Subtropical Plant Science, 49: 65-70.1997

Management of Citrus Leafminer in Texas: Chemical Options

J. Victor French[1], Jesusa Legaspi[2], Santiago Villarreal[1] and Robert Saldana[2]

[1]*Texas A&M-Kingsville Citrus Center P.O. Box 1150, Weslaco, TX. 78599*
[2]*Texas A&M Research and Extension Center, Weslaco, TX 78596*

ABSTRACT

Management stratagies for citrus leafminer (CLM), *Phyllocnistis citrella* Stainton, on Texas citrus include the use of chemicals for short term control and utilization of indigenous and introduced exotic natural enemies for long term control. Since chemical options currently available to growers are limited, 3 orchard spray trials were conducted to identify new chemical products for inclusion in the CLM management program. Two trials were conducted in 1996, with test chemicals applied when 1st and 2nd stage CLM were first observed on new flush leaves. In a third trial conducted in 1997, chemicals were timed to the first appearance of eggs and emerging 1st stage CLM on new leaves. Alert 2SC (chlorfenapyr) at test rates of 224 and 336 g ai/ha (0.20 and 0.30 lb ai/A) and tank mixed with 0.5% NR 435 Oil was included in both 1996 trials, and consistently provided ≥ 85% CLM mortality (averaged for 3 post-spray counts in each trial). Experimental CM-006 1.0 EC (milbemectin) tested at 34 g ai/ha (0.03 lb ai/A) in trial 1 was slightly more effective applied alone than in tank mixes with either 0.5% NR 435 Oil or 0.0125% Kinetic Adjuvant (≥ 86% versus ≤ 83% CLM mortality). Provado 1.6F (imidacloprid) at 56 g ai/ha (0.05 lb ai/A) tank mixed with 0.0125% Silwet Surfactant averaged ≥ 89% CLM mortality in trial 2. In trial 3, tank mix treatments of Micromite 25W (diflubenzuron) at 360 g ai/ha (0.32 lb ai/A) plus 0.5% NR 435 Oil and Confirm 2F (tebufenozide) at 290 g ai/ha (0.26 lb ai/A) plus 0.5% NR 435 Oil consistently averaged ≥ 95% CLM mortality for 3 post-spray counts, comparable to the Agri-Mek 0.15EC at 13 g ai/ha (0.012 lb ai/A) plus 0.5% NR 435 Oil standard treatment. In a bioassay using insectary-reared adult beneficial parasitoids, *Allorhogas pyralophagus* Marsh (Hymenoptera: Braconidae), no mortality was recorded after a 6-8 h exposure to field-collected leaves from trees sprayed with Alert 2SC, Provado 1.6F, Micromite 25W or Agri-Mek 0.15EC, at the aforementioned rates.

RESUMEN

Entre las estrategias para el manejo del minador de la hoja de los cítricos (MHC), *Phyllocnistis citrella* Stainton, en los cítricos en Texas se incluye el uso de químicos para el control a corto plazo y la utilización de enemigos naturales nativos e introducidos para control a largo plazo. Ya que las opciones de control químico disponibles para los agricultores en la actualidad son limitadas, se condujeron 3 ensayos consistentes en aspersión a huertas para identificar nuevos productos químicos que pudiesen ser incluidos en el programa de manejo del MHC. Se realizaron dos ensayos en 1996, en los cuales los químicos estudiados fueron aplicados al momento de la detección del primer y segundo estadío del MHC en las hojas de los brotes nuevos. En un tercer ensayo realizado en 1997, el tiempo de aplicación de los químicos se programó con el momento de la aparición inicial de los huevecillos y del primer estadío emergente del MHC en las hojas nuevas. El producto Alert 2SC (chlorfenapyr) en las dosis experimentales de 224 y 336 g ia/ha (0.20 y 0.30 lb ia/A) mezclado en tanque con aceite NR 435 al 0.5% se incluyó en los dos ensayos de 1996, y consistentemente brindó ≥ 85% de mortalidad del MHC (promediado en los 3 conteos post aspersión en cada ensayo). El producto experimental CM-006 1.0 EC (milbemectin) aplicado en el primer ensayo a 34 g ia/ha (0.03 lb/A) fue ligeramente más efectivo cuando se aplicó solo que cuando se aplicó mezclado en tanque con aceite NR435 al 5% o con Adjuvante Kinético al 0.0125% (≥ 86% contra ≤ 83% mortalidad del MHC). Provado 1.6F (imidacloprid) a 56 g ia/ha (0.05 lb de ia/A) mezclado con surfactante Silwet al 0.0125% promedió 89% de mortalidad del MHC en el segundo ensayo. En el tercer ensayo, los tratamientos de mezclas en tanque de Micromite 25W (diflubenzuron) a 360 g ia/ha (0.32 lb ia/A) mas Aceite NR435 al 0.5% y Confirm 2F (tebufenozide) a 290 g ia/ha (0.26 lb ia/A) mas Aceite NR 435 al 0.5 % consistentemente promediaron ≥ 95% de mortalidad del MHC en los 3 conteos post aspersión comparable al tratamiento estandard de Agri-Meek 0.15 EC a 13g ia/ha (0.012 lb ia/A) mas Aceite NR 435 al 0.5 %. En un bioensayo usando parasitoides benéficos adultos liberados en insectario, *Allorhogas pyralophagus* Marsh (Hymenoptera: Braconidae), no se registró mortalidad después de 6 a 8 horas de exposición a hojas colectadas en campo en árboles asperjados con Alert 2SC, Provado 1.6 F, Micromite 25W o Agri-Mek 0.15EC a las dosis mencionadas arriba.

Additional index words: parasitoid, bioassay, mortality

The citrus leafminer (CLM), *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae), a major old world citrus pest from Southeast Asia was first found in citrus nurseries in Homestead, Florida (Dade County) in May 1993 (Heppner, 1993a). CLM was likely introduced on infested plant material from the Bahamas, and in a span of only three months it was distributed (via infested nursery stock) throughout all of Florida's citrus growing areas (Heppner, 1993b). CLM was found on citrus in Louisiana in June 1994, and shortly thereafter in the Montemorelos-Linares citrus area, state of Nuevo Leon, Mexico (Knapp, 1995). In mid-August 1994, CLM was found in the Texas Lower Rio Grande Valley (LRGV) on a hedge-row of sour orange, *Citrus aurantium* L, near Bayview in eastern Cameron County (French, et.al., 1994). An immediate survey showed CLM already well established in Bayview (14 commercial orchards) and Los Fresnos (8 orchards) citrus areas. A subsequent survey near the Gulf coast in the Brownsville area, revealed that CLM was not only established in orchards, but a large citrus nursery was also heavily infested and had sustained severe foliar damage and even tree loss. CLM's west and northward movement was rapid, with infested orchards reported in mid-Valley (Weslaco - San Juan) and Monte Alto - Hargill (northern Hidalgo Co.) and Raymondville (Willacy Co.) areas by early October. Spread of CLM throughout the LRGV's three county citrus area was complete when a November survey revealed infestations in some 22 orchards in the Texan Gardens area of western Hidalgo Co. Thus, after the initial CLM finds in the Bayview area, this pest moved across Valley citrus orchards and nurseries in a period of about two and a half months (French, 1994).

New flush foliage on virtually all grapefruit and orange cultivars grown commercially in the LRGV has sustained CLM leaf mining injury. CLM foliar mining has also been common on various lemon, lime, tangelo, calamondin, kumquat and mandarin cultivars. CLM injury is especially severe on young, tender nursery stock and 1-3 year old trees, many of which have been planted in orchards since the 1989 freeze.

Management strategies for CLM include the use of chemicals for short term control and utilization of indigenous and introduced exotic natural enemies for long term control. Seven native parasitoid species have been identified attacking CLM (Legaspi and French, 1996). These have been supplemented with several releases in LRGV orchards of the exotic parasitoid, *Ageniaspis citricola* Logvinovskaya (Hymenoptera: Encyrtidae) obtained from Florida. Although parasitism of CLM by *A. citricola* reached 17% at one release site, this parasite has not become established in Valley orchards to date (French and Legaspi, 1996). Chemicals currently available to Texas citrus growers for CLM control are limited to: Agri-Mek® O.15EC (abamectin), Neemix® (azadirachtin), and Eclipse® 25W (fenoxycarb); the latter labeled for use only on non-bearing citrus. Petroleum spray oils are also available for use alone or in tank mixes with registered chemicals. New registrations are definitely needed to provide growers with added chemical alternatives for use in their CLM integrated management program.

This paper reports results of chemical efficacy trials against CLM conducted during 1996 and 1997, both with new experimental compounds and products presently labeled for CLM in Florida. Concomitant with one of the 1996 trials, a bioassay was conducted to determine the impact of the test chemicals on an exotic beneficial parasitic wasp, *Allorhogas pyralophagus* Marsh, in culture at the Texas Agricultural Experiment Station (TAES) in Weslaco.

MATERIALS AND METHODS

Two separate trials were conducted in 1996 and a single trial in 1997, each in a different Citrus Center orchard. Trial 1–was initiated on 13 June 1996, in a block of 35-yr-old 'Ruby Red' grapefruit trees on a 4.88 X 6.70 m (16 X 22 ft) spacing. Trial 2–was initiated on 12 September 1996, on 3-yr-old 'Rio Red' grapefruit trees on a 5.50 X 7.32 m (18 X 24 ft) spacing. Trial 3–was initiated on 13 June 1997, on 4-yr-old 'Marrs' early orange trees on 4.25 X 7.32 m (14 X 24 ft) spacing. The chemicals and rates varied in the different trials, and in some cases the test chemical was evaluated alone and in tank mix combinations with petroleum spray oil or a surfactant/ adjuvant.

Chemical formulations and rates tested. Agri-Mek 0.15EC, (abamectin), a mixture of avermectins containing 80% avermectin B_1a and avermectin B_1b, at a test rate of 13 g ai/ha (0.012 lb ai/A) (Novartis Crop Protection, Minneapolis, MN); Alert® 2SC, (chlorfenapyr), 4-bromo-2-(4-chlorophrnyl) amino carbonyl) -1- (ethoxymethyl) -5-(trifluoromethyl)-1H-pyrrole-3-carbonitrile, at test rates of 224 and 336 g ai/ha (0.20 and 0.30 lb ai/A) (American Cyanamid, Wayne, NJ); Confirm ® 2F, (tebufenozide), N-tert-butyl-N-(4-ethylbenzoyl)-3,5-dimethylbenzohydrazide (IUPAC), at test rates of 145 and 290 g ai/ha (0.13 and 0.26 lb ai/A) (Rohm and Haas, Philadelphia, PA); Micromite® 25W, (diflubenzuron), N-[[(4-Chlorophryl)amino] carbonyl]-2,6 difluorobenzamide, at a test rate of 360 g ai/ha (0.32 lb ai/A) (Uniroyal Chemical, Middlebury, CT); Provado ® 1.6F, (imidacloprid), 1[(6-Chloro-3-pyridinyl)methyl]-N-nitro-2-imidazolidinimine, at a test rate of 56 g ai/ha (0.05 lb ai/A) (Bayer, Kansas City, MO); and experimental CM-006 1.0EC, (milbemectin), (chemistry not released), at a test rate of 34 g ai/ha (0.03 lb ai/A) (Sankyo,Tokyo, Japan).

Additives combined in tank mixes with certain of the test chemicals included: Narrow range (NR) 435 petroleum oil with emulsifier and unsulfonated residue rating of 92% minimum, A.P.I. gravity at 15.5°C (60°F) of 34.8 minimum, 50% distillation point at 10 mm Hg reduced pressure 227°C (435°F) and 10-90% range of 27°C (80°F) maximum, at a test rate of 0.5% volume/volume (Sun Oil, Philadelphia, PA); Kinetic® Nonionic Adjuvant, blend of polyalkylenoxide modified polydimethylsiloxane and nonionic surfactants 99% and 1% inert ingredients, at a rate of 0.0125% volume/volume (Helena Chemical, Memphis, TN); and Silwet® L-77 Surfactant, polyalkyleneoxide modified heptamethyltrisiloxane 99.5% and inert ingrediants 0.5% at a test rate of 0.0125% volume/volume (Helena Chemical, Memphis, TN).

Plot Design and Spray Application. Treatments were completely randomized and replicated on 4 single tree plots. A minimum of 24 new flush terminals 2-5 cm long were tagged in each treatment tree prior to spray application. In Trials 1 and 2, initiation of treatment sprays was timed to the appearance of CLM 1st and 2nd stage larvae on the new leaves. In Trial 3, treatment applications were carefully timed to the appearance of CLM eggs and emerging 1st stage larvae on new flush leaves. Treatment trees were sprayed to foliar runoff using a HyPro 5200 (HyPro Sprayers, Saint Paul, MN) high pressure handgun sprayer operating at 150-200 psi.

CLM Mortality Counts. At each pre- and post-spray count date, 4 tagged new flush terminals (each with 8-12 leaves) were randomly collected per replicate tree and taken to the laboratory for examination. All live and dead CLM 1st-4th stage larvae and pupae were counted on each terminal. CLM were recorded as dead by lack of movement when probed with a teasing needle and/or evidence of desiccation when examined microscopically at 20X. Percent mortality of all CLM immature stages was determined for each treatment. Post-spray counts were made at 3-4 d and weekly thereafter until no CLM were recorded on the foliage.

Bioassay on Beneficial Parasitoid. When these trials were initiated, parasitoids (native and exotic) of CLM were unavailable for conducting chemical toxicity bioassays. However, upon initiation of Trial 2, *Allorhogas pyralophagus* Marsh (Hymenoptera: Braconidae), an exotic wasp parasitoid of the Mexican riceborer, *Eoreuma loftini* (Dyar) (Lepidoptera: Pyralidae), was in culture in the laboratory of the second author (J.C. Legaspi). Therefore, it was decided to utilize *A. pyralophagus* in preliminary screening of test chemicals for toxicity to beneficials. *A. pyralophagus* were exposed to excised leaves in individual petri dishes (15 cm in diameter) for 6-8 h; the leaves were collected in the field from treated and control trees at intervals 1h and 24h after spraying. The parasitoids were anaesthetized using CO_2 for 3-5 s to facilitate their transfer onto the leaves in the petri dishes. Each petri dish was fitted with a plastic tube connected to a vacuum pump to provide air circulation and prevent any fumigant action of the chemical. The bioassay was conducted in an insectary room maintained at 26°C and 65% RH. Treatments were arranged in a complete randomized design with 5 replicates (petri dishes) per treatment each containing 20 parasitoids. Mortality of *A. pyralophagus* was recorded at the end of the 6-8 h exposure period.

Statistical Analysis. All count data were subjected to analysis of variance and means were separated by Waller-Duncan K-Ratio Test ($P< 0.001$). Data was transformed by Arcsin $Y^{1/2}$ for analysis.

RESULTS

In **Trial 1**, Alert 2SC (224 and 336 g ai/ha) + NR 435 Oil, and experimental CM-006 1.0EC (34 g ai/ha) alone and tank mixed with NR 435 Oil or Kinetic Adjuvant were compared to Agri-Mek 0.15EC (13 g ai/ha) + NR 435 Oil standard treatment for efficacy against CLM. The percent CLM mortality recorded at each count and averaged for each treatment across all post-spray count dates are shown in Table 1. All treatments averaged ≥ 80 % CLM mortality (mean for 3 post-spray counts), but experimental CM-006 1.0EC tank mixed with either NR 435 Oil or Kinetic Adjuvant were slightly less effective against CLM than the Alert 2SC + NR 435 Oil or standard Agri-Mek 0.15EC + NR 435 Oil treatments. The trial was terminated after the 21 d post-spray count due to the lack of CLM and to the maturing (hardening-off) of flush foliage.

In **Trial 2**, Micromite 25W (360 g ai/ha) alone and tank mixed with NR 435 Oil, Provado 1.6F (56 gm ai/ha) + Silwet Surfactant were compared to the Alert 2SC (224 and 336 g ai/ha) and the standard Agri-Mek 0.15EC (13 g ai/ha) treatments all tank mixed with NR 435 Oil. Trial results are shown in Table 2. Tank mix combination treatments of Micromite 25W+ NR 435 Oil, Alert 2SC+ NR 435 Oil and Provado 1.6F + Silwet Surfactant all averaged ≥ 85% CLM mortality (mean for 3 post-spray counts), comparable to control by the standard Agri-Mek 0.15EC + NR 435 Oil

Table 1. Percent Mortality 1st - 4th stage Citrus Leafminer (CLM) on new flush leaves of sprayed and unsprayed mature 'Ruby Red' grapefruit trees, Citrus Center Research Farm, Weslaco, TX. 1996.

		% CLM Mortality				
			(Days) Post-spray:			Post-Spray Mean
Treatment[z]	Rate g ai/ha	Pre-Spray	(+4)	(+12)	(+21)	
ALERT 2SC +0.5%NR 435 Oil	224	8.3a[Y]	85.1 abc	81.3 b	90.0 a	85.4 ab
ALERT 2SC	336	6.3 a	88.8 a	88.3 ab	90.0 a	89.0 a
CM-006 1.0EC	34	4.2 a	85.7 ab	88.5 a	86.3 ab	86.8 ab
CM-006 1.0EC +0.5% NR 435 Oil	34	5.1 a	76.0 c	86.5 ab	78.3 b	80.3 c
CM-066 1.0EC +0.0125% Kinetic	34	1.8 a	79.0 bc	83.8 ab	86.3 ab	83.0 bc
AGRI-MEK 0.15EC +0.5% NR 435 Oil	13	3.6 a	88.4 ab	90.0 a	90.0 a	89.5 a
Control	—	2.0 a	11.7 d	3.9 c	12.2 c	8.9 d

[Z] Treatment sprays applied 13 June 1996, with each treatment replicated 4 times on single tree plots.

[Y] Treatment means within a column not showing a common letter are significantly different as separated by Waller-Duncan K-Ratio Test ($P\leq .001$). Data was transformed by Arcsin $Y^{1/2}$ for analysis.

treatment. The Micromite 25W treatment without NR 435 Oil was much less effective in controlling CLM, with a mean percent mortality of ≤ 72%.

In **Trial 3**, Confirm 2F (145 and 290 g ai/ha) + NR 435 Oil, Micromite 25W (360 g ai/ha) alone and + NR 435 Oil, were compared to the standard Agri-Mek 0.15EC (13 g ai/ha) + NR 435 Oil treatment. Treatment sprays were carefully timed to the appearance of CLM eggs and 1st stage larvae on new flush foliage. Tank mix treatments of Confirm 2F high rate (290 g ai/ha) + NR 435 Oil and Micromite 25W + NR 435 Oil treatments consistently averaged ≥95% mortality for each of the 3 post-spray counts, comparable to the standard Agri-Mek 0.15EC + NR 435 Oil treatment (Table 3). The Confirm 2F low rate (145 g ai/ha) + NR 435 Oil and the Micromite 25W treatment without NR 435 Oil treatment were less effective in controlling CLM. The trial was terminated after the third count (17 d post-spray) due to the lack of CLM and maturing i.e., hardening-off of the flush foliage.

No tank mix incompatibility or phytotoxicity was observed on fruit or foliage following spray treatment applications in any of the 3 Trials.

Beneficial Bioassay. No mortality of adult *Allorhogas pyralophagus* parasitoids was recorded in any of the treatments after a 6 h exposure period to leaves sampled at 1 h i.e., immediately after the spray treatments had dried on the foliage (Table 4). Generally, the bioassay would have been terminated when no parasitoid mortality occurred during this first exposure period. However, due to the ready availability of parasitoids, a second bioassy was conducted on leaves sampled 24 h after the spray treatment. No mortality occurred even when the parasitoids were given an extended 8 h exposure to spray treated leaves, varifying the non-toxicity of the test chemicals on adult *A. pyralophagus.*

Table 2. Percent Mortality 1st - 4th stage Citrus Leafminer (CLM) on new flush leaves of sprayed and unsprayed 3-yr-old 'Rio Red' grapefruit trees, Citrus Center Research Farm, Weslaco, TX. 1996.

			% CLM Mortality			
			(Days) Post-spray			
Treatment[Z]	Rate g ai/ha	Pre-Spray	(+3)	(+12)	(+21)	Post-Spray Mean
MICROMITE 25W	360	2.0 a[Y]	48.1 c	77.8 c	87.7 b	71.3 c
MACROMITE 25W +0.5%NR 435 Oil	360	8.8 a	81.4 ab	86.3 bc	100.0 a	89.2 ab
PROVADO 1.6F +0.0125% Silwet	56	4.0 a	85.5 ab	89.8 ab	93.1 ab	87.9 ab
ALERT 2SC +0.5% NR 435 Oil	224	3.1 a	80.9 b	89.8 ab	92.9 ab	87.9 ab
ALERT 2SC +0.5% NR 435 Oil	336	6.8 a	81.4 ab	85.4 bc	89.3 ab	85.4 b
AGRI-MEK 0.15EC +0.5%NR 435 Oil	13	2.4 a	91.3 a	96.3 a	86.4 b	91.3 a
CONTROL	—	9.9 a	6.6 d	2.5 d	6.8 c	5.3 d

[Z] Treatment sprays applied 12 September 1996, with each treatment replicated 4 times on single tree plots.

[Y] Treatment means within a column not showing a common letter are significantly different as separated by Waller-Duncan K-Ratio Test (P≤ .001). Data was transformed by Arcsin $Y^{1/2}$ for analysis.

Table 3. Percent Mortality 1st - 4th stage Citrus Leafminer (CLM) on new flush leaves of sprayed and unsprayed 4-yr-old 'Marrs' orange trees, Citrus Center Research Farm, Weslaco, TX. 1996.

			% CLM Mortality			
			(Days) Post-spray			
Treatment[Z]	Rate g ai/ha	Pre-Spray	(+3)	(+10)	(+17)	Post-Spray Mean
CONFIRM 2F +0.5%NR 435 Oil	145	0.34 a	100.00 a[Y]	84.60 c	79.80 c	88.13 b
CONFIRM 2F +0.5%NR 435 Oil	290	0.06 a	99.33 ab	97.50 ab	96.40 ab	97.74 a
MICROMITE 25W	360	0.04 a	51.90 c	92.90 bc	87.30 bc	77.36 c
MICROMITE 25W +0.5% NR 435 Oil	360	1.30 a	95.60 b	99.61 a	98.90 a	98.04 a
AGRI-MEK 0.15EC +0.5% NR 435 Oil	13	0.22 a	99.50 ab	99.39 ab	96.90 ab	98.60 a
CONTROL	—	0.38 a	0.26 d	0.08 d	1.10 d	0.48 d

[Z] Treatment sprays applied 13 June 1997, with each treatment replicated 4 times on single tree plots.

[Y] Treatment means within a column not showing a common letter are significantly different as separated by Waller-Duncan K-Ratio Test (P≤ .001). Data was transformed by Arcsin $Y^{1/2}$ for analysis.

Table 4. Percent mortality of adult parasitoids, *Allorhogas pyralophagus*, exposed to leaves field collected from 3 yr-old 'Rio Red' grapefruit trees sprayed with different chemical treatments, Weslaco, Tx. 1996

		% Parasitoid Mortality[Z] Post-spray	
Treatment[Y]	Rate g ai/ha	1 h	24 h
MICROMITE 25W	360	0.0	0.0
MICROMITE 25W + 0.5% NR 435 Oil	360	0.0	0.0
PROVADO 1.6F + 0.125% SILWET	56	0.0	0.0
ALERT 2SC + 0.5% NR 435 Oil	224	0.0	0.0
ALERT 2SC + 0.5% NR 435 Oil	336	0.0	0.0
AGRI-MEK 0.15EC + 0.5% NR 435 Oil	13	0.0	0.0
CONTROL	—	0.0	0.0

[Z] Percent Mortality of *A. pyralophagus* adults after a 6-8 h exposure period to leaves field collected at 1 h and 24 h post-spray; 5 replicates of 20 parasitoids (100 per treatments).

[Y] Treatment sprays applied 12 September 1996.

DISCUSSION

As reported herein these data showed several very promising new chemical products for citrus leafminer control. Alert 2F (formerly AC 303,630) and CM-006 1.0EC are both experimental compounds that have undergone extensive testing against insect and mite pest species on many fruit and vegetable crops. Both have shown excellent acaricidal activity in numerous screening trials against the phytophagous mite complex on Texas citrus (French & Rakha, 1994, French & Jackson, 1995; French & Villarreal, 1996 & 1997). Micromite 25W, an insect and mite growth regulator, is registered in Florida not only for control of citrus leafminer, but also for citrus rust mite, and the citrus root weevil complex. Confirm 2F (RH-5992), another insect growth regulator, is being tested against lepidopterous pest species on many crops. The latter chemicals are ineffective against late stage larvae and adults. Trial 3 results showed that by carefully timing spray treatments to the egg stage and newly emerging 1st stage larvae, excellent CLM control was achieved-particularly with the Confirm 2F high rate (290 g ai/ha) and Micromite 25W (360 g ai/ha) plus 0.50% NR 435 Oil treatments. The same rate of Micromite 25W without NR 435 Oil was much less effective in controlling CLM. In earlier studies, only Agri-Mek 0.15EC plus NR 435 Oil demonstrated a significant improvement in efficacy against CLM over NR 435 Oil sprays (1.5%-5.0%) applied alone (Stansley et.al., 1993 and 1994). Oil sprays are effective because CLM female adult moths avoid sprayed foliar surfaces, leading to reduced oviposition.

Florida currently has a Section 18 citrus registration for Provado 1.6 F and Admire 2F to control citrus leaf miner and the brown citrus aphid, *Toxoptera citricida* (Kirkaldy). Provado 1.6F is applied as a foliar contact spray, and as shown in these trials provided good CLM control. Longer term CLM control has been shown with Admire 2F applied as a soil drench near the tree trunk base; this was due to the highly systemic nature of the active ingrediant, imidacloprid (Knapp, 1995). Use of Admire 2F for CLM control in citrus nursery and young tree orchard replant situations would appear to be especially advantageous.

Data from the preliminary bioassay conducted concomitant with spray trial 2, showed that Alert 2SC, Micromite 25W, Provado 1.6F and Agri-Mek 0.15EC were non-toxic to the exotic parasitoid, *Allorhogas pyralophagus*. Thus, these chemicals appear to be easy on beneficials, with potential for inclusion into the CLM management program. However, more extensive chemical bioassays specifically against insectary-reared and field-collected beneficial parasitoid species of CLM are currently underway, with the data to be reported in future publications.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge support of this research by grants-in-aid from the following companies: American Cyanamid, Wayne, NJ; Bayer, Kansas City, MO; Rohm and Haas, Philadelphia, PA; Sankyo, Tokyo, Japan; and Uniroyal, Middlebury, CT.

LITERATURE CITED

French, J.V., S. Villarreal and R. Saldana. 1994a. Citrus leafminer hits Valley. TX. A&M University-Kingsville Citrus Center Newsletter 12 (5):1-2.

French, J.V. 1994b. Fall pest status. TX A&M University-Kingsville Citrus Center Newsletter 12 (6): 1-2.

French, J.V. and M. A. Rakha. 1994. False spider mite on Texas citrus: damage and control. Subtropical Plant Science 46:16-19.

French, J.V. and M.B. Jackson. 1995. Evaluation of AC 303,630 for rust mite control on Texas citrus. Arthropod Management Tests 20:53.

French, J.V. and S. Villarreal. 1996. Citrus rust mite control with AC 303,630 on Texas citrus. Arthropod Management Tests 21:69-70.

French, J.V. and J.C. Legaspi. 1996. Citrus leafminer parasite recovered. TX. A&M University-Kingsville Citrus Center Newsletter 14 (5):1-2.

French, J.V. and S. Villarreal. 1997. Evaluation of CM-006 for citrus red mite control. Arthropod Management Tests 22:60-61.

Heppner, J.B. 1993a. Citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae: Phyllocnistinae). Fla. Dept. Agric. Consumer Serv., Div. Plant Indus., Entomol. Circ., 359:1-2.

Heppner, J.B. 1993b. Citrus leafminer, *Phyllocnistis citrella*, in Florida (Lepidoptera: Gracillariidae: Phyllocnistinae), Trop. Lepid., 4:49-64.

Knapp, J.L. 1995. Citrus Leafminer, *Phyllocnistis citrella* Stainton: Current Status in Florida. Fla. Cooperative Extension Service. Institute of Food and Agric. Sciences. Univ. of Florida, Gainsville Fla. 35p.

Legaspi, J.C. and J.V. French. 1996. The citrus leafminer and its natural enemies. TX. A&M University-Kingsville Citrus Center. Circ. B96-1. 4p.

Stansley, P. A. and J.L. Knapp. 1994. Chemical control of citrus leafminer in Florida grapefruit. Arthropod Management Tests 19:47.

Stansley, P.A. and G.L. Fulcher. 1996. Chemical control of citrus leafminer (CLM) on 'Valencia' orange in Southwest Florida, Fall, 1994. Arthropod Management Tests 21:81.