars against leafminer, *Liriomyza trifolii* (Burgess) infesting tomato in mid-hills of Meghalaya, India. Insect Environment, 25 (3): 392-397.

Lee, D. H.; Park, J.J. and Cho, K. (2005): Estimation of Leafminer density of *Liriomyza trifolii* (Diptera:Agromyzidae) in cherry tomato greenhouses using fixed precision sequential sampling plans. J. Asia-Pacific Entomol., 8(1):81-86.

Lee, D. H.; Park, J.J.; Park, H. and Cho, K. (2004): Characterization of leaf mining damage of *Liriomyza trifolii* (Diptera:Agromyzidae) in Cherry-tomato greenhouse. J. Asia-Pacific Entomol., 7(2):201-205.

Morsy, A. R.; El-Shewy A.M. and Elgizawy, K.K.H. (2019): Comparative study on the effectiveness of chemical versus biological control against *Liriomyza trifolii* (Diptera: Agromyzidae) under field and greenhouse conditions. European J. Biolog. Sci., 11 (1): 01-07.

Reitz, S.R.; Gao, Y.L. and Lei, Z.R. (2013): Insecticide use and the ecology of invasive Liriomyza leafminer management. In: Trdan, S. (Ed.), Insecticides - Development of Safer and more Effective Technologies. In Tech, Rijeka, pp. 235–255.

Saradhi, P. P. and Fatniar, N. C. (2004): Seasonal population fluctuation of serpentine leafminer, *Liriomyza trifolii* (Burgess) in different host plants. J. Appl. Zool. Res., 15 (1):60-63.

Seal, D. R.; Betancourt, R. and Sabines, C. M. (2002): Control of *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) using various insecticides. Proc. Fla. Hortic. Soc., 115: 308–314.

Spencer, K.A. (1990): Host Specialization in the World Agromyzidae (Diptera). Kluwer Academic Publishers, London.

SPSS (2016): SPSS Statistical Software Package 16.0 (SPSS Inc., Chicago, IL, USA).

Thorat, S.S.; Saxena, S. P.; Patel, J.D.; Patil, V .M. and Patel, A.D. (2017): Incidence of leafminer (*Liriomyza trifolii* Burgess) on tomato crop in relation to the climatic conditions of South Gujarat. Trends in Biosciences, 10(8):1673-1676.

Tran, D. H.; An Tran, T. T.; Mai, L. P.; Ueno, T. and Takagi, M. (2007): Seasonal abundance of *Liriomyza sativae* (Diptera: Agromyzidae) and its parasitoids on vegetables in Southern Vietnam. J. Fac. Agr., Kyushu Univ., 52(1): 49–55.

Weintraub, P. G. (1999): Effects of cyromazine and abamectin on the leafminer, *Liriomyza huidobrensis* and its parasitoid, *Diglyphus isaea* in celery. Ann. appl. Biol., 135:547-554.

Weintraub, P. G. (2001): Effects of cyromazine and abamectin on the pea leafminer *Liriomyza huidobrensis* (Diptera: Agromyzidae) and its parasitoid *Diglyphus isaea* (Hymenoptera: Eulophidae) in potatoes. Crop Protection, 20: 207-213.

Yıldırım, E. M.; Ünay, A. and Civelek, H. S. (2010): The effect of *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) on some leaf characteristics of bean (*Phaseolus vulgaris* L.). J. Food, Agric. & Enviro., 8 (3&4): 839-841.