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A predatory mite, *Amblyseius swirskii*, and plastic mulch for managing melon thrips, *Thrips palmi,* in vegetable crops

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ABSTRACT

Melon thrips, *Thrips palmi* Karny (Thysanoptera: Thripidae), is a significant pest of vegetable crops and ornamental plants due to feeding and oviposition injury to vegetative and reproductive tissues. As an integrated approach, we evaluated the efficacy of a phytoseiid mite, *Amblyseius swirskii* Athias-Henriot, and different colored and UV-reflective plastic mulches for managing *T. palmi* in snap bean (*Phaseolus vulgaris* L.), cucumber (*Cucumis sativus* L.), yellow squash (*Cucurbita pepo* L.), eggplant (*Solanum melongena* L.), Jalapeño pepper (*Capsicum annuum* L.), and tomato (*Solanum lycopersicum* L.). The five mulch treatments evaluated were: "Shine N′ Ripe" (Metalized top and black bottom), "Can-Shine" (Metalized top and white bottom), "Black" plastic black-on-black (Can-Grow-XSB), black-on-white (Can-Grow XSB), "White" plastic; white-on-black (Can-Grow XSB), and bare soil with no mulch. The number of *T. palmi* adults and larvae in leaf samples collected from the middle third (stratum) of plants in each treatment was determined. In 2015 at 49 days after planting (DAP), curative release of 40–50 *A. swirskii* per plant did not suppress *T. palmi* effectively when the thrips population was high. There were no significant interactions between *A. swirskii* and crop or *A. swirskii* and mulch type on the number of *T. palmi*. However, in 2016 at 15 DAP, preventive release of *A. swirskii,* reduced the number of *T. palmi* in each of the mulch and crop treatments. Metalized mulch reduced the number of *T. palmi* early in the season when plants' canopy did not shade the mulched area. These results suggest that use of metalized reflective mulch and *A. swirskii*, each have the potential to manage *T. palmi* at low population densities.

1. Introduction

Melon thrips (*Thrips palmi*) is a significant pest of nearly all vegetable crops and ornamental plants due to the injuries it causes on the vegetative and reproductive organs of plants (Mound and Teulon, 1995; Seal, 2001; Seal and Sabines, 2012). Worldwide, there is a heavy reliance on chemical insecticides for controlling thrips pests, including *T. palmi* (Seal and Kumar, 2010; Bao et al., 2014), and some reports have suggested a reduced susceptibility to many chemical insecticides (Young and Zhang, 1998; Seal et al., 2013). Currently, none of the commonly used insecticides provide satisfactory control of *T. palmi* when applied alone. Moreover, the potentially adverse effects of insecticides on the health of humans and animals suggest a need to employ biological and/or cultural control methods for *T. palmi* as economical and environmentally safe alternatives to chemical pesticides (Parrella and Lewis, 1997; Cock et al., 2010).

Amblyseius swirskii Athias-Henriot (Acari: Phytoseiidae) is a generalist phytoseiid mite that has been used for biological control since 1962 (Messelink et al., 2008; van Lenteren, 2012). Following its commercialization in 2005, it has gained wide-spread use as a biological control agent. *Amblyseius swirskii* has the potential to control several pest species including whiteflies, *Bemisia tabaci* (Gennadius) (Calvo et al., 2015); western flower thrips, *Frankliniella occidentalis* (Pergande) (Brodsgaard and Stengaard, 1992; Messelink et al., 2005); chilli thrips, *Scirtothrips dorsalis* Hood (Young and Zhang, 1998; Arthurs et al., 2009; Doğramaci et al., 2011); broad mites *Polyphagotarsonemus* spp. (Stansly and Castillo, 2009); and spider mites, *Tetranychus urticae* Koch (Calvo et al., 2015) in vegetable and ornamental crops. Blasco et al. (2012) reported that *A. swirskii* successfully controlled the eggs and first instar nymphs of Asian citrus psyllids, *Diaphorina citri* Kuwayma, in the laboratory. Kakkar et al.

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(2016) reported that populations of *T. palmi* were reduced by *A. swirskii* in a cucumber field in Homestead, Florida, USA. It has also been shown that *A. swirskii* is a more efficient thrips predator than *Neoseiulus cucumeris* (Oudemans) or *Amblyseius degenerans* Berlese (Acari: Phytoseiidae), which are also commercially available (van Houten et al., 2005; Arthurs et al., 2009; Reitz et al., 2011; Kakkar et al., 2016). In a greenhouse trial, release of 20–25 *A. swirskii* per square meter effectively controlled *T. palmi* in eggplant (Shibao et al., 2010). In a laboratory, a gravid *A. swirksii* female can consume 4–7 first instar larvae of *T. palmi* per day (M. A. Razzak, personal observation). In Spain, *A. swirskii* has been used as a biological control agent for cucumber, eggplant, sweet pepper and zucchini grown in protected environmental conditions (Calvo et al., 2015). There are many successful examples of controlling thrips, whiteflies, and other insects using phytoseiid predatory mites including *A. swirskii*, but mostly in protected environments such as greenhouses and shade houses. There are a few reports of the effectiveness of *A. swirskii* for controlling melon thrips and other thrips species in the field.

Plastic mulches with specific color and reflectance properties have the potential to deter or attract insects by influencing their vision and locomotory behavior (Summers et al., 2010; Tyler-Julian et al., 2015). Mulches with a metalized micro-layer on the surface that reflects ultraviolet (UV) radiation have been reported to repel insects and thereby reduce the infestation from various insect pests including thrips in field-grown vegetable crops (Reitz et al., 2003; Riley and Pappu, 2004; Razzak and Seal, 2017).

Integrated pest management strategies combining a biological control agent such as *A. swirskii* and plastic (UV- reflective and various colored) mulches can be an alternative to chemicals for managing *T. palmi* in field-grown vegetable crops. The objective of this study was to investigate the combined effects of different plastic mulches and *A. swirskii* for managing *T. palmi* in field-grown vegetable crops.

2. Materials and methods

2.1. Field and site preparation

Experiments were conducted in field research plots at the University of Florida, Tropical Research and Education Center (TREC), Homestead, Florida, USA (Latitude: 25° 30′ 40.809″ N; Longitude: 80° 30′ 3.983″ W). Raised beds 91 cm wide and 15 cm high with 1.83 m between centers were prepared with Kennco superbedders (Kennco Manufacturing Co Inc., Atoka, OK, USA). Granular fertilizer (N–P–K: 6-12-12) (Loveland Products Inc., Greely, CO, USA) was then applied at 1307 kg/ha in two furrows, each 20 cm from and parallel to either side of the seed or transplant row and was incorporated within the top 15 cm of the soil. Pre-emergence herbicide, halosulfuron methyl (55 g/ha, Sandea®, Gowan Company LLC., Yuma, AZ, USA) was applied between rows to control weeds. Subsequently, plastic mulch was placed on the beds using a plastic layer (Kennco micro-combo, Kenco Manufacturing Co Inc., Atoka, OK, USA). At the time of placing the plastic mulch, two drip tapes (Ro-Drip, Rivulis Irrigation Inc., San Diego, CA, USA) with emitters spaced 30 cm apart were placed parallel 15 cm apart (7 cm from the center of the bed) on each side of each bed for irrigation.

2.2. Experimental design

Separate experiments were conducted in 2015 and 2016. In 2015, six vegetable crops were tested: snap bean (*Phaseolus vulgaris* L. var. Opus, Fabaceae), cucumber (*Cucumis sativus* L. var. Poinsett 76, Cucurbitaceae), yellow squash (*Cucurbita pepo* L. var. Straight neck, Cucurbitaceae), eggplant (*Solanum melongena* L. var. Santana, Solanaceae), Jalapeño pepper (*Capsicum annuum* L. var. Jalapeño-Tormenta, Solanaceae), and tomato (*Solanum lycopersicum* L., var. Charger, Solanaceae). In each crop, five mulch treatments were evaluated in 2015: (1) "Shine N' Ripe" (1.25 mil Metalized top and black bottom/silver on black), (2) "Can-Shine" (1 mil Metalized top and white bottom/silver on white), "Black" plastic (3) black-on-black (Can-Grow-XSB, 0.6 mil), (4) black-on-white (Can-Grow XSB, 0.9 mil), (5) "White" plastic; white-on-black (Can-Grow XSB, 0.9 mil), and (6) bare soil with no mulch. The mulches were manufactured by Canslit Inc., Victoriaville, Quebec, Canada and supplied by Imaflex, Inc., Thomasville, North Carolina, USA.

The experimental design was randomized complete block with split plots. There were three blocks (replicates); each block consisted six beds (main plots), where each 54-m long whole plot was one mulch treatment and was divided into 12 equal 3.05-m long subplots. Each subplot was a different crop. Within each bed, there was a 1.52 m buffer between each subplot to minimize the dispersion of *A. swirskii* from one subplot to the next. Each of the six crop species was established in one-half of a main plot where *A. swirskii* was released. Similarly, the six crops were arranged in the other half of the main plot, where no *A. swirskii* was released (control treatment). A 91-cm center to center spacing was maintained between main plots. Each block was separated by a 3.05 m fallow area, which was kept weed free mechanically throughout the experiments to prevent the dispersal of *A. swirskii*.

In 2016, the only crops tested were eggplant and cucumber. Mulch treatments were two reflective mulch types, silver on white and silver on black, and the standard white on black. Based on our 2015 study, the number of mulches and crops were reduced in 2016. In 2015, higher number of *T. palmi* was found in eggplant and cucumber compared to other four crops. Moreover, among non-UV-reflective plastic mulches, white on black mulch had higher number of melon thrips compared to black on black and black on white plastic mulches. Even, a greater number of melon thrips was present in white on black mulch compared to no mulch control treatment. In contrast, both UV reflective mulches had lesser number of *T. palmi* than the other plastic mulch and control treatments.

The experimental design in 2016 was similar to that of 2015; however, there were four blocks (replicates). Each block had three 22.86-m long parallel beds (main plots) for each mulch treatment. Main plots were divided into four equal 4.57-m long subplots one of each crop for the mite treatment and one of each crop for the no mite (control) treatment. There was a 1.52 m buffer between subplots. Within blocks, main plots were separated by 1.8 m to minimize the dispersion of *A. swirskii*. Crops were randomized within each plastic mulch treatment and mulch treatments were randomized within each block. Blocks were separated by a 3.05 m fallow area, which was kept weed free as was done in the 2015 experiment.

2.3. Crop establishment

In 2015 on 13 Nov., greenhouse-grown, insect-free five-week-old transplants of tomato, eggplant, and pepper were planted manually in the field within beds spaced 45, 45 and 31 cm apart, respectively. For crops grown from seed, two seeds of squash, three seeds of cucumber, and three seeds of snap bean were manually seeded 31, 31, and 15 cm apart, respectively. Following germination, squash and cucumber were thinned to one plant and snap bean to two plants per hole. Transplants of tomato, pepper, and eggplant were planted on the day when 95% of bean, squash, and cucumber seeds germinated to develop a homogeneous foliage canopy for melon thrips adults.

In 2016, on 8 Nov., cucumber was directly seeded, and greenhouse-grown, insect-free transplants of eggplant were planted on 12 Nov., one day after the germination of cucumber.

2.4. Crop management

In 2015 and 2016, following transplantation, approximately 230 ml of starter fertilizer (20-20-20: N–P–K; Diamond R Fertilizer Inc. Ft. Pierce, FL, USA) solution (20 g/3.78 L of water) was applied as a drench at the base of each transplant using a backpack sprayer without a nozzle tip. Irrigation (drip system) and fertilizer (N–P–K: 3-0-10; Helena Chemical Co., Alachua, FL, USA) applications were maintained followed the recommended standard practices for vegetable production in Florida (Dittmar et al., 2015). Lepidopteran insects, including melonworms, *Diaphania hyalinata* (L.) and pickleworms, *Diaphania nitidalis* (Stoll), were controlled with DiPel® DF (*Bacillus thuringiensis* var. 'Kurstaki' strain ABTS-351, Valent Biosciences Co., Walnut Creek, CA, USA) and Xentari® DF (*B. thuringiensis* var. 'Aizawa' Valent Biosciences Co.), each applied at 2.24 kg/ha twice each year each crop. Bacterial and fungal pathogens were controlled with copper hydroxide (0.8 L/ha, Kocide® 3000, BASF Ag Products, Research Triangle Park, NC, USA), and chlorothalonil (1.75 L/ha, Bravo Weather Stik®, Syngenta Crop Protection Inc., Greensboro, NC, USA) and Mancozeb (1.68 kg/ha, Dithane® DF, Dow Agro Sciences, Zionsville, IN, USA) in weekly rotation. In 2015, application of the above-mentioned products was discontinued 25 days before releasing *A. swirskii*. However, because *A. swirskii* were released early in 2016, applications of the above-mentioned fungicides and biological insecticides continued that year after releasing *A. swirskii*, although, applications were discontinued within three days of releasing *A. swirskii*.

2.5. Source and maintenance of *A. swirskii*

A. swirskii were supplied by Koppert Biological Systems Inc., Howell, Mississippi, USA. Upon arrival, mites in vermiculite with bran were stored in a growth chamber maintained at 11 ± 1 °C, $60 \pm 5\%$ RH, with a 12h light: 12h dark period and released 24–48 h after arrival.

2.6. Pre-release sampling and *A. swirskii* application

In 2015, pre-release leaf sampling was done on 25 December, 24 h before the first release of *A. swirskii*. Sampling was done by collecting five fully expanded leaves randomly from the middle third of five plants in each subplot. Samples were processed as described by Seal and Baranowski (1992) and melon thrips adults and larvae were counted using a binocular microscope (Leica MZ6, Leica MicrosystemsInc., Buffalo Grove, IL, USA) at a 10X magnification.

The number of mites released on each plant was 40–50. At a time, ten to fifteen mites were released on each plant's broader leaves at the middle stratum by collecting roughly 0.10 g of bran from the vermiculite using long forceps (Specimen-10-Forceps, Bioquip products, Inc., CA, USA) with a flat tip. The amount of bran and number of *A. swirskii* in the bran were standardized by collecting bran from vermiculite at least 10 times and counting *A. swirskii* under a stereomicroscope at a 20X magnification. The number of mites per plant was increased to 40–50 by four releases over two consecutive days in each crop. In the first phase, curative release of *A. swirskii* was made on all crops at 49 days after planting (DAP) on 26–27 December 2015. A second release was performed four weeks after the first release (77 DAP, 25–26 January 2016), with the same number of *A. swirskii* and application methods as described for the first release. The second release was made only on Jalapeño pepper and eggplants because cucumber, snap bean and squash had reached senescence by that date. Tomato was excluded from the second release because *A. swirskii* did not establish on tomato after the first release. *Amblyseius swirskii* was released in the morning (8:00 am) and afternoon (5:00 pm) to avoid high solar intensity. Releasing *A. swirskii* during periods of heavy rains and high wind was also avoided.

In 2016, the method and numbers of *A. swirskii* released were generally the same as in 2015. An exception was that in 2015, *A. swirskii* was released early in the season (preventive release) when the population of melon thrips was low. Pre-release visual sampling was done by counting the thrips on the lower surface of the leaf. Five plants were selected randomly from each subplot for visual sampling. *Amblyseius swirskii* were released on 27 November 2016 when the number of melon thrips adults was 0–5/plant. The first release of *A. swirskii* was done 15 days after germination of cucumber and planting of eggplant. The second release was done 18 days after the first release (33 DAP).

2.7. Evaluation method

In 2015, post-release sampling was done two weeks after the first release as previously described for pre-release sampling. The number of thrips at each sample was determined as described by Seal and Baranowski (1992). For the second phase predator release, thrips were counted seven days after the release of *A. swirskii*.

In 2016, the first thrips count was done two weeks after the first mite release following the method as described in pre-release sampling. The second and third evaluations were done 10 d and 20 d, respectively, after the second release. In the second release, evaluation was done by sampling four fully expanded leaves from each subplot.

2.8. Statistical analyses

All data were subjected to square root transformation before statistical analyses to meet the assumption of normality. Data were analyzed separately for each year and each evaluation date using a mixed model ANOVA (PROC GLIMMIX model, SAS version 9.3, SAS Institute Inc. Cary, NC, USA) with the fixed effects consisting mulch and crop type, and mite treatment and their interactions. Replication for each factor was considered as random effects in the model. In the PROC GLIMMIX model, the method of Kenward-Roger's was used to compute degrees of freedom. For adults, larvae, and total numbers of *T. palmi*, differences among means were determined by Tukey's HSD (Honestly Significant Difference) procedure in SAS (SAS Institute, Inc. Cary, NC, USA). All data were analyzed at the 5% significance level. Non-transformed means and standard errors are presented in the figure and tables.

3. Results

In 2015, during the first release at 49 DAP, there were no significant statistical interactions between crop and *A. swirskii* treatment or mulch and *A. swirskii* treatment ($P > 0.05$) (Table 1). *Amblyseius swirskii* did not reduce the populations of adults, larvae or the total number of *T. palmi* compared with the no *A. swirskii* treatment in the same crop and same mulch treatment (Tables 1–4). After the second release at 77 DAP, *A. swirskii* reduced the number of *T. palmi* compared to the control treatment ($P < 0.05$) (Table 1). Fewer adults, larvae and total thrips were found in the plots in which *A. swirskii* was released relative to the plots with no *A. swirskii* released (Tables 1 and 2). There was a significant interaction between crop and mite treatment ($P < 0.05$) (Table 1). In both eggplant and pepper in 2015, melon thrips populations were significantly lower in the plots where mites were released than in the control plots (Table 3). There were no significant interactions between *A. swirskii* and mulch treatments. On both sampling dates, numbers of melon thrips were not different in metalized mulches as well as in the other mulches and no mulch treatment (Table 4).

In 2016, preventive release of *A. swirskii* at 15 DAP and evaluated 14 days after release (DAR) significantly reduced the number of *T. palmi* larvae and the total number of thrips compared with the control treatment (Tables 1 and 2). The number of *T. palmi* larvae was 50% lower in the *A. swirskii* treated plots than the non-treated plots. However, the number of adult thrips was not reduced by the *A. swirskii* treatment. In 2016, there were no significant interactions between *A. swirskii* and mulch treatments, or *A. swirskii* and crop (Table 1). The number of *T. palmi* in each crop did not differ significantly from that of the control treatment (Table 5). The number of thrips was also similar in the control and mite-treated plots for each mulch treatment. The number of *T. palmi* in the *A. swirskii* treatment was 47%, 45% and 37% lower in the silver on black, silver on white and white on black mulch treatments, respectively compared to the control treatment with no mites released (Table 6).

In 2016, the second release of *A. swirskii* at 33 DAP, evaluated 10 DAR did not significantly reduce the number of melon thrips (Table 1).

Table 1

Analysis of Variance (ANOVA) table of effects of crop, *A. swirskii* and mulch treatments on the number of *T. palmi*.

Year	Release times	Evaluation	Effect	Thrips stage								
				Adults			Larvae			Total (Adults + Larvae)		
				df*	*F*	*P*	df*	*F*	*P*	df*	*F*	*P*
2015	49 DAP	14 DAR	Mite treatment	1, 142	1.38	0.24	1, 22	1.02	0.32	1, 22	1.18	0.29
			Crop × Mite treatment	5, 142	1.17	0.33	5, 120	0.99	0.43	5, 120	1.15	0.34
			Mulch × Mite treatment	5, 142	0.21	0.96	5, 22	0.43	0.82	5, 22	0.38	0.86
			Crop × Mulch × Mite treatment	25, 142	0.62	0.92	25, 120	0.24	0.99	25, 120	0.24	0.99
2015	77 DAP	7 DAR	Mite treatment	1, 24	33.49	<0.0001	1, 46	32.41	<0.0001	1, 46	36.32	<0.0001
			Crop × Mite treatment	1, 24	35.91	<0.0001	1, 46	22.02	<0.0001	1, 46	24.90	<0.0001
			Mulch × Mite treatment	5, 24	0.68	0.64	5, 46	0.76	0.58	5, 46	0.75	0.59
			Crop × Mulch × Mite treatment	5, 24	0.43	0.82	5, 46	0.80	0.55	5, 46	0.74	0.60
2016	15 DAP	14 DAR	Mite treatment	1, 36	1.25	0.27	1, 9	18.37	0.002	1, 27	14.36	0.0008
			Crop × Mite treatment	1, 36	2.45	0.13	1, 18	1.33	0.26	1, 27	3.86	0.06
			Mulch × Mite treatment	2, 36	0.0	1.0	2, 9	0.94	0.43	2, 27	0.18	0.84
			Crop × Mulch × Mite treatment	2, 36	2.48	0.1	2, 18	0.01	0.99	2, 27	1.04	0.37
2016	33 DAP	10 DAR	Mite treatment	1, 33	0.26	0.61	1, 36	1.66	0.21	1, 36	1.52	0.22
			Crop × Mite treatment	1, 33	0.27	0.61	1, 36	2.81	0.10	1, 36	2.67	0.11
			Mulch × Mite treatment	2, 33	0.54	0.59	2, 36	2.67	0.08	2, 36	2.62	0.08
			Crop × Mulch × Mite treatment	2, 33	2.45	0.10	2, 36	0.42	0.66	2, 36	0.53	0.59
2016	33 DAP	20 DAR	Mite treatment	1, 36	5.25	0.03	1, 36	4.34	0.04	1, 36	5.75	0.02
			Crop × Mite treatment	1, 36	0.21	0.65	1, 36	0.98	0.33	1, 36	0.96	0.33
			Mulch × Mite treatment	2, 36	0.96	0.39	2, 36	0.92	0.41	2, 36	1.12	0.34
			Crop × Mulch × Mite treatment	2, 36	1.30	0.28	2, 36	3.43	0.04	2, 36	3.67	0.03

DAP (Days after planting), DAR (Days after release). *Numerator and denominator of df.

Table 2

Effect of *A. swirskii* on the mean ± SE number of *T. palmi* pooled for all crop and mulch treatments.

Year	Release times	Evaluation	Treatment	Mean (±SE) numbers per sample		
				No. adults	No. larvae	No. total
2015	49 DAP	14 DAR	C	91.49 ± 9.68a[a]	982.73 ± 105.46a[a]	1074.22 ± 113.50a[a]
			T	102.46 ± 10.90a	1077.63 ± 117.79a	1180.09 ± 125.99a
	77 DAP	7 DAR	C	8.69 ± 1.65a	74.67 ± 17.21a	83.36 ± 18.66a
			T	2.19 ± 0.37b	19.86 ± 3.73b	22.06 ± 4.0b
2016	15 DAP	14 DAR	C	67.00 ± 18.07a	141.21 ± 22.65a	208.21 ± 36.26a
			T	58.00 ± 17.20a	65.92 ± 10.31b	123.92 ± 22.39b
	33 DAP	10 DAR	C	125.00 ± 17.27a	2077.50 ± 457.71a	2202.50 ± 466.86a
			T	115.71 ± 15.72a	2684.25 ± 584.69a	2799.58 ± 593.24a
		20 DAR	C	177.50 ± 32.11a	1433.33 ± 125.53a	1610.83 ± 131.82a
			T	128.75 ± 24.73b	1214.17 ± 134.27b	1342.92 ± 147.99b

[a] Means in the same column for control (C) and *A. swirskii* (T) treatments with different letters are significantly different according to Tukey's HSD test ($P \leq 0.05$). Total = adults + larvae; DAP (Days after planting); DAR (Days after release).

There were no significant interactions between *A. swirskii* and crop or *A. swirskii* and mulch treatment ($P > 0.05$). In some instances, the number of larvae and the total number of melon thrips were higher in the *A. swirskii* treated plots than in the control plots for each crop and mulch treatment (Tables 5 and 6).

The second release of *A. swirskii* at 33 DAP evaluated at 20 DAR in 2016, reduced the number of adult, larva, and total number of melon thrips compared to the control plots with no mites released (Tables 1 and 2). There were no significant interactions between mite and crop or mite and mulch treatment ($P > 0.05$). The mean number of *T. palmi* adults, larvae and the total number did not differ between the *A. swirskii* treated plots and the control plots for each crop and mulch treatment (Tables 5 and 6).

Throughout the entire sampling period in 2016, the number of thrips was lower in both metalized reflective mulch treatments (silver on black and silver on white) than in the white on black mulch treatment (Table 6). Late season sampling in 2015 showed that the thrips number did not differ in metalized and non-metalized mulch treatments (Table 4).

4. Discussion

In 2015, curative release of *A. swirskii* at 49 DAP, did not reduce *T. palmi* adults or larvae regardless of crop or mulch treatment. This may have been due to the lack of adequate time for *A. swirskii* populations to increase to a sufficient density to cope with prey populations. Arévalo et al. (2009) reported that both preventive and curative releases of *Amblyseius cucumeris* (Oudemans) (Acari: Phytoseiidae) alone or in combination with *Orius insidiosus* Say (Hemiptera: Anthocoridae) did not control flower thrips in blueberry due to the short period after release, which was not sufficient to build up the population for natural enemies. In the present study, by the time *A. swirskii* was released, the population of *T. palmi* was high making it difficult for *A. swirskii* to control melon thrips. The density of *T. palmi* (adult plus larva) per five-leaf sample was 2015, 1415, 728, 273, 63 and 20 in eggplant, cucumber, squash, snap bean, pepper, and tomato, respectively (Fig. 1).

During the week that the mites were released for the first time in 2015, there was a heavy rain (0.91 cm) recorded by a weather station of the Florida Automated Weather Network (FAWN) located within a few

Table 3
Effect of *A swirskii* on the number of *T. palmi* on different crops at 14 and 7 days after release (DAR) in 2015.

Release times	Evaluation	Crop	Treatment	Mean (±SE) numbers per sample		
				No. adults	No. larvae	No. total
49 DAP	14 DAR	Cucumber	C	187.3 ± 18.3a[a]	1270.0 ± 115.4a[a]	1448.3 ± 119.6a[a]
			T	231.8 ± 21.8a	1541.1 ± 115.9a	1772.9 ± 114.4a
		Eggplant	C	200.5 ± 17.7a	2075.6 ± 154.3a	2276.1 ± 167.9a
			T	196.7 ± 17.5a	2056.4 ± 200.2a	2253.1 ± 207.4a
		Squash	C	147.5 ± 17.6a	2393.3 ± 192.9a	2540.8 ± 204.4a
			T	162.7 ± 19.9a	2716.7 ± 237.9a	2879.4 ± 249.3a
		Snap bean	C	16.9 ± 2.0a	136.1 ± 12.9a	153.0 ± 14.5a
			T	18.4 ± 1.9a	127.6 ± 11.9a	146.0 ± 13.1a
		Pepper	C	3.8 ± 0.6a	16.9 ± 1.9a	20.8 ± 2.1a
			T	3.9 ± 0.8a	18.6 ± 2.7a	21.9 ± 2.8a
		Tomato	C	1.9 ± 0.3a	4.5 ± 0.8a	6.4 ± 0.9a
			T	1.7 ± 0.4a	5.5 ± 1.2a	7.2 ± 1.4a
77 DAP	7 DAR	Eggplant	C	16.6 ± 2.0a	145.4 ± 25.1a	161.9 ± 26.6a
			T	3.8 ± 0.5b	37.5 ± 4.6b	41.3 ± 4.7b
		Pepper	C	0.8 ± 0.2a	4.0 ± 0.4a	4.8 ± 0.4a
			T	0.6 ± 0.2b	2.2 ± 0.3b	2.8 ± 0.3b

[a] Means within the same column for each crop with different letters are significantly different according to Tukey's HSD test ($P \leq 0.05$). Total = adults + larvae; C (control), T (*A. swirskii* treated); DAP (Days after planting).

Table 4
Effect of *A swirskii* on the number of *T. palmi* detected in different mulch treatments at different days after release (DAR) in 2015.

Release times	Evaluation	Mulch	Treatment	Mean (±SE) numbers per sample		
				No. adults	No. larvae	No. total
49 DAP	14 DAR	SB	C	86.4 ± 20.7*	910.0 ± 228.3*	996.4 ± 245.9*
			T	83.8 ± 23.6	901.4 ± 219.9	985.3 ± 238.4
		SW	C	88.3 ± 23.6	1015.8 ± 249.1	1104.2 ± 266.5
			T	110.7 ± 30.0	1113.1 ± 306.0	1223.8 ± 324.7
		BB	C	88.1 ± 22.4	946.4 ± 257.3	1034.6 ± 275.0
			T	99.9 ± 24.7	1198.4 ± 297.5	1298.3 ± 317.1
		BW	C	102.4 ± 27.1	991.1 ± 263.9	1093.5 ± 286.4
			T	108.5 ± 26.0	1156.1 ± 286.2	1264.6 ± 309.1
		WB	C	103.6 ± 30.0	1153.6 ± 332.3	1257.2 ± 359.6
			T	129.4 ± 36.9	1091.9 ± 343.2	1221.3 ± 371.6
		NM	C	80.1 ± 19.8	879.4 ± 238.3	959.4 ± 254.6
			T	82.4 ± 19.9	1004.7 ± 300.6	1087.8 ± 314.4
77 DAP	7 DAR	SB	C	8.3 ± 4.2	46.3 ± 28.8	54.7 ± 32.9
			T	1.7 ± 0.8	18.2 ± 9.2	19.8 ± 9.9
		SW	C	9.0 ± 3.9	70.5 ± 39.1	79.5 ± 42.6
			T	2.2 ± 1.0	26.2 ± 11.6	28.3 ± 12.4
		BB	C	12.3 ± 5.6	115.3 ± 67.2	127.7 ± 72.5
			T	3.2 ± 1.5	16.5 ± 7.8	19.7 ± 9.3
		BW	C	9.8 ± 4.9	87.0 ± 50.5	96.8 ± 54.6
			T	1.7 ± 0.7	16.8 ± 7.9	18.5 ± 8.5
		WB	C	6.3 ± 3.5	37.0 ± 17.8	43.3 ± 20.8
			T	2.5 ± 0.6	12.8 ± 5.7	15.3 ± 5.8
		NM	C	6.3 ± 3.5	91.8 ± 42.8	98.2 ± 45.8
			T	2.0 ± 0.9	28.7 ± 13.0	30.7 ± 14.0

*There was no significant difference between *A. swirskii* treatments within each mulch treatment according to Tukey's HSD test ($P > 0.05$).
Silver on black (SB), Silver on white (SW), and White on black (WB). Total = adults + larvae; C (control), T (*A swirskii* treated); DAP (Days after planting).

thousand meters of the research plots (https://fawn.ifas.ufl.edu/). This rain could have hindered the population buildup of *A. swirskii*, although there was a high population density of thrips at that time (Fig. 1). Environmental factors such as temperature, relative humidity and rainfall, as well as starvation in natural environments can inhibit the population buildup of arthropod communities (Wolda, 1978; Yaninek et al., 1998; Ghazy et al., 2016).

Melon thrips adults and larvae were controlled by *A. swirskii* after the second release at 77 DAP (29 January 2016). In the late season, when leaves of crops began to senesce, the thrips population decreased. At that time, there was a clear difference between *A. swirskii* treated and non-treated plots with considerably higher numbers of *T. palmi* in the non-treated plots. Moreover, we observed 5–10 *Orius insidiosus* in almost all samples of eggplant and pepper. *Orius* is an efficient predator of *T. palmi* adults and larvae (Seal, 1997). In previous studies, *Orius insidiosus* effectively reduced *Frankliniella* thrips in field-grown pepper (Funderburk et al., 2000; Ramachandran et al., 2001) and chilli thrips in greenhouse-grown pepper (Doğramaci et al., 2011). Chow et al. (2010) found that *Orius insidiosus* can control *Frankliniella occidentalis* and coexist with *A. swirskii* on greenhouse roses. Moreover, *Orius insidiosus* did not show preference for *A. swirskii* over larvae or adult of *F. occidentalis* when the number of prey (*F. occidentalis*) was higher than *A. swirskii*. Therefore, some of the reductions in melon thrips observed in the present study were presumably due to *O. insidiosus*.

In 2016, the number of melon thrips larvae and the total number of thrips was reduced in response to the preventive release of *A. swirskii* at 15 DAP when the population density of melon thrips was low. Several studies have demonstrated that *A. swirskii* reduced the number of thrips

Table 5
Effect of *A swirskii* treatment on the number of *T. palmi* detected on cucumber and eggplant leaves at different days after release (DAR) in 2016.

Release times	Evaluation	Crop	Treatment	Mean (±SE) numbers per sample		
				No. adults	No. larvae	No. total
15 DAP	14 DAR	Cucumber	C	40.8 ± 14.8[a]	68.6 ± 11.5[a]	109.4 ± 22.4a[a]
			T	59.8 ± 29.2	34.6 ± 10.9	94.3 ± 33.9
		Eggplant	C	93.2 ± 32.0	213.8 ± 32.5	307.0 ± 56.8
			T	56.3 ± 19.6	97.3 ± 12.1	153.5 ± 28.1
33 DAP	10 DAR	Cucumber	C	95.0 ± 19.4	2187.5 ± 805.0	2282.5 ± 817.1
			T	80.6 ± 20.2	2235.2 ± 798.6	2315.8 ± 811.1
		Eggplant	C	155.0 ± 26.9	1967.5 ± 475.2	2122.5 ± 492.6
			T	150.8 ± 20.1	3133.3 ± 869.0	3284.2 ± 878.2
	20 DAR	Cucumber	C	227.5 ± 59.7	1081.7 ± 137.0	1309.2 ± 180.1
			T	179.2 ± 43.7	1063.3 ± 240.6	1242.5 ± 276.4
		Eggplant	C	127.5 ± 17.0	1785.0 ± 157.0	1912.5 ± 153.9
			T	78.3 ± 13.6	1365.0 ± 115.7	1443.3 ± 115.6

[a] There was no significant difference between *A. swirskii* treatments within each crop according to Tukey's HSD test ($P > 0.05$). Total = adults + larvae; C (control), T (*A. swirskii* treated); DAP (Days after planting).

Table 6
Effect of *A swirskii* treatment on the number of *T. palmi* in different mulch treatments detected at different days after release (DAR) in 2016.

Release times	Evaluation	Mulch	Treatment	Mean (±SE) numbers per sample		
				No. adults	No. larvae	No. total
15 DAP	14 DAR	SB	C	18.6 ± 3.9*	108.8 ± 37.8*	127.4 ± 42.6*
			T	13.1 ± 3.3	54.8 ± 18.4	68.1 ± 20.6
		SW	C	18.9 ± 2.5	119.5 ± 21.7	136.4 ± 22.7
			T	11.3 ± 1.5	63.9 ± 13.1	75.1 ± 13.8
		WB	C	165.5 ± 33.4	195.4 ± 50.3	360.9 ± 75.6
			T	149.4 ± 33.4	79.1 ± 22.3	228.5 ± 44.5
33 DAP	10 DAR	SB	C	125.0 ± 33.5	821.3 ± 112.9	946.3 ± 144.2
			T	80.1 ± 17.2	800.5 ± 161.1	880.6 ± 170.1
		SW	C	77.5 ± 12.2	991.3 ± 149.1	1068.8 ± 160.0
			T	94.5 ± 22.2	967.3 ± 233.2	1061.8 ± 241.5
		WB	C	172.5 ± 32.0	4420.0 ± 923.1	4592.5 ± 936.5
			T	172.5 ± 30.6	6285.0 ± 716.8	6457.5 ± 716.2
	20 DAR	SB	C	121.3 ± 16.1	1285.0 ± 265.5	1406.3 ± 266.4
			T	93.8 ± 17.4	1117.5 ± 194.9	1211.3 ± 189.6
		SW	C	136.3 ± 28.0	1293.8 ± 181.2	1430.0 ± 179.0
			T	57.5 ± 7.7	925.0 ± 242.3	982.5 ± 241.4
		WB	C	275.0 ± 84.1	1721.3 ± 185.0	1996.3 ± 190.8
			T	235.0 ± 56.1	1600.0 ± 215.6	1835.0 ± 257.0

*There was no significant difference between *A. swirskii* treatments within each mulch treatment according to Tukey's HSD test ($P > 0.05$).
Silver on black (SB), Silver on white (SW), and White on black (WB). Total = adults + larvae; C (control), T (*A. swirskii* treated), DAP (Days after planting).

species infesting vegetable crops in greenhouse, shade house or semi-field situations where thrips population density was low (Arthurs et al., 2009; Messelink et al., 2008; Calvo et al., 2011; Doğramaci et al., 2011; Kakkar et al., 2016). In the present study, although we recorded reductions in the population of thrips larvae, we did not see a similar pattern with adults. The inability of *A. swirskii* to control *T. palmi* adults in the field could have been due to the mobility of the adults. We noticed that *T. palmi* adults were not preyed upon by *A. swirskii* in a choice test (M. A. Razzak, unpublished results). Again, *A. swirskii* failed to control *T. palmi* when the *T. palmi* population density increased after the second release in 2016 (sampled 10 DAR), which is supported by the results from the mite release at 49 DAP in 2015. Similar to the findings of Kakkar et al. (2016), reduction in the *T. palmi* density 20 days after releasing *A. swirskii* demonstrates that this mite can effectively control thrips if environmental conditions are favorable for this mite species.

Early in the season in 2016, the number of melon thrips was lower in the metalized reflective mulches than in white on black mulch which is supported by Reitz et al. (2003); Riley and Pappu (2004) and Razzak and Seal (2017). In 2015, late season sampling when plants canopy shaded the mulched area, melon thrips number were almost similar in metalized reflective and non-metalized mulches, and no mulch area which is consistent with the previous reports of Kring and Schuster (1992); Csizinszky et al. (1995); and Summers et al. (2010). Therefore, metalized reflective mulch may be useful for controlling *T. palmi* in field grown vegetable crops.

5. Conclusions

The curative release of *A. swirskii* is not effective for managing *T. palmi* populations in vegetable crops where the potential for thrips infestation is high. Preventive release of *A. swirskii* is more effective than curative release but may require additional integrated tactics to manage *T. palmi* adults. Potential integrated tactics for effective management of *T. palmi* may involve utilizing UV reflective mulch and weekly releases of *A. swirskii. Amblyseius swirskii* has potential as a component of an integrated management approach to control *T. palmi* in vegetable crops. The information generated from this study should be helpful for developing an environmentally friendly integrated management program for controlling *T. palmi* or other thrips species in vegetable crops.

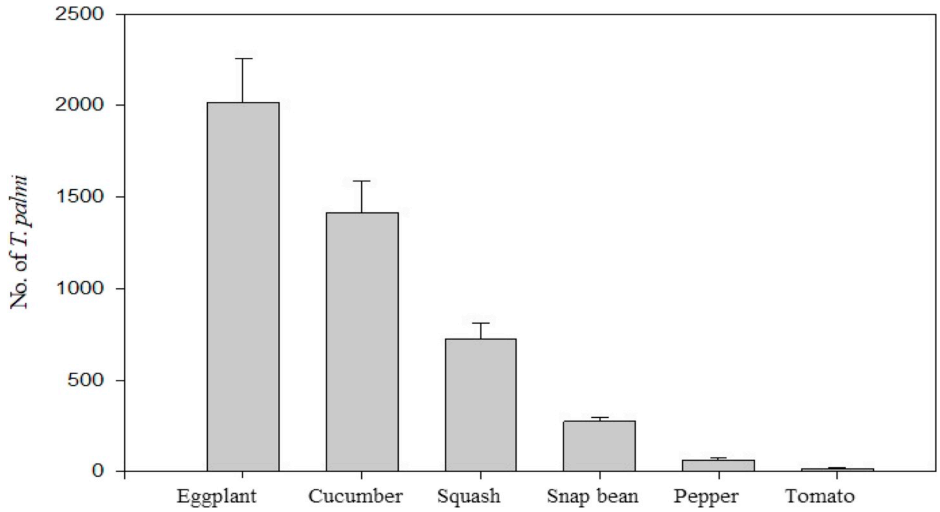

Fig. 1. Prerelease mean ± SE number of *T. palmi* per five-leaf sample in six vegetable crops, 2015

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References

Arévalo, H.A., Fraulo, A.B., Liburd, O.E., 2009. Management of flower thrips in blueberries in Florida. Fla. Entomol. 92, 14–17.

Arthurs, S., McKenzie, C.L., Chen, J., Dogramaci, M., Brennan, M., Houben, K., Osborne, L., 2009. Evaluation of *Neoseiulus cucumeris* and *Amblyseius swirskii* (Acari: Phytoseiidae) as biological control agents of chilli thrips, *Scirtothrips dorsalis* (Thysanoptera: Thripidae) on pepper. Biol. Control 49, 91–96.

Bao, W.X., Narai, Y., Nakano, A., Kaneda, T., Murai, T., Sonoda, S., 2014. Spinosad resistance of melon thrips, *Thrips palmi*, is conferred by G275E mutation in α-6 subunit of nicotinic acetylcholine receptor and cytochrome P450 detoxification. Pestic. Biochem. Physiol. 112, 51–55.

Blasco, M.J., Qureshi, J.A., Urbaneja, A., Stansly, P.A., 2012. Predatory mite, *Amblyseius swirskii* (Acari: Phytoseiidae), for biological control of asian citrus psyllid, *Diaphorina citri* (Hemiptera: psyllidae). Fla. Entomol 95, 543–551.

Brodsgaard, H.F., Stengaard, L.H., 1992. Effect of *Amblyseius cucumeris* and *Amblyseius barkeri* as biological control of *Thrips tabaci* on glasshouse cucumbers. Biocontrol Sci. Technol. 2, 215–223.

Calvo, F.J., Blockmans, K., Belda, J.E., 2011. Control of *Bemisia tabaci* and *Frankliniella occidentalis* in cucumber by *Amblyseius swirskii*. Biocontrol 56, 185–192.

Calvo, F.J., Knapp, M., Houten, van Y.M., Hoogerbrugge, H., Belda, J.E., 2015. *Amblyseius swirskii*: what made this predatory mite such a successful biological control agent? Exp. Appl. Acarol. 65, 419–433.

Chow, A., Chau, A., Heinz, K.M., 2010. Compatibility of *Amblyseius* (*typhlodromips*) *swirskii* (Athias-Henriot) (Acari: Phytoseiidae) and *Orius insidiosus* (Hemiptera: Anthocoridae) for biological control of *Frankliniella occidentalis* (thysanoptera: Thripidae) on roses. Biol. Control 53, 188–196.

Cock, M.J., Lenteren, J.C., Brodeur, J., Barratt, B.I., Bigler, F., Bolckmans, K., 2010. Do new access and benefit sharing procedures under the convention on biological diversity threaten the future of biological control? Biol. Control 155, 199–218.

Csizinszky, A., Schuster, D., Kring, D.J., 1995. Color mulches influence yield and insect pest populations in tomatoes. J. Am. Soc. Hortic. Sci. 120, 778–784.

Dittmar, P.J., Freeman, J.H., Vallad, G.E. (Eds.), 2015. Commercial Vegetable Production in Florida. Vegetable Production Handbook of Florida. UF, IFAS extension, University of Florida, p. 248.

Doğramaci, M., Arthurs, S., Chen, J., Mckenzie, C.L., Irriza, F., Osborne, L., 2011. Management of chili thrips, *Scirtothrips dorsalis* (thysanoptera: Thripidae) on peppers by *Amblyseius swirskii* (Acari: Phytoseiidae) and *Orius insidiosus* (Hemiptera: anthochoridae). Biol. Control 59, 340–347.

Funderburk, J., Stavisky, J., Olson, S., 2000. Predation of *Frankliniella occidentalis* (thysanoptera: Thripidae) in field peppers by *Orius insidiosus* (Hemiptera: Anthocoridae). Environ. Entomol. 29, 376–382.

Ghazy, N.A., Osakabe, M., Negm, M.W., Schausberger, P., Gotoh, T., Amano, H., 2016. Phytoseiid mites under environmental stress. Biol. Control 96, 120–134.

Kakkar, G., Kumar, V., Seal, D.R., Liburd, O.E., Stansly, P.A., 2016. Predation by *Neoseiulus cucumeris* and *Amblyseius swirskii* on *Thrips palmi* and *Frankliniella schultzeii* on cucumber. Biol. Control 92, 85–91.

Kring, J.B., Schuster, D.J., 1992. Management of insects on pepper and tomato with UV-reflective mulches. Fla. Entomol. 75, 119–129.

Messelink, G.J., Steenpaal, S.E.F., Wensveen, W.V., 2005. *Typhlodrompis swirskii* (Athias-Henriot) (Acari: Phytoseiidae): a new predator for thrips control in greenhouse cucumbers. IOBC-WPRS Bull. 28, 183–186.

Messelink, G.J., Maneen, R., Steenpaal, Jan S.V., Seen, A., 2008. Biological control of thrips and whiteflies by a shared predator: two pests are better than one. Biol. Control 44, 372–379.

Mound, L.A., Teulon, D.A.J., 1995. Thysanoptera as phytophagous opportunists. In: Parker, B.L., Skinner, M., Lewis, T. (Eds.), Thrips Biology and Management. Plenum, New York, pp. 2–19.

Parrella, M.P., Lewis, T., 1997. Integrated pest management (IPM) in field crops. In: Lewis, T. (Ed.), Thrips as Crop Pests. CAB International, Wallingford, UK, pp. 595–614.

Ramachandran, S., Funderburk, J., Stavisky, J., Olson, S., 2001. Population abundance and movement of *Frankliniella* species and *Orius insidiosus* in pepper. Agric. For. Entomol. 3, 1–10.

Razzak, M.A., Seal, D.R., 2017. Effect of plastic mulch on the abundance of *Thrips palmi* Karny (Thysanoptera: Thripidae) and yield of 'Jalapeno' pepper in south Florida. Proc. Fla. State Hortic. Soc. 130, 124–128.

Reitz, S.R., Yearby, E.L., Funderburk, J.E., Stavisky, J., Momol, M.T., Olson, S.M., 2003. Integrated management tactics for *Frankliniella* thrips (Thysanoptera: Thripidae) in field grown pepper. J. Econ. Entomol. 96, 1201–1214.

Reitz, S.R., Gao, Y., Lei, Z., 2011. Thrips pests concern to China and the United States. Agric. Sci. China 10, 867–892.

Riley, D.G., Pappu, H.R., 2004. Tactics for management of thrips (Thysanoptera: Thripidae) and tomato spotted wilt *Tospovirus* in Tomato. J. Econ. Entomol. 97, 1648–1658.

Seal, D.R., 1997. Management and biology of *Thrips palmi* karny (thysanoptera: Thripidae). In: Bondari, K. (Ed.), New Developments in Entomology. Research Signpost, T, India, pp. 161–181. C. 36/248 (1), Trivandrum-695008.

Seal, D.R., 2001. Seasonal abundance and distribution of *Thrips palmi* karny (thysanoptera: Thripidae) in southern Florida. Proc. Fla. State Hortic. Soc. 114, 337–342.

Seal, D.R., Baranowski, R.M., 1992. Effectiveness of different insecticides for the control of Thrips palmi Karny (Thysanoptera: Thripidae) affecting vegetables in south Florida. Proc. Fla. State Hort.Soc. 105, 315–319.

Seal, D.R., Kumar, V., 2010. Biological responses of chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae), to various regimes of insecticides. Crop Protect. 29, 1241–1247.

Seal, D.R., Sabines, C.M., 2012. Combating melon thrips, *Thrips palmi* karny (Thysanoptera: Thripidae) in south Florida. Proc. Fla. State Hortic. Soc. 125, 196–200.

Seal, D.R., Kumar, V., Kakkar, G., Mello, S.C., 2013. Abundance of Adventive *Thrips palmi* karny (Thysanoptera: Thripidae) populations in Florida during the first sixteen years. Fla. Entomol. 96, 789–796.

Stansly, P.A., Castillo, J.A., 2009. Control of broad mites, spider mites, and whiteflies using predaceous mites in open field pepper and eggplant. Fla. State Hort. Soc. 122, 253–257.

Summers, C.G., Newton, A.S., Mitchell, J.P., Stapleton, J.J., 2010. Population dynamics of arthropod associated with early season tomato plants as influenced by soil surface microenvironment. Crop Protect. 29, 249–254.

Tyler-Julian, K.A., Funderburk, J.E., Olson, S.M., Paret, M.L., 2015. A stimulo-deterrent method of thrips and Tomato Spotted Wilt virus management in tomatoes. Acta Hortic. (Wagening.) 1069, 251–258.
van Houten, Y.M., Ostlie, M.L., Hoogerbrugge, H., Bolckmans, K., 2005. Biological control of western flower thrips on sweet pepper using the predatory mites *Amblyseius cucumeris, Iphiseius degenerans, A. andersoni* and *A. swirskii*'. IOBC-WPRS Bull. 28, 283–286.
van Lenteren, J.C., 2012. The state of commercial augmentative biological control: plenty of natural enemies, but a frustrating lack of uptake. Biocontrol 57, 1–20.
Wolda, H., 1978. Seasonal fluctuations in rainfall, food and abundance of tropical insects. J. Anim. Ecol. 47, 369–381.
Yaninek, J.S., Mégevand, B., Ojo, B., Cudjoe, A.R., Abole, E., Onzo, A., Zannou, I., 1998. Establishment and spread of *Typhlodromalus manihoti* (Acari Phytoseiidae), an introduced phytoseiid predator of *Mononychellus tanajoa* (Acari: tetranychidae) in Africa. Environ. Entomol. 27, 1496–1505.
Young, G., Zhang, L., 1998. Control of the Melon Thrips, *Thrips Palmi*. Northern Territory of Australia Ag. Note 753. Ag. dex 230/612. 3pp.