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COMPARISON OF SPRAY INSECTICIDES AGAINST CITRUS LEAFMINER

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ABSTRACT

A field experiment was conducted on 'Tangor Murcott' spring flushes during 1999 to control citrus leafminer (CLM) *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) in Cordeirópolis County, State of São Paulo, Brazil. Insecticides and respectively concentrations (g AI / 100 liters of water) used were thiamethoxam 250 WG (3.0; 4.0 and 5.0), thiamethoxam (4.0) + petroleum oil (PO) 80EC (200.0), abamectin 18EC (0.54) + PO (200.0), lufenuron 50EC (3.75) + PO (200.0), pyridaphention 400EC (30.0), pyridaphention (30.0) + PO (200.0) and PO (200.0 and 800.0). Two foliar sprays were made at interval of ten days. Three days after the 1st application, abamectin + PO and lufenuron + PO, both considered as standards, provide significantly greater CLM larval mortality, with 86.8% and 93.3% of larval density reduction, respectively. During the same date, only lufenuron + PO showed good control of larvae + pupae (86.2%). For all insecticide treatments, with the exception of thiamethoxam at 3.0g and 4.0g, the number of larvae per flush was lower than for untreated control at 7 days after the 1st application, ranging from 57.4% (PO - 200.0g) to 98.9% of reduction (abamectin + PO). In this evaluation, abamectin + PO caused the highest reduction (87.2%), thiamethoxam (5.0) provided good control (74.0%) while pyridaphention treatments were not significantly different from the check, based on the number of CLM larvae + pupae. Five days after the 2nd application, only abamectin + PO provided significant reduction in larval (93.9%) and larval + pupal (95.0%) densities. In the same date, lufenuron + PO showed significantly lower larval + pupal density per flush (75.4% of reduction). Although thiamethoxam + PO has been inferior to standard insecticides 5 days after the 2nd application, it caused a 63% of CLM larval reduction. Eleven days after the 2nd application no significant differences in larval or larval + pupal infestation were detected among treatments. The results suggest that studies with thiamethoxam to control *P. citrella* should be developed at 2.0 g AI / 100 liter of water or higher doses with the addition of PO.

KEY WORDS: Insecta, pest, citrus, *Phyllocnistis citrella*, chemical control.

RESUMO

O experimento de campo foi conduzido em brotações de primavera de 'Tangor Murcott' para controlar o minador das folhas citros (MFC) *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) no município de Cordeirópolis, Estado de São Paulo. Os inseticidas e respectivas concentrações (g IA / 100 litros de água) utilizados foram: thiamethoxam 250 WG (3,0; 4,0 e 5,0), thiamethoxam (4,0) + óleo mineral (OM) 80 CE (200,0), abamectin 18 CE (0,54) + OM (200,0), lufenuron 50 CE (3,75) + OM (200,0), pyridaphention 400 CE (30,0), pyridaphention (30,0) + OM (200,0) e, OM sozinho (200,0 e 800,0). Duas aplicações foliares foram realizadas no intervalo de 10 dias. Aos 3 dias após a 1ª. aplicação, abamectin + OM e lufenuron + OM, ambos considerados padrões, apresentaram as maiores mortalidades larvais do MFC, com 86,8% e 93,3% de redução, respectivamente. Na mesma data, apenas lufenuron + OM mostraram bons resultados no controle de larvas + pupas (86,2%). Para todos os tratamentos inseticidas testados, com exceção de thiamethoxam a 3,0g e 4,0g, o número de larvas por brotação foi mais baixo que a testemunha aos 7 dias após a 1ª. aplicação, variando de 57,4% (OM - 200,0g) até 98,9% de redução (abamectin + OM). Nesta avaliação, abamectin + OM apresentou a maior redução populacional de *P. citrella* (87,2%), thiamethoxam (5,0g) alcançou razoável controle (74,0%), enquanto os tratamentos com pyridaphention foram semelhantes à testemunha com base no número de larvas + pupas. Aos 5 dias após a 2ª. aplicação, somente no tratamento abamectin + OM foi registrada uma redução significativa na população larval (93,9%) e larval + pupal (95,0%). Na mesma data, lufenuron + OM mostrou significativamente menor densidade larval + pupal por brotação (75,4%). Embora thiamethoxam + OM tenha sido inferior aos inseticidas padrões aos 5 dias após a 2ª. aplicação, o número de larvas do MFC foi reduzido em 63,0%. Aos 11 dias após 2ª. aplicação não houve diferenças entre os tratamentos quanto ao número de larvas e de larvas + pupas.

PALAVRAS-CHAVE: Insecta, praga, citros, *Phyllocnistis citrella*, controle químico.

INTRODUCTION

The citrus leafminer (CLM), *Phyllocnistis citrella* Stainton (Lep.: Gracillariidae: Phyllocnistinae) is a serious pest of citrus and related species of Rutaceae (HEPPNER, 1993). CLM is considered to be an Asian species (HOY & NGUYEN, 1997), originally described from Calcutta, India in 1856 (KNAPP et al., 1995).

Until 1993 *P. citrella* was known from East Africa, West Africa, China, Philippines, Japan, Australia and Taiwan (KNAPP et al., 1995). *Phyllocnistis citrella* was found in Florida, North America in 1992. Within three years, CLM invaded countries in the Mediterranean, the Caribbean, Central America and South America (HOY & NGUYEN, 1997). In Brazil the pest was registered for the first time in a citrus-nursery, region of Limeira, State of São Paulo, by March, 1996 (FEICHTENBERGER & RAGA, 1996).

Leafminer populations build on flush growth. Larval feeding affects photosynthesis and a leaf area between 1 and 7 cm^2 can be consumed per larva. The edge of the leaves curl upward, followed by chlorosis and later by necrotic spots. Mining also may occurs in stems or fruits. Nursery trees and newly planted trees have reduced growth as a result of heavy leafminer infestation (KNAPP et al., 1995). CLM larvae just eats a little layer of the spongy parenchyma tissue. At the injured area the cells undergo an active division forming a wound periderm (VOLPE et al., 1998).

Sometimes much more important for the crop is the indirect damage of the pest. In this particular case, CLM can help spread citrus canker *Xanthomonas axenopodis* pv. *citri* (SINHA et al., 1972; HEPPNER, 1993; GOTTWALD et al., 1997; RODRIGUES et al., 1998; SCHUBERT, 1999; CHAGAS, 1999). When the *P. citrella* life cycle is completed the mine may shelter the leprosis mite *Brevipalpus phoenicis* (Geijslkes) that is a key pest in all Brazilian citrus-growing regions (SATO & RAGA, 1998; RODRIGUES *et al*., 1998).

The goal of cultural, chemical and other control tactics is to protect the main growth flushes. Effective chemical control of CLM is difficult because the larva is protected by leaf cuticle and the pupa is protected by rolled leaf margins. For several authors, the foliar application provides control for only two weeks (MACEDO et al., 1996; RAGA et al., 1998a; RAGA et al., 1998b). Insecticide efficacy is diluted as the young flush expands (KNAPP et al., 1995). CLM has also a long history of resistance to many insecticides (TAN & HUANG, 1996). The purpose of this study was to evaluate the efficacy of selected conventional and experimental insecticides to CLM in field conditions.

MATERIALS AND METHODS

A randomized complete-block design experiment was established in a 'Tangor Murcott' orchard in Cordeiropolis County, State of São Paulo (22º29'S 47º28'W; 632m). The commercial orchard was of three years old (1.6-1.8m tall plants) and 2.16 ha in area, with a 3.0 m x 6.0 m tree spacing. The plot consisted of eight adjacent trees and samples were taken from the central six plants. Each treatment was replicated four times.

Insecticides (commercial products) and respectively concentrations (g AI / 100 liters of water) used were thiamethoxam (Thiamethoxam) 250 WG (3.0; 4.0 and 5.0), thiamethoxam (4.0) + petroleum oil – PO (Joint Oil) 80 EC (200.0), abamectin (Vertimec) 18 EC (0.54) + PO (200.0), lufenuron (Match) 50 EC (3.75) + PO (200.0), pyridaphention (Ofunack) 400 EC (30.0), pyridaphention (30.0) + PO (200.0) and PO (200.0 and 800.0).

No treatment for disease, mite or other pests was made during the experiment. The insecticides were applied using CO_2 sprayer at pressure of 60 lb / pol^2, delivering about 0.40 liter / tree on both sides of the leaves. The products were applied on 6 and 16 December. During the period of the experiment the average temperature was between 20.5º and 26.2ºC and the total rainfall registered was 166.1mm.

Ten immature growth flushes were examined from each plot on 6 (Pre-treatment), 9, 13, 21 and 27 December. Variables measured per flush were the average number of surviving larvae per flush and the average number of surviving larvae + pupae per flush. Data, transformed using square root (x + 1), were analyzed using ANOVA procedure, and treatments means comparisons were conducted using Tukey's Multi Comparison test. The original means were shown on the tables. Reduction levels were calculated using the formula of HENDERSON & TILTON (1955).

At 27 December, it was collected 100 infested leaves (with one larva or pupa) outside the experimental area to evaluate the natural parasitization level. For achieving the emergence of parasitoids, CLM-infested leaves were placed in a plastic bag, transported to the lab an kept for two weeks. Emerging parasitoids were identified by Dr. Valmir A. Costa (Biological Institute, Campinas, SP, Brazil).

RESULTS AND DISCUSSION

Before the application, the average number of larvae per flush varied between 2.08 and 2.65 while the average number of larvae + pupae ranged from 2.28 to 3.05 (Table 1). For both parameters, no significantly difference was observed among the treatments.

Table 1 - Mean number of surviving larvae (L) and surviving larvae + pupae (L + P) of *Phyllocnistis citrella* per flush of 'Tangor Murcott'. Cordeirópolis, SP, 1999.

Treatment	Rate g AI / 100 L water	Mean[1] ± SEM					
		Pretreatment		3 d after 1th application		7 d after 1th application	
		L	L + P	L	L + P	L	L + P
Thiamethoxam	3.0	2.23 ± 0.17a[2]	2.28 ± 0.16a	1.25 ± 0.47ab	1.25 ± 0.47ab	0.98 ± 0.17ab	1.15 ± 0.20ab
Thiamethoxam	4.0	2.25 ± 0.22a	2.60 ± 0.37a	0.90 ± 0.29ab	0.98 ± 0.28ab	1.03 ± 0.25ab	1.13 ± 0.22ab
Thiamethoxam	5.0	2.25 ± 0.12a	2.43 ± 0.17a	0.58 ± 0.38ab	0.58 ± 0.38ab	0.60 ± 0.07 bc	0.83 ± 0.07 b
Thiameth. + PO	4.0+200.0	2.35 ± 0.27a	2.58 ± 0.20a	0.35 ± 0.13ab	0.60 ± 0.14ab	0.78 ± 0.20 bc	0.88 ± 0.24 b
Abamectin +PO	0.54+200.0	2.65 ± 0.10a	3.05 ± 0.16a	0.30 ± 0.07 b	0.45 ± 0.09ab	0.03 ± 0.03 c	0.33 ± 0.24 b
Lufenuron +PO	3.75+200.0	2.60 ± 0.19a	2.95 ± 0.33a	0.15 ± 0.09 b	0.30 ± 0.15 b	0.48 ± 0.35 bc	0.50 ± 0.38 b
Pyridaphention	30.0	2.35 ± 0.21a	2.75 ± 0.23a	1.23 ± 0.24ab	1.38 ± 0.20ab	0.93 ± 0.18 bc	1.13 ± 0.11ab
Pyridaph. + PO	30.0+200.0	2.23 ± 0.23a	2.30 ± 0.19a	1.23 ± 0.19ab	1.43 ± 0.18ab	0.85 ± 0.19 bc	1.03 ± 0.18ab
Petroleum Oil (PO)	200.0	2.13 ± 0.22a	2.60 ± 0.14a	0.70 ± 0.15ab	0.85 ± 0.24ab	0.93 ± 0.24 bc	1.00 ± 0.24ab
Petroleum Oil	800.0	2.20 ± 0.11a	2,40 ± 0.18a	1.05 ± 0.47ab	1.20 ± 0.49ab	0.65 ± 0.06 bc	0.73 ± 0.11 b
Control	-	2.08 ± 0.17a	2.58 ± 0.23a	1.78 ± 0.42a	1.90 ± 0.39a	2.13 ± 0.29a	2.18 ± 0.30a
C.V. (%)		5.9	6.3	15.4	15.3	11.3	11.5

[1]Analysis was made on x + 1 square root transformation of the data: untransformed data is presented.
[2]Means followed by the same letter in each column do not differ using Tukey's test (P=0.05).

The Figures 1 and 2 present the percentage of reductions of larval density and larval + pupal density, respectively, for the different insecticides tested in this study. At 3 days after the 1st application, abamectin + PO and lufenuron + PO, both considered as standards, provided significantly greater CLM larval mortality, with 86.8% and 93.3% of reduction, respectively (Table 1). In this evaluation, only lufenuron + PO gave good control of larvae + pupae (86.2%).

When compared with the unsprayed control, all treatments, with the exception of thiamethoxam at 3.0g and 4.0g (Table 1), differed significantly on the number of larvae per flush at 7 days after the 1st application, ranging from 57.4% (PO - 200.0g) to 98.9% of reduction (abamectin + PO). In this evaluation, abamectin + PO caused the highest reduction (87.2%), thiamethoxam (5.0) provided good control (74.0%) while pyridaphention treatments were not significantly different from the check, based on the number of CLM larvae + pupae. Different oil concentrations did not show differences in reduction of the number of larvae and larvae + pupae per flush. For the same interval between the treatment and the evaluation, Raga et al. (1998a) reported 42.7% reduction of larval population in plots treated with PO at 0.25%.

No significant difference in any variable was observed among PO concentrations and the pyridaphention treatments at 7 days after application. But the addition of PO to thiamethoxam showed satisfactory control of larval population. Beattie et al. (1995) suggest that recommendations for control of leafminer should be based on the use of sprays containing 0.25% to 0.50% of oil in water. Petroleum oils act as an ovipositional deterrent to *P. citrella* when an adequate film exists on the immature leaves (Rae et al., 1996; Liu et al., 1999). Oil sprays must be applied as soon as the largest leaves of a flush are >1cm in length, and then at every 6-7 days until the flushes harden (Rae et al., 1996).

At 5 days after the 2nd application, only abamectin + PO provided significant reduction in larva (93.9%) and larva + pupa (95.0%) populations. In the same evaluation, lufenuron + PO showed significantly lower larval + pupal density per flush (75.4% of reduction). Although thiamethoxam + PO have been inferior to standard insecticides at 5 days after 2nd application, the number of CLM larvae was reduced in 63.0%.

At 11 days after the 2nd application, no significant difference in larval or larval + pupal infestation was detected among the treatments. The current results suggest that studies with thiamethoxam to control *P. citrella* should be developed at 4.0 g AI / 100 liters of water or higher concentrations with the addition of PO.

None of the treatments caused visible phytotoxicity in the 'Tangor Murcott' trees. In general the results indicate that ten days is the maximum period of efficacy for all tested insecticides. CLM larval stage can occupy only 4-5 days and the period from egg to adult as short as 14 days (Browning et al., 1999). Paiva et al. (1998) estimated in 7 and 16 days the CLM larval phase during summer and winter, respectively, in brazilian sweet orange. Peña & Duncan (1993) and Raga et al. (1998a) observed that all insecticide treatments had similar larval infestation as the untreated control two weeks after spray.

According to several authors, the application of abamectin + PO provides the most effective control of leafminer (Peña & Duncan, 1993; Rae et al.,1996; Raga et al., 1998a). In Florida, a maximum of three application of abamectin per year is recommended for CLM control. In Brazil, abamectin + PO have been used once a week to protect the leaves against leafminer infestation in some citrus nurseries. Thus we need alternative insecticides in order to prevent the development of pesticide resistance in *P. citrella*.

During the evaluations, all treatments showed very low parasitism level. On the same orchard, three eulophids *Galeopsomyia fausta* La Salle (39), *Cirrospilus* sp. (2), *Horismenus* sp. (1); and one eurytomid, *Eurytoma* sp. (1), emerged from 100 infested leaves collected outside of the experimental area at 11 days after the 2nd application. Consequently the parasitism level achieved 43%. *Galeopsomyia fausta* is a widely distributed species in the Neotropical region, probably from Mexico to Argentina (LaSalle & Peña, 1997), being the most abundant species in Nicaragua (Cano et al., 1996), Brazil (Costa et al., 1999) and Colombia (León & Campos, 1999). Until 1997 six native parasitoids have been identified in the southeast region of the State of São Paulo, from which *G. fausta* corresponded to more than 90% of the specimens (Costa et al., 1999).

Natural enemies present in Florida have caused in excess of 50% mortality of larvae and pupae of CLM in some areas (Browning et al., 1999). Despite high parasitization level, parasitism alone may be not enough to maintain CLM density under control during the summer (Peña et al., 1996). The chemical control can become the unique measure to guarantee efficacy in controlling *P. citrella* (Garijo & Garcia, 1994). In citrus growing-region infected by citrus canker bacteria the CLM population must be maintained in very low levels because few mines in spring or summer flushes can be main focus to help the spread of the disease.

Table 2 - Mean number of surviving larvae (L) and surviving larvae + pupae (L + P) of *Phyllocnistis citrella* per flush of 'Tangor Murcott'. Cordeirópolis, SP, 1999.

Treatment	Rate g AI / 100 L water	Mean[1] ± SEM			
		5 d after 2th application		11 d after 2th application	
		L	L + P	L	L + P
Thiamethoxam	3.0	0.65 ± 0.16ab[2]	0.80 ± 0.12abc	0.23 ± 0.16a	0.60 ± 0.19a
Thiamethoxam	4.0	1.13 ± 0.40a	1.18 ± 0.38ab	0.80 ± 0.20a	1.03 ± 0.13a
Thiamethoxam	5.0	0.85 ± 0.18ab	1.10 ± 0.15ab	0.45 ± 0.10a	0.78 ± 0.05a
Thiameth. + PO	4.0+200.0	0.43 ± 0.15ab	0.68 ± 0.24ab	0.63 ± 0.14a	0.95 ± 0.05a
Abamectin +PO	0.54+200.0	0.08 ± 0.08 b	0.08 ± 0.08 c	0.25 ± 0.25a	0.50 ± 0.29a
Lufenuron +PO	3.75+200.0	0.25 ± 0.25ab	0.38 ± 0.24 bc	0.68 ± 0.27a	0.75 ± 0.28a
Pyridaphention	30.0	0.93 ± 0.17ab	1.10 ± 0.11ab	0.55 ± 0.13a	1.40 ± 0.31a
Pyridaph. + PO	30.0+200.0	0.65 ± 0.16ab	0.85 ± 0.09abc	0.73 ± 0.15a	1.28 ± 0.19a
Petroleum Oil (PO)	200.0	0.80 ± 0.20ab	0.90 ± 0.17abc	0.45 ± 0.19a	0.75 ± 0.13a
Petroleum Oil	800.0	0.95 ± 0.23ab	1.08 ± 0.22ab	0.50 ± 0.34a	1.03 ± 0.17a
Control	-	1.03 ± 0.21a	1.35 ± 0.31a	0.93 ± 0.06a	1.18 ± 0.09a
C.V.(%)		11.6	10.2	12.5	10.4

[1]Analysis was made on x + 1 square root transformation of the data: untransformed data is presented.
[2]Means followed by the same letter in each column do not differ using Tukey's test (P=0.05).

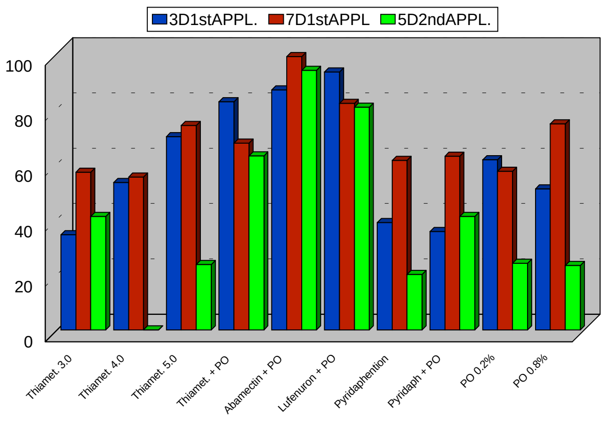

Fig. 1 – Reduction (%) of larval density of *Phyllocnistis citrella* in 'Tangor Murcott'. Cordeirópolis, SP, 1999.

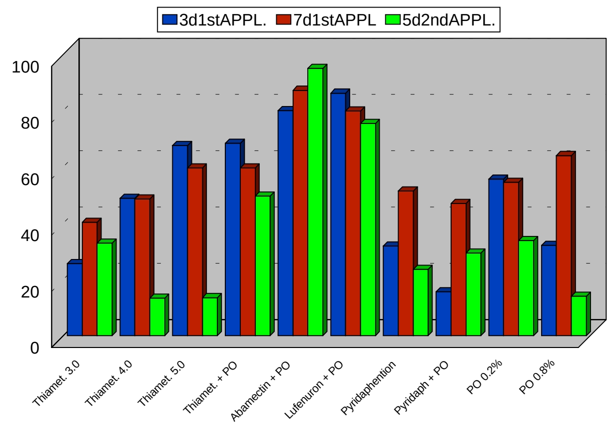

Fig. 2 – Reduction (%) of larval + pupal density of *Phyllocnistis citrella* in 'Tangor Murcott'. Cordeirópolis, SP, 1999.

References

Beattie, G.A.C.; Liu, Z.M.; Watson, D.M.; Clift, A.D.; Liang, L. Evaluation of ptroleum spray oils and polysaccharides for control of *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillaridae). J. Aust. Ent. Soc. 34: 349-353, 1995.

Browning, H.W., Bullock, R.C.; Knapp, J.L.; Peña, J.; Stansly, P.A. Citrus Leafminer. In: Knapp, J.L. (Ed.) 1999 Florida citrus pest management guide. Florida: IFAS, University of Florida,1999. p. 14.1-2.

Cano, E., La Llana, A. De; Hernandez, J.; Ruiz, F.; Peña, J.E.; Evans, G. Dynamics and biological control of the citrus leafminer in Nicaragua. p. 76. In: Hoy, M.A. (Ed.). Managing the Citrus Leafminer. Proceedings International Conference, Orlando, Florida: University of Florida, 1996. 119p.

Chagas, M.C.M. *Phyllocnistis citrella* Stainton, 1856 (Lepidoptera: Gracillariidae): bioecologia e relação com o cancro cítrico. Piracicaba: 1999. 229p. [Tese (Doutorado) - Escola Superior de Agricultura "Luiz de Queiroz"-USP].

Costa, V.A., Sá, L.A.N.; La Salle, J.; Nardo, E.A.B De; Arellano, F.; Fuini, L.C. Indigenous parasitoids (Hym., Chalcidoidea) of *Phyllocnistis citrella* Stainton (Lep.: Gracillaridae) in Jaguariúna, São Paulo State, Brazil: preliminary results. *J. Appl. Entomol.*, v. 123, p. 237-240, 1999.

Feichtenberger, E. & Raga, A. First report of citrus leafminer *Phyllocnistis citrella* (Lep.: Gracillariidae) in Brazil. pp. 45. In: REUNIÃO INTERAMERICANA DE HORTICULTURA TROPICAL 42., 1996, Curitiba, PR. *Abstracts*. Curitiba, PR: 1996. p. 45.

Garijo, C. & Garcia. E.J. *Phyllocnistis citrella* (Stainton, 1856) (Insecta: Lepidoptera: Gracillariidae: Phyllocnistidae) en los cultivos de cítricos de Andalucía (Sur España): Biología, ecología y control de la plaga. *Bol. San. Veg. Plagas*. v. 20, p. 815-826, 1994.

Gottwald, T.R.; Graham, J.H.; Schubert, T.S. An epidemiological analysis of the spread of citrus canker in urban Miami, Florida, and synergistic interaction with the Asian citrus leafminer. *Fruits*, v.52, p. 383-390, 1997.

Henderson, C.F. & Tilton. E.W. Tests with acaricides against the brown wheat mite. *J. Econ. Entomol.*, v. 48, p. 157-161, 1955.

Heppner, J.B. Citrus leafminer, *Phyllocnistis citrella*, in Florida (Lepidoptera: Gracillaridae: Phyllocnistidae). *Trop. Lepid.*, v.4, p. 49-64, 1993.

Hoy, M. A. & Nguyen. R. Classical biological control of the citrus leafminer in Florida. *Citrus Ind., v.* 75, n. 4, p. 22, 1994.

Hoy, M. A. & Nguyen. R. Classical biological control of the citrus leafminer *Phyllocnistis citrella* Stainton. *Trop. Lepid.*, v.8, p. 1-20, 1997. suppl. 1.

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.; Stansly. P.A. Citrus leafminer, *Phyllocnistis citrella* Stainton: current status in Florida -1995. Gainesville, Florida Cooperative Extension Service, IFAS, Univ. Florida, 1995. 26p.

Lasalle, J. & Peña, J.E. A new species of *Galeopsomyia* (Hymenoptera: Eulophidae: Tetrastichinae): a fortuitous parasitoid of the citrus leafminer, *Phyllocnisits citrella* (Lepidoptera: Gracillariidae). *Fla. Entomol.*, v.80, p. 461-470, 1997.

León, G.A. & Campos, J.C. Parasitóides del minador de los cítricos *Phyllocnistis citrella* (Lepidoptera: Gracillaridae) en El Piedomonte del Departamento Del Meta. *Rev. Col. Entomol.*, v. 25, n. 3-4, p. 143-146, 1999.

Liu, Z.M.; Beattie, G.A.C.; Jiang, L.; Watson, D.M. Volumes of petroleum spray oil required for control of *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) in mature citrus orchards. *Aust. J. Entomol.*, v.38, p. 141-144, 1999.

Macedo, N.; Botelho, P.S.M.; Rubin, C.A. Eficiência de inseticidas no controle da lagarta minadora dos citros. *Laranja*, v. 17, n.1, p. 31-39, 1996.

Paiva, P.E.B.; Benvenga, S.R.; Gravena, S. Observações sobre a lagarta minadora dos citros e seus parasitóides no Estado de São Paulo. *Laranja*, v. 19, n.2, p. 285-292, 1998.

Peña, J.E. & Duncan, R. Control of the citrus leafminer in

South Florida. *Proc. Fla. State Hortic. Soc.*, v. 106, p. 47-51, 1993.

PEÑA, J.E.; DUNCAN, R.; BROWNING, H. Seasonal abundance of *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) and its parasitoids in South Florida citrus. *Environ. Entomol.*, v. 25, p.698-702, 1996.

RAE, D.J.; WATSON, D.M; LIANG, W.G.; TAN, B.L.; LI, M.; HUANG, M.D.; DING, Y.; XIONG, J.J.; DU, D.P.; TANG, J.; BEATTIE, G.A.C. Comparison of petroleum spray oils, abamectin, cartap and methomyl for control of citrus leafminer (Lepidoptera: Gracillariae) in Southern China. *J. Econ. Entomol*., v. 89, p. 493- 499, 1996.

RAGA, A.; CERÁVOLO, L.C.; SOUZA FILHO, M.F. DE; MONTES, S.M.N.M.; ROSSI, A.C.; SATO, M.E. Ação de inseticidas sobre *Phyllocnisitis citrella* Stainton (Lep.: Gracillaridae) em citros (*Citrus sinensis* L. Osbeck). *Arq.Inst.Biol*., São Paulo, v. 6, p. 35-42, 1998a.

RAGA, A.; CERÁVOLO, L.C.; SATO, M.E.; SOUZA FILHO, M.F.; MONTES, S.M.N.M.; ROSSI, A.C. Efeito de inseticidas sobre *Phyllocnistis citrella* Stainton (Lep.: Gracillaridae) em laranja Pera (*Citrus sinensis* L. Osbeck). *Rev. Agric.*, Piracicaba, v. 73, p. 143-154, 1998b.

SATO, M.E. & RAGA, A. Ácaro da leprose. *Biológico*, São Paulo, v. 60, n.1, p. 61-69, 1998.

SCHUBERT, T.S. Florida's experience with citrus canker: lessons learned from history. In: V. KLASSEN (Ed.). Proceedings of the T-Star Workshop Mitigating the Effects of Exotic Pests on Trade and Agriculture - Part A The Caribbean. Homestead: USDA, 1999. p. 149-158.

SINHA, M.K.; BATRA, R.C.; UPPAL, D.K. Role of citrus leafminer (*Phyllocnistis citrella* Stainton), on the prevalence and severity of citrus canker (*Xanthomonas citri* Hasse) Dowson) - *Madras Agric. J.*, v. 59, p. 240-245, 1972.

TAN, B. & HANG, M. Managing the citrus leafminer in China. p. 49-52. In: HOY, M.A. (Ed.). *Managing the Citrus Leafminer*. In: Hoy, M.A. (Ed.). Managing the Citrus Leafminer. Proceedings International Conference, Orlando, Florida: University of Florida, 1996. 119p.

VALADARES, J.C.V.; ROSSETTI, V.; MARCOS MACHADO, M.ª; TEÓFILO SOBRINHO, J.T.; NOGUEIRA, N.L. Lagarta minadora dos citros: um fator do aumento de pragas e cancro cítrico. *Laranja*, v. 19, n. 1, p. 49-60, 1998.

VOLPE, A.; CAMARGO E CASTRO, P.R.; APPEZZATO-DA-GLORIA, B. Alterações anatômicas causadas pela lagarta minadora nas folhas de Tangerineira 'Ponkan'. *Laranja*, v. 19, n.1, p. 27-38, 1998.

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