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Abundance and Management of Melon Thrips, *Thrips palmi* Karny (Thysanoptera: Thripidae)

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This manuscript contains information on *Thrips palmi* seasonal abundance in bean, *Phaseolus vulgaris* (L.) 'Benton', fields extending from 2004 to 2010. Information on insecticides of diverse mood of action in controlling *T. palmi* is also provided to develop appropriate management program. Population abundance was significantly high in 2004. Population started decreasing until 2008, and increased thereafter. In managing *T. palmi*, spinosad, spinetoram, chlorofenapyr and formatenate hydrochloride provided a significant level (>90%) of control. Among new insecticides, rynaxypyr and cyazypyr were effective in providing 50% to 65% reduction of *T. palmi*. In a recent study conducted in 2010, spinetoram did not provide superior level (<70%) of control of *T. palmi*. Clothianidin and tolfenpyrad showed potentiality in managing *T. palmi.* This information will help develop effective management program for controlling *T. palmi* using insecticides of different modes of action.

The melon thrips, *Thrips palmi* Karny, is a key pest of various vegetable crops in South Florida. It invaded southern Florida in 1990 and caused significant yield loss to various vegetable crops. In a severe instance of population abundance, it caused complete defoliation of host crops due to feeding damage within a week of its initiation of infestation (Seal and Baranowski, 2003). In the wake of such severe economic loss due to *T. palmi* infestation, Seal et al. (1994) conducted several insecticide evaluation studies. In these studies, none of the labeled insecticides provided satisfactory control of this pest.

Thrips palmi originated in Sumatra (Waterhouse and Norris, 1987). Later it moved to Sudan, Pakistan, India, Bangladesh, Thailand, Malaysia, Singapore, Indonesia, Philippines, Hong Kong, China, Taiwan, Japan, and Guam (Sakimura et al., 1986). It was discovered in Hawaii in 1984 and Puerto Rico in 1986 (Johnson, 1986). *Thrips palmi* is widely established in Africa. It invaded Florida in 1990. Its infestation on ornamental and vegetable plants in the Netherlands was reported in 1996 (Seal and Klassen, 1995).

Thrips palmi has a wide host range causing damage both directly by feeding and indirectly by transmitting viral diseases (Honda et al., 1989, Kameya-Iwaki et al., 1988; Sakimura, 1961). During the last few decades, *T. palmi* has extended its host range, which includes plants of the Solanaceae, Cucurbitaceae, and Leguminosae (Nakahara, 1984). In addition to the above host plants, *T. palmi* has been found on onion, cotton, avocado, citrus, peach, plum, muskmelon, carnation, and chrysanthemum in different countries (Bournier, 1983; Gutierrez, 1981; Ruhendi, 1979; Wangboonkong, 1981; Yoshihara, 1982). *Thrips palmi* attacks various legumes, fruiting and leafy vegetables in many countries in tropical and subtropical regions (Bhatti, 1980; Johnson, 1986; Negai et al., 1981). *Thrips palmi* has been recorded as an important pest of vegetable crops in Japan since 1978. In southern Florida, *T. palmi* devastated bean, potato, pepper, squash, cucumber, and eggplant (Seal, 1994; Seal and Baranowski, 1992).

The pattern of population growth and development of *T. palmi* on different host crops vary and contribute to the survival of the pest throughout the year. Consequently, a thorough knowledge of the patterns of seasonal abundance is essential to the development of effective management strategies for *T. palmi*. However, information on population parameters is limited. Johnson (1986) studied population trends of *T. palmi* on watermelon in Hawaii. Seal (1995) recorded the pest's seasonal abundance on potato and eggplants in southern Florida. Seal and Stansly (2000) studied seasonal abundance and within plant distribution of this pest on beans in southern Florida.

Considering the importance of *T. palmi* to fruit, vegetable, and ornamental industries, development of a knowledge-based effective management program has become essential. Information on the effectiveness of various insecticides in managing *T. palmi* and the mode of action of these insecticides is very important. Kawai (1990) evaluated 30 insecticide treatments to control *T. palmi* on vegetable crops and concluded that very few insecticides were effective against this pest. In his study endosulfan and methamidophos provided greater than 50% mortality of *T. palmi*. In 1992, Seal and Baranowski conducted a field study using various insecticides to control *T. palmi* on 'Pod Squad' bean. In this study, formatenate hydrochloride provided significant control *T. palmi*. Combination of azinphosmethy and methomyl in rotation with abamectin significantly suppressed *T. plami* population. Imidacloprid was effective in reducing *T. palmi* on bean (Seal, 1994). In this study use of imidacloprid at planting as a soil drench followed by foliar application provided better results than using either in soil or as a foliar application. Cermell et al. (2002) observed satisfactory reduction of *T palmi* larvae due to imidacloprid (85.97%). avermectin (74.74%), pyropoxifen (69.57%), cartap (57.16%), flufenoxuron (51.36%), diflubenzuron + oil (24.70%). They observed similar results in the control of adults.

The present study has been planned to provide information on the population pattern of *T. palmi* during the last 16 years. In addition, information on the effectiveness of various insecticides

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belonging to various classes having different mode of action will be presented.

Materials and Methods

Seasonal abundance. Studies on population abundance of *T. palmi* in snap bean was conducted in each of 16 consecutive year starting from 1994 to 2010. However, data were presented for each alternate year. For this study, snap bean was planted six times each year; each planting lasted for 2 months. In each planting, 'Pod Squad' bean was directly seeded into a rock dale soil at Tropical Research and Education Center research plots on the first week of the month. Each planting consisted of 12 rows each160 ft long. Seeds were spaced 6 inches within the row and 36 inches in-between the rows. Bean plants were irrigated once daily using a drip system. Fertilizer (N–P–K mix) was applied at 200–50–240 lb/acre. To control weed trifluralin [Treflan EC, 24 lb (product)/acre] was used once 10 d before planting, supplemented during the middle of the season with mechanical cultivation.

The experimental fields were divided into four equal blocks, each 40 ft long and 12 ft wide. Sampling for *T. palmi* was initiated 3 weeks after each planting. Sampling was conducted by collecting four subsamples of five full-grown young leaves, one leaf/plant, from each block. Leaf samples by subplot was placed in a ziplock bag and transported to the laboratory. The leaves were then washed with 70% ethanol to separate thrips adults and larvae from leaves. Total number of *T. palmi* adults and larvae in each subsample was recorded using a bionocular microscope (10×). Mean of all subsamples of a month was presented in the figure.

Effectiveness of various insecticides. Insecticides of various chemical classes were studied to evaluate their effectiveness in controlling *T. palmi* on beans. Various chemical classes included in this study were: 1) glycoside insecticide and fermentation products, 2) benzoyl phenyl urea, 3) carbamates, 4) organophosphates, 5) arylpyrrole, 6) neonicotinoids, and 7) anthranilic diamide. The insecticides belonging to each class evaluated in the present study are shown in Table 1.

Snap bean was planted in 2010 at TREC research plot on three dates, 12 Dec., 22 Feb. and 20 May. Planting and management of crop were as discussed in the seasonal abundance study. Treatment plots consisted of two rows each 30 feet long. Plots were arranged in a randomized complete block design replicated three times. Five feet unplanted buffer area separated the blocks from each other. Treatments were applied on four dates at weekly intervals using a CO_2 backpack sprayer with two nozzles/row delivering100 GPA at 30 psi. Treatments were evaluated weekly 24 h after each application by collecting 10 leaves, one leaf/plant, per treatment plot. Leaves were processed to separate *T. palmi* larvae and adults by following methods as described in the seasonal abundance study. Percentage reduction in the number of *T. palmi* due to each treatment was determined based on the numbers in the nontreated control treatment. Averages across all sampling dates are presented in the table.

Potentiality of new insecticides. Based on the previous study, this study was undertaken to evaluate two potential new insecticides, tolfenpyrad (Torac®, Nichino America) and

Table 1. Percentage control of *Thrips palmi* on 'Pod Squad' bean treated with various insecticides.

Common name	Trade name	Formulation[z]	Rate in oz (lb a.i.)/ acre	Mode of action group	Range of control (%)	Mean % control
			Glycoside insecticide and fermentation products			
Abamectin	Agrimek®	0.15EC	16.0 (0.02)	6	48–67	59.8
Spinosad	Spintor®	2SC	8.0 (0.13)	5	58–75	70.2
Spinetoram	Radiant™	2SC	8.0 (0.13)	5	63–77	74.5
			Benzoylurea			
Diflubenzuron	Dimilin®	2L	2.0 (0.50)	15	38–52	47.6
Novaluron	Rimon®	0.83EC	12.0 (0.74)	15	42–55	48.2
			Carbamates			
Formatenate hydrochloride	Carzol	SP	16.0 (0.92)	1A	82–98	94.8
Oxamyl	Vydate®	L	16.0 (0.25)	1A	52–68	61.2
Methomyl	Lannate	LV	16.0 (0.25)	1A	54–70	63.5
Carbaryl	Sevin	XLR Plus	32.0 (0.88)	1A	41–55	51.4
Methiocarb	Mesurol®	750	16.0 (0.75)	1A	36–51	45.2
			Arylpyrrole			
Chlorfenapyr	Alert®		12.0 (0.71)	13	84–97	93.4
			Neonicortinoids			
Imidacloprid	Admire	2F	16.0 (0.25)	4A	45–56	50.2
Imidacloprid	Provado	1.6F	3.8 (0.05)	4A	48–65	56.4
Thiamethoxam	Platinum		8.0 (0.11)	4A	38–49	46.2
Thiamethoxam	Actara®	25WG	4.0 (0.06)	4A	39–47	45.4
Clothianidin	Belay®	15 EC	8.0 (0.07)	4	55–78	70.5
			Anthranilic diamide			
Cyazypyr™	DPX-HGW86	10 SE	13.5 (0.07)	28	48–64	59.6
Rynaxypyr	Coragen®	1.67SC	5.0 (0.07)	28	38–51	44.2
			Pyrazole			
Tolfenpyrad	Hatchi Hatchi	15EC	21.0 (0.08)	21	52–76	69.6

[z]EC, emulsifiable concentrarate; F or L, flowable liquid; LV, low volume; SC, suspension concentrates; SE, suspo-emulsion; SP, soluble powder; WG, wettable granule.

clothianidin (Belay®, Valent USA Corp., Walnut Creek, CA) were evaluated for their effectiveness against *T. palmi* adults and larvae in beans. 'Pod Squad' bean was directly seeded into a rock dale soil in TREC research plots on 10 Mar. 2010. Bean plants were maintained following cultural practices as described in the previous study. Treatment plots consisted of two rows each 30 ft long. Plants were spaced 6 inches within the row and 36 inches between rows. Treatments evaluated in the study consisted of 1) a nontreated control; 2) clothianidin 6 (0.05 lb a.i.) and 8 (0.07 lb. a.i.) oz/acre, Belay® (Valent USA Corp.); 3) tolfenpyrad (21.0 (0.08 lb a.i.) oz/acre; Torac®; Nichino America; Linden Park, Wilmington, DE). Dyne-Amic at 0.25% v/v was added to each treatments. Treatment plots were arranged in a randomized complete-block design replicated four times. A 5-ft unplanted area separated the blocks from each other. Application of treatments was initiated on 29 Mar. and continued on four dates at weekly intervals. Treatments were sprayed by using a CO_2 backpack sprayer with two nozzles/row delivering 70 gal/acre at 30 psi. Evaluation of treatments was made on four dates 24 h after each application by randomly collecting 10 leaves/plot, one leaf/plant. All leaves of a plot were placed in a ziplock bag and marked with date, block number and treatment. The leaves were then transformed to the laboratory and washed with 70% ethanol to separate various stages of *T. palmi*. The alcohol containing thrips were then checked using a binocular microscope (10×) to record numbers of larvae and adults of *T. palmi*.

Statistical analysis. Data of third study were subjected to square root (x + 0.25) transformation. Transformed data were analyzed using SAS statistical package (SAS Institute 1990). The Duncan muliple *K* ratio *t* test was used to separate treatment means where significant ($P < 0.05$) differences occurred (Waller and Duncan, 1969).

Results and Discussion

Seasonal abundance. *Thrips palmi* population abundance was recorded on beans all round the year during this study (Fig. 1). Mean numbers of thrips were significantly low in October and start increasing thereafter. Thrips population peaked during Mar. to May, and starts decreasing in June. This pattern of *T. palmi* population abundance was observed in each year of this study. Vegetable season in the southern Florida starts in late September or early October. It peaks in January to April and ends in mid June. As *T. palmi* feeds and reproduce on all vegetable crops, except tomato, its appearance and disappearance in vegetable fields agree with vegetable growing season.

It is worthy to note that mean numbers of peak populations in different years were 500, 240, 220, 200, 105, 40, 30, 890, and 100 in 1994, 1996, 1998, 2000, 2002, 2004, 2006, 2008, and 2010, respectively. *T. palmi* population showed decreasing trend from 1994 to 2006, and increased in 2008 and 2010. The overall decreasing pattern of *T. palmi* population could be due to growers' use of proper management program including spinosad, spinetoram and other effective insecticides. Naturally occurring predator *O. insidiosus* also played an important role in reducing *T. palmi*.

Insecticide evaluation

Fermentation products. Products of this group were the most effective in suppressing *T. palmi* population (Table 1). Abamectin provided over 60% reduction of *T. palmi* on bean. Abamectin is neuroactive and affects ion transfer through cell membrane. Spinosad and spinetoram were the highly effective insecticides commonly used by commercial growers in controlling *T. palmi* on all vegetable hosts. These two products are also neuroactive and their mode of action is similar to nicotinoids.

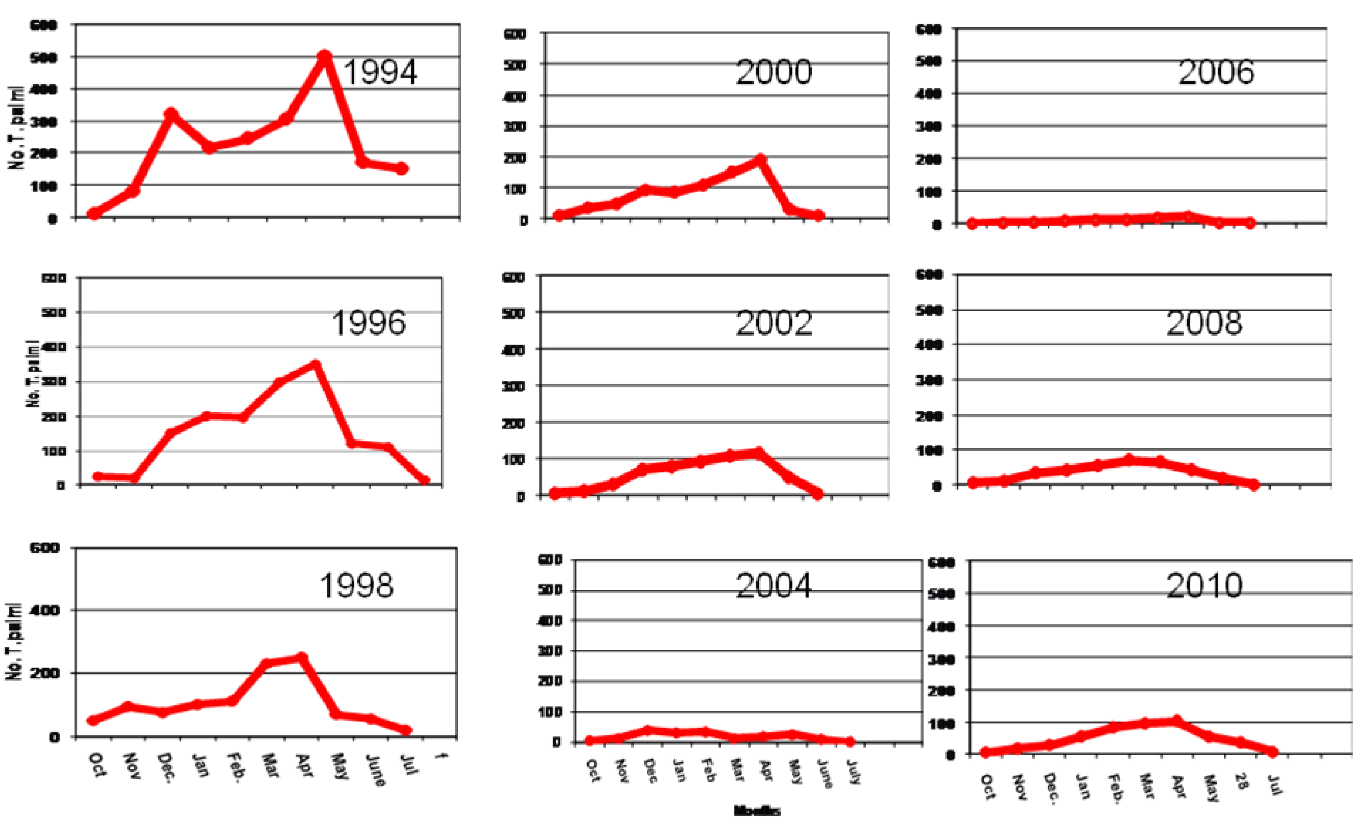

Fig. 1. Seasonal abundance of *Thrips palmi* in 'Pod Squad' beans during 1994–2010.

Benzoylureas. Diflubenzuron and novaluron were the two products of this group tested for *T. palmi* control. They provided 35% to 45% control of *T. palmi* (Table 1). These products are chitin synthesis inhibitor. They interfere with formation of exoskeleton after molting.

Carbamates. Various insecticides in this group provide variable level of control of *T. palmi* ranging from 42% to 97% (Table 1). Formatenate hydrochloride was the most effective one providing >95% control of *T. palmi* consistently in all trials in the present study. All insecticides in this group are acetylcholine esterase inhibitor. These insecticides inhibit cholinesterase enzymes from breaking down acetylcholine.

Arylpyrrole. Chlorfenapyr (Alert®) was the only insecticide of this group used in the present study. It provided superior control (>95%) of *T. palmi* consistently in all trials (Table 1). It is highly effective as an uncoupler of oxidative phosphorylation via disruption of the proton gradiant.

Neonicotinoids. Various insecticides of the neonicotinoid group provided 42% to 75% control of *T. palmi* (Table 1). They were applied both as foliar spray or soil drench. Foliar application of these insecticides provided higher level of reduction of *T. palmi* than the soil drench. Among these insecticides, clothianidine (Belay®) provided higher level (>70%) of *T. palmi* control than the others. These insecticides are nicotinic acetylcholine receptor agonists.

Anthranilic diamide. Rynaxypyr and cyazypyr are the two insecticides of this group available for insect control. Cyazypyr was more effective than rynaxypyr (Table 1). It provided 52% to 65% control of *T. palmi* in the present study. These insecticides work as a ryanodine receptor modulators.

Pyrazole. Tolfenpyrad was the only insecticide of this group was used in the present study. It provided significant level (62% to 74%) of reduction of *T. palmi*. It is a mitochondrial electron transport inhibitor. It inhibits the electron transfer system of energy metabolism and respiration in the mitochondria of *T. palmi*.

In the third study, clothianidn, tolfenpyrad, and spinetoram significantly reduced *T. palmi* population when compared with the nontreated control (Fig. 2). Clothianidine at 8.0 oz/acre provided better control than the same at 6.0 oz/acre. Both larvae and adults were similarly controlled by these treatments.

Seasonal study data indicate that *T. palmi* population decreased consistently until 2008. After 2008, population showed an increasing trend which alerts researcher to evaluate previously used all effective insecticides and determine their current level of effectiveness. An understanding of mode of action of these insecticides is essential to avoid repeated use of closely related insecticides in rotation or in combination. Further study is warranted to determine the compatibility of these insecticides with the commonly occurring natural enemies.

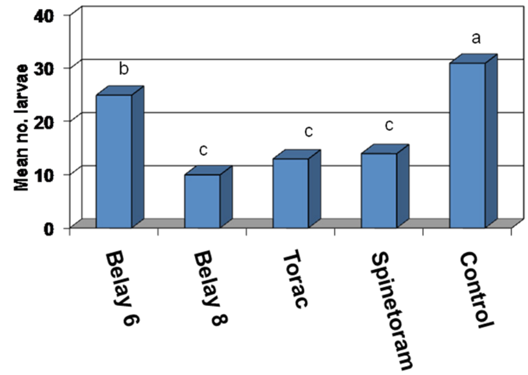

Fig. 2. Effectiveness of tolfenpyrad (Torac) and clothianidine (Belay) in controlling *Thrips palmi* in 'Pod Squad' bean, 2010.

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