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Effect of foliar spray with Aluminium silicates on citrus leaf miner *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) and its parasitoids

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Abstract

In the present study field experiments were carried out in three different citrus orchards, lemon (Adalia), mandarin (Morkite) and summer orange trees in Giza Governorate, Egypt during seasons ,2021 and 2022 to evaluate the influence of foliar application with aluminum silicates in comparison with abamectin as bio-insecticide to reduce the infestation with citrus leaf miner (CLM) *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae). Aluminum silicates was applied at a concentration of 1 kg/20L and 0.5 kg /20L water and the bioinsecticides was used at a concentration of 3ml/20L water. An emulsifier (Tencotic) was added with a concentration of 40 ml/ 20Lwater. Each compound was sprayed individually twice in each season, the duration between them was 14 days. The results showed that, the low concentration of A. silicates (0.5kg/20L) gave a higher reduction percentage of the studied aspects of CLM with the three tested citrus species than the high one(1kg/20L). Morkite scored the highest reduction percents 82.71%, 92.77%, 70.98% and 70.98% of live mines, larvae pupae and eggs, respectively at the lowest concentration of A. silicates compared to abamectin which scored 88.63 %, 83.00%, 82.17% and 74.72%, respectively. there was a highly significant difference between the two sprays in the case of the percent reduction of mines, larvae and eggs. Spray (2) recorded a lower mean numbers and higher reduction percentages of different aspects than spray in all studied citrus species. After treatment with the two concentrations of A. silicates in the three used citrus species, the mean number of parasitoids was higher than that of abamectin. The results of the study proved that foliar spray with A. silicates reduced the mean number and increased the reduction percentages of live mines, larvae, pupae and eggs of CLM infested, adalia, morkite and summer orange trees without a negative effect on the number of the associated parasitoids, so it can be used in the management of this serious insect.

Introduction

Citrus fruit is considered the most important fruit in Egypt due to its cheap price, very high nutritional value, economic importance and its high quality in foreign markets. Citrus is attacked by many insect pests, from those is a citrus leaf miner (CLM), *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae). It is a microlepidopteran insect that infest newly tender leaves resulting in severe damage especially in the young trees (Salas and Goane, 2001). The eggs of this insect which laid individually on the lower surface of the leaves (Knapp *el al*., 1995) hatched into larvae (Have four instars) within 2-10 days and cause severe damage to the leaves during feeding resulting in formation of mines and wounds, which serve as a source for infection by a bacterium causing citrus canker (Ujiye, 2000 and Gottwald *et al*., 2001). The other symptoms of infestation of citrus trees by CLM are, curling of the leaf margins by prepupae which emerge later to adults repeating the life cycle, the presence of silver film in leaf mine (Beattie, 1989), a drop of the fruits before maturation and leaf drop, this finally leading to a reduction in annual yield (Peña *et al*., 2000 and Graham *et al*., 2004).

Effective control of CLM by extensive use of chemical insecticides is difficult and has resulted in many problems such as, appearing of insecticide resistant population of the insect, high costs, in addition to its larvae and pupae being protected from the insecticides contact by leaf cuticles and leaf margin, respectively (Raga *et al*., 2001). So, it is necessary to develop an alternative safe technique to control this dangerous pest, increasing plant resistance to insects is one of the safe methods.

Enhancing the rigidity and strength of the cell walls of the plants by deposition of the silicon in the plant tissue increases the resistance of the plants to many stresses (Hodson *et al*., 2005). Silicon occurs in plants as silicon dioxide (SiO2), which is known as silica. Strengthening plant cells by application of silicates results in regulation of insect population and inducing defences of the plant (Epstein, 1999). Silicon induces plant defenses to biotic and abiotic stresses (Correa *et al*., 2005).

The present investigation aimed to study the effect of foliar sprays with aluminum silicates in comparison with abamectin as bioinsecticide on the infestation with citrus leaf miner CLM and its parasitoids in three different orchards of citrus trees, lemon (Adalai), mandarin (Morkite) and summer orange.

Materials and methods

The experiment was performed in three citrus orchards five years old, lemon (Adalai), mandarin (Morkite) and summer orange at Giza Governorate, Egypt, through seasons ,2022 and 2023 to study the efficacy of foliar spray with aluminum silicates paralell to Abamectin as bioinsecticide against citrus leaf miner, *P. citrella*. Aluminum silicates was applied at a concentration of 1 kg/20L and 0.5 kg /20L water and the bioinsecticides was used at a concentration of 3ml/20L water.

An emulsifier (Tencotic) was added with a concentration of 40 ml/20Lwater.The solution of each compound was sprayed individually on each type of the citrus trees in the morning by means of back spray motor of 20 litre capacity and the trees were completely covered by the spray solution, between the two treatments a row without treatment was left as a barrier.

Each compound was sprayed twice in each season, the duration between them was 14 days. Six replicates (Six trees) from each citrus orchard for each compound were used parallel to six replicates without treatment as control. In the second spray of the two seasons, three replicates were sprayed with the previous concentration of aluminium silicates and the others were sprayed with the half (Low) concentration, 0.5kg/20Lwater.

Samples from new flushes were randomly taken from the tested citrus trees and the control one day before treatment. After 7 days from every spray, three samples (Three branches) were collected randomly from each tested replicate and the untreated

control, then they were placed in a plastic cage and a laboratory examination under binuclear was done, recording number of some surviving aspects of citrus leaf miner per branch as, mines, larvae, pupae, eggs and parasitoids. Number of parasitoids associated with larvae and pupae was counted and recorded. Reduction percentages of different survived aspects were calculated according to Henderson and Tilton (1955),

% Reduction = [1-(Ta×Cb/Tb×Ca)] 100],

Ta= Number of survived (Mines, larvae, pupae or eggs) in the treatment after spraying.

Cb= Number of survived (Mines, larva, pupae or eggs in the untreated control before spraying.

Tb= Number of survived (Mines, larva, pupae or eggs) in the treatment before spraying.

Ca= Number of survived (Mines, larva, pupae or eggs) in the untreated control after spraying.

Obtained results were statistically analyzed as factorial, using Proc GLM in SAS (Anonymous, 2003). Differences between means were compared by Duncan multiple range test (*P*= 0.05 level) in the same program.

Results and discussion

Data of Tables (1-7) are the obtained results of foliar sprays of the three citrus species , adalia , morkite and summer orange with Aluminium silicates and abamectin during two successive seasons .The results illustrated in Table (1) clear that , mean number of live mines of citrus leaf miner in the three tested citrus species is very highly decreased after foliar spray application with the two used different concentrations of A. silicates and the bioinsecticide, abamectin comparing to the control and pre-treatment trees.

On the other hand, morkite scored the highest reduction percent of live mines 82.71% at low concentration of A. silicates (0.5kg/20L), and there was no significant difference compared to abamectin 88.63 % followed by summer orange 69.90% percent reduction with the same concentration of A. silicates compared to 88.15 % with abamectin while adalia scored 68.89% reduction percent with the same concentration comparing to 80.25% with abamectin.

The results of the table are clear that, a low concentration of A. silicates recorded a higher percent reduction in live mines than high one, in the case of adalia and summer orange there was highly significant difference in the percent reduction of live mines between the high and low concentration of A. silicates and abamectin.

Table (1): Mean number and reduction percentage of live mines of (CLM) in three citrus species after foliar application with Aluminium silicates during season, 2021 and 2022.

Tested compounds	Lemon (Adalia)		Mandarin (Morkite)		Summer orange	
	Mean number	% Reduction	Mean number	% Reduction	Mean number	% Reduction
Control	23.2	--	23.2	--	26.25	--
Before –spray	18.8	--	18	--	23.80	--
Abamectin	3.7	80.25 a	2	88.63 a	2.75	88.15 a
A. silicates(1kg/20L)	7.8	58.40 c	5.7	68.26 b	10.25	55.73 c
A. silicates(0.5kg/20L)	6.2	68.89 b	6.3	82.71 a	7.3	69.90 b
F	--	13.75	--	15.85	--	26.13
P	--	< .0001	--	< .0001	--	< .0001

Data with different letters within the column are significant different (p < 0. 05).

Data obtained in Table (2) clear high depression in the mean number of larvae of CLM in adalia , morkite and summer orange trees after foliar application with the two used concentrations of A. silicates and abamectin compared with control and before treatment trees. There was a significant difference in the reduction percentage of larvae of CLM between the two tested concentrations. The low concentration of A. silicates (0.5kg/20L) gave higher reduction percentage with the three tested citrus species than the high one(1kg/20L). Morkite scored the highest reduction percentage 92.77% followed by summer orange 85.50% and adalia 83.17 % at the low concentration compared to abamectin 83.00, 89.14 and 81.70 % percent reduction with morkite, summer orang and adalia trees, respectively.

Table (2): Mean number and reduction percentage of larvae of (CLM) in three citrus species after foliar application with Aluminium silicates during season, 2021 and 2022.

Tested compounds	Lemon (Adalia)		Mandarin (Morkite)		Summer orange	
	Mean number	% Reduction	Mean number	% Reduction	Mean number	% Reduction
Control	12.7	--	10	--	13.75	--
Before –spray	12.2	--	8	--	11	--
Abamectin	2.25	81.70 ab	1.2	83.00 ab	1.75	89.14 a
Aluminium silicates(1kg/20L)	3.5	69.73 b	2.6	67.90 b	4.50	70.90 b
Aluminium silicates(0.5kg/20L)	2	83.17 a	1.8	92.77 a	2.42	85.50 ab
F	--	3.4	--	4.88	--	3.76
P	--	0.049	--	0.016	--	0.037

Data with different letters within the column are significant different (p < 0. 05).

Results of Table (3) showed a high decrement in the mean number of pupae of *P. citrella* in the tested citrus species, adalia, morkite and summer orange trees after treatment with the tested concentrations of A. silicates and the standard bio-insecticides compared with untreated control and before spray trees. At a concentration (0.5kg/20L) of A. silicates, morkite recorded the highest reduction percentage 70.98% followed by adalia recorded 62.2% at the same concentration compared to abamectin 82.17% and 82.20% with two citrus species respectively. There was no significant difference found in the reduction percentage of pupae between the two concentrations of A. silicates in the case of adalia and summer orange trees, while there was a significant difference between them and the standard, abamectin.

Table (3): Mean number and reduction percentage of pupae of (CLM) in three citrus species after foliar application with Aluminium silicates during season, 2021 and 2022.

Tested compounds	Lemon (Adalia)		Mandarin (Morkite)		Summer orange	
	Mean number	% Reduction	Mean number	% Reduction	Mean number	% Reduction
Control	9.25	--	9	--	10.25	--
Before –spray	8.30	--	8.3	--	9	--
Abamectin	1.30	82.20 a	0.7	82.17 a	0.83	90.48 a
Aluminium silicates(1kg/20L)	3.40	56.94 b	2.5	56.94 b	4.8	46.82 b
Aluminium silicates(0.5kg/20L)	3.30	62.20 b	4.2	70.98 ab	4.5	49.29 b
F	--	7.80	--	8.83	--	32.29
P	--	0.0023	--	0.0013	--	< .0001

Data with different letters within the column are significant different (p < 0. 05)

The mean number of eggs of *P. citrella* infests tested species of citrus trees, adalia , morkite and summer orange as a result of foliar spray with A. silicates and abamectin are shown in Table (4). It was obvious that there was a high decrement in the mean number of eggs after treatment with A. silicates and the bio-insecticides compared with before spray and untreated control trees. Regarding to reduction percentages of the eggs, the data in the table clear that, there was a significant difference between the two treatments of A. silicates and abamectin. Morkite recorded the highest percent reduction of eggs 78.32% at the low concentration of A. silicates compared with 69.37 % with high one and 74.72 % percent reduction with the bio-insecticides followed by adalia recorded 77.53 % and 69. 37% reduction percentage with low and high concentrations, respectively and 74.72 % with abamectin. Summer orange scored73.1% ,64.88% and 68.6 % reduction percentages with low and high concentrations of A. silicates and the bio-insecticides, respectively.

Table (4): Mean number and reduction percentage of eggs of CLM in three citrus species after foliar application with Aluminium silicates during season,2021 and 2022.

Tested compounds	Lemon (Adalia)		Mandarin (Morkite)		Summer orange	
	Mean number	% reduction	Mean number	% reduction	Mean number	% reduction
Control	40	--	28.5	--	43	--
Before –spray	42.2	--	28.8	--	44.3	--
Abamectin	10.6	74.72 ab	11	74.72 ab	13.9	68.60 ab
Aluminium silicates(1kg/20L)	12.9	69.37 b	9.2	69.37 b	15.58	64.88 b
Aluminium silicates(0.5kg/20L)	9.5	77.53 a	10	78.32 a	12	73.1 a
F	--	4.03	--	4.43	--	3.96
P	--	0.03	--	0.02	--	0.032

Data with different letters within the column are significant different (p < 0. 05).

Comparing the efficacy of the two foliar sprays (1 and 2) during the two seasons on the studied aspects of citrus leaf miner, the results in Table (5) clear that, there was a highly significant difference between the two sprays in the case of the percent reduction of mines, larvae and eggs and spray (2) recorded lower mean number and higher reduction percentages than spray (1) in all tested citrus species, while in case of pupae, there was no significant difference found between them. Data from the table also show that morkite scored the highest percent reduction of tested aspects of citrus leaf miner, 84.42, 89.43 ,74.75, 82.35 and 89.43 % for mines, larvae, pupae and eggs, respectively.

Table (5): Effect of two foliar sprays (1 and 2) with Aluminium silicates and Abamectin to three different species of citrus trees on mean number and reduction percentage of different aspects of CLM.

Some (CLM) aspects	The spray	Lemon (Adalia)		Mandarin (Morkite)		Summer orange	
		Mean	% reduction	Mean	% reduction	Mean	% reduction
Mines	Spray1	10.9	58.05 b	9.2	71.60 b	12.2	61.91 b
	Spray 2	7.2	76.69 a	6.4	84.42 a	8.1	77.95 a
	F	--	29.29	--	13.77	--	19.95
	P	--	< .0001	--	.001	--	0.0001
Larvae	Spray1	6	64.01 b	4.3	63,15 b	7.1	66.05 b
	Spray 2	3.4	86.01 a	2.6	89.43 a	3.4	91.16 a
	F	--	19.82	--	12.64	--	16.46
	P	--	0.0002	--	0.0015	--	0.0004
Pupae	Spray1	4.2	62.47 a	3.8	62.47 a	4.6	63.17 a
	Spray 2	3.2	71.83 a	2.7	74.75 a	3.8	65.85 a
	F	--	4.6	--	5.38	--	3.52
	P	--	0.042	--	0.29	--	0.07
Eggs	Spray1	22.4	59.73 b	18.2	59.73 b	26.16	52.53 b
	Spray 2	12.9	82.09 a	10.1	82.35 a	15.4	78.35 a
	F	--	92.94	--	89.43	--	137.06
	P	--	< .0001	--	< .0001	--	< .0001

Data with different letters within the column are significant different (p < 0. 05).

Regarding the effect of the first and the second season on the different aspects, mines, larvae, pupae and eggs of CLM in the tested citrus species, results in Table (6) show that, the first season recorded higher reduction percentages and higher mean number of these aspects than the second one. There was a significant difference in the reduction percentage of live mines in the case of adalia and summer orange and no significant difference was found in morkite trees.

On the other hand, while no significant differences were found for the reduction percentages of larvae and pupae of *P. citrella* between the two seasons in adalia and morkite trees, a high significant difference between them was found in summer orange trees. The obtained data proved that, foliar application of A. silicates reduced the mean number and reduction percentages of the studied aspects of CLM infested, adalia, morkite and summer orange trees, this may be due to A. silicates improved leaf characters such as thickness, strength and the contents of studied citrus trees and this may enhance the leaves to resist the infestation with that pest.

Table (6): Effect of the two seasons, 2021and 2022 of foliar sprays with Aluminium silicates in three different species of citrus trees on mean number and reduction percentage of different aspects of CLM.

Some (CLM) aspects	The season	Lemon (Adalia)		Mandarin (Morkite)		Summer orange	
		Mean	% reduction	Mean	% reduction	Mean	% reduction
Mines	Season2021	10.6	76.9 a	9.45	83.2 a	12.3	79.2 a
	Season 2022	8.6	69.6 b	7.42	80.1 a	9.8	71.9 b
	F	--	6.87	--	1.6	--	6.57
	P	--	0.0123	--	0.21	--	0.014
Larvae	Season 2021	5.8	81.7 a	4.1	82.2 a	5.7	89 a
	Season 2022	4.4	78 a	3.4	79.4 a	5.2	76 b
	F	--	1.11	--	0.37	--	9.7
	P	--	0.297	--	0.55	--	0.003
Pupa	Season 2021	4.4	74.6 a	4.1	76.9 a	4.8	78.5 a
	Season 2022	3.6	68.9 a	3	70.4 a	4.3	61.7 b
	F	--	1.52	--	2.1	--	16.5
	P	--	0.225	--	0.15	--	0.0002
Eggs	Season 2021	19.5	74.78 a	15.9	73.1 a	23.3	68.35 a
	Season 2022	18.5	73.5 a	13.6	73.1 a	20.57	68.9 a
	F	--	0.43	--	0.01	--	0.08
	P	--	0.5	--	0.94	--	0.78

Data with different letters within the column are significant different (p < 0. 05).

These results agree with Epstein (1999) who reported that, application of silicates provides regulation of insect populations by strengthening plant cells and inducing other plant defences. Silica supplies a protective effect for plants against insect herbivores and appositive correlation was found between level of its accumulation in plant tissue and increased resistance of plants (Juma *et al*., 2015 and Meyer and Keeping, 2005). From the most significant effect of silicon on plants, is improving fitness to adverse environmental conditions (Chanchal *et al.*, 2016). Also, Dito (2016) reported that, when citrus seedlings were fertilized with soluble silicon, citrus leaf miner decreased compared with untreated plants. The present results also agree with Abo El-Enien et *al*. (2017) who found a negative correlation between infestation percentage of citrus leaf miner and leaf silicon content.

Data of Table (7) compared the mean number and percent reduction of different aspects of citrus leaf miner in the three used citrus orchards. The data cleared that, in the case of mines, morkite recorded the highest reduction percentages79.39 % and there were no found significant differences between adalia and summer orange while in the case of

reduction percentages of larvae and pupae there were no significant differences found between the three citrus species. In the case of eggs there were no found significant differences between adalia and morkite while there were a significant between them and summer orange scored the highest reduction percent of eggs 68.63%.

Table (7): infestation rate (Mean number) and percent reduction of some aspects of *Phyllocnistis citrella* in citrus orchards after different treatments.

Citrus species	Mines		Larvae		Pupae		Eggs	
	Mean number	% reduction	Mean number	% reduction	Mean number	% reduction	Mean number	% reduction
Lemon (Adalia)	9.6	69.24 b	5.1	78.29 a	4.0	68.08 a	19.0	73.14 a
Mandarin (Morkite)	8.4	79.39 a	3.7	77.20 a	3.6	69.84 a	14.75	73.3 a
Summer orange	11	71.53 b	5.45	81.12 a	4.6	64.78 a	21.9	68.63 b
F	---	8.6	---	0.48	---	0.92	---	8.23
P	---	0.0004	---	0.62	---	0.40	---	0.0006

Data with different letters within the column are significant different (p < 0. 05).

The obtained previous results cleared that, the three used citrus species differ in their susceptibility to infestation with citrus leaf miner, this may be due to differences in the nature of the flushes and leaves of each citrus tree. These results are supported by Knapp *et al.* (1995) who reported that, the flushing patterns of the citrus trees effect on susceptibility among different citrus species. The obtained data in Table (8) showed the effect of A. silicates on the parasitoids densities of *P. citrella* pupae. The results proved that, after treatment with the tested concentrations of A. silicates in the three used citrus species, the mean number of parasites was higher than that of abamectin. In the case of adalia and summer orange there was no significance difference between the two concentrations in the mean number of parasites while there was a high significance between them and abamectin in the three citrus species. The results of the table also cleared that, there was no found significant difference in the effect of the two seasons or the two sprays on the mean number of the parasitoids. The results also proved that, all the parasites found associated with fourth instars larvae, this runs in full agreement with Vercher *et al*. (2005) who showed that, all species of parasites of citrus leaf miner developed from third and fourth instars larvae.

Table (8): Effect of foliar application of lemon (Adalia) and mandarin (Morkite) summer orange with aluminium silicates and Abamectin on mean number of parasites associated with pupae of *Phyllocnistis citrella.*

The treatment		Mean number	
	Lemon (Adalia)	Mandarin (Morkite)	Summer orange
Control	10 a	10.25 a	9.5 a
Pretreatment	10 a	9.83 a	10.33 a
Aluminium silicates (1kg/20L)	7.58 b	5.67 c	10.92 a
Aluminium silicates (0.51kg/20L)	6.5 b	7.7 b	9.17 a
Abamectin	1 c	0.92 d	0.92 b
F	29.37	39.37	46.98
P	< .0001	< .0001	< .0001
The season			
Season 2021	6.62 a	6.62 a	7.42 a
Season 2022	6.79 a	6 .12 a	8.12 a
F	0.07	0.75	1.47
P	0.79	0.39	0.23
The spray			
Spray1	6.44 a	5.55a	7.67 a
Spray2	6.08 a	6.12 a	7.21 a

Data with different letters within the column are significant different (p < 0. 05).

References

Abo El-Enien, M.M.S.; Abo El-Kassim, A. B.; El-Azaze1, A.M. and El- Sayed, F.S. (2017): Effect of silicon, potassium and calcium compounds on growth and increase the efficiency of citrus seedlings to resist citrus leaf miner *(Phyllocnistis citrella*). J. Product. & Dev., 22(3): 729 – 749.

Anonymous (2003): SAS Statistics and graphics guide, release 9.1.SAS

Beattie, G.A.C. (1989): Citrus leaf miner, biological and chemical Research institute, Rydalmere, NSW Agric. And Fish. Ag. Fact. No. H2 AE4, Sydney.

Chanchal, M. C.H.; Kapoor, R. and Ganjewala, D. (2016): Alleviation of abiotic and biotic stresses in plants by silicon supplementation. Sci. Agri., 13 (2): 59-73.

Correa, R.S.; Moraes., J.C. ;Auad, A.M. and Carvalho, G.R. (2005): Silicon and acibenzolar-Smethyl as resistance inducers in cucumber, against the whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidiae) biotype B. Neotropical Entomology, 34(3): 429- 433.

Dito, D. F. (2016): The potential management of citrus leaf miner, *Phyllocnistis citrella* (Stainton) (Lepidoptera: Gracillariidae), by use of soluble silicon fertilizers. Ph.D. Thesis, University of California.USA.

Epstein, E. (1999): Silicon. Annual Review of Plant Physiology and Plant Molecular Biology, 50(1): 641-664.

Gottwald, T.R.; Hughes, G.; Grahm, J.H.; Sun, X. and Riley, T. (2001): The citrus canker epidemic in Florida: the scientific basis of regulatory eradication policy for an invasive species. J. Phytopathol., 91: 30-34.

Graham, J. H; Gottwald, T.R; Cubero, J. and Achor, D.S. (2004): *Xanthosmonas axonopodis* pv. citri: factors affecting successful eradication of citrus canker. Mol. Plant Pathol., 5:1–15.

Henderson, C. F. and Tilton, E. W. (1955): Tests with acaricides against the brown wheat mite. Journal of Economic Entomology, 48(2): 157-161.

Hodson, M.J.; White, P.J.; Mead, A. and Broadley, M.R. (2005): Phylogenetic variation in the silicon composition of plants. Ann. Bot., 96: 1027-1046.

Institute,Cary, North Carolina 27513, USA.

Juma, G.; Ahuya, P. O.; Ong'amo, G.; Le Ru, B.; Magoma, G.; Silvain J.-F., *et al.* (2015): Influence of plant silicon in *Busseola fusca* (Lepidoptera: Noctuidae) larvae–*Poaceae* interactions. Bull. Entomol. Res., 105: 253–258.

Knapp, J.L.; Albrigo, L.G.; Browning, H. W.; Bullock, R.C.; Heppner, J.B.; Hall, D.G.; Hoy, M.A.; Nguyen, R. ; Peña, J. E. and Stansly, P.A. (1995): Citrus leaf miner, *Phyllocnistis citrella* Stainton: Current Status in Florida. Coop. Ext. Serv., Univ. Florida, Gainesville: 26.

Meyer, J.H. and Keeping, M.G. (2005): Impact of silicon in alleviating biotic stress in sugar cane in South Africa. Sugarcane Int., 23: 14-18.

Peña, J. E.; Hunsberger, A. and Schaffer,B. (2000): Citrus leaf miner (Lepidoptera: Gracillariidae) density: effect on yield of 'Tahiti'lime. Journal of Economic Entomology, 93(2): 374-379.

Raga, A.; Satol, M. E.; Souza, M. F. and Siloto, R. C. (2001): Comparison of spray insecticides against citrus leaf

miner. Arquivos Do Instituto Biologico (Sao Paulo), 68(2): 77-82.

Salas, H. and Goane, L. (2001): Monitoring of the principal pests of lemon in Tucuman. Avance Agroindustrial, 22(3):27-30.

Ujiye, T. (2000): Biology and control of the citrus leafminer, *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) in Japan. Japan Agric. Res. Quart., 34(3): 167-173.

Vercher, R.; Costa-Comelles, J.; Marza, C. and Garci´A-Mari, F. (2005): Recruitment of native parasitoid species by the invading leaf miner *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) on citrus in Spain. Environ. Entomol., 34(5): 1129-1138.