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Predation by *Neoseiulus cucumeris* and *Amblyseius swirskii* on *Thrips palmi* and *Frankliniella schultzei* on cucumber ☆

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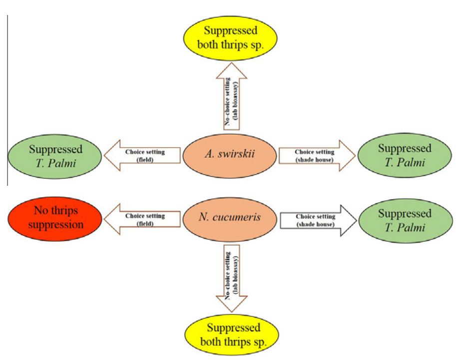
HIGHLIGHTS

- Predator potential of two phytoseiid mites was evaluated.
- In lab bioassay, both the mites were effective in suppressing two thrips species.
- None of the mite species controlled *F. schultzei* in shade house and field trial.
- Unlike shade house, *A. cucumeris* failed to suppress *T. palmi* in field conditions.
- *A. swirskii* was consistent in suppressing *T. palmi* in all the studies.

GRAPHICAL ABSTRACT



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ABSTRACT

Thrips palmi Karny and *Frankliniella schultzei* Trybom (Thysanoptera: Thripidae) are serious pests of various crops of economic importance across the globe. Two species of phytoseiid mites were evaluated as potential predators of *T. palmi* and *F. schultzei* in the laboratory, a shade house and a commercial cucumber production field. In a no-choice lab bioassay, both *Amblyseius swirskii* (Athias-Henriot) and *Neoseiulus cucumeris* Oudemans (Mesostigmata: Phytoseiidae) preyed in equal measure on larvae of *T. palmi* and *F. schultzei* placed on leaf disks. In the shade house, mites were only recovered from leaf samples and not in flowers. Consequently, they were only effective in controlling *T. palmi* on leaves. Two rates of mites (20 and 40 mites/plant) were tested in the field. Neither species nor rate suppressed *F. schultzei* in blooms. In contrast, both rates of *A. swirskii* suppressed *T. palmi* on leaves, although the high rate acted more rapidly and therefore had a greater overall effect over the course of the 22-day study. These results suggest that *A. swirskii* can serve as an effective alternative to conventional insecticide-based management of *T. palmi* in commercial open field cucumber production in Florida.

1. Introduction

The melon thrips, *Thrips palmi* Karny (Thysanoptera: Thripidae) is a polyphagous pest of vegetable crops in various parts of the world (CABI, 1998) including Hawaii, Puerto Rico and southern parts of Florida (Capinera, 2000). Following detection in Florida

☆ Trade names or commercial products mentioned in this publication is entirely for research and education purpose and do not imply endorsement.

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(Mead, 1991), *T. palmi* was reported as a serious pest of various greenhouse and field crops including, eggplant (*Solanum melongena* L.), pepper (*Capsicum annum* L.), potatoes (*Solanum tuberosum* L.), beans (*Phaseolus vulgaris* L.), and cucumber (*Cucumis sativus* L.) (Seal and Baranowski, 1992).

Adults and larvae of *T. palmi* feed preferably on foliage causing bronzing and premature abscission. Heavy infestations may result in scarred and/or deformed fruit with no marketable value (Seal et al., 2013). Besides the feeding and oviposition damage, *T. palmi* is known vector of several plant-damaging tospoviruses (Honda et al., 1989; Reitz et al., 2011). In Homestead, Florida, it has caused economic damage to all vegetable crops except tomato, emerging in recent years as a key pest of field cucumbers and posing serious threat to cucumber growers in the region (Seal per. obs.).

Appearance in Florida of a new invasive thrips species, *Frankliniella schultzei* (Trybom) (Thysanoptera: Thripidae) on various vegetable crops has further aggravated thrips problems encountered by vegetable growers in this region. Previously reported from flowers of ornamental plants in southern and central Florida (Funderburk et al., 2007), *F. schultzei* has now established on vegetable crops in southeastern region of the state (Kakkar et al., 2012a; Seal et al., 2014). Also known as a key pest of tomato in South America, *F. schultzei* has been recently associated with the economically important Tomato Chlorotic Spot Virus (TCSV) on tomato in Florida (Londoño et al., 2012). *F. schultzei* is an anthophilous pest and inhabits flowers of its host crop which can lead to improper setting of fruits or production of deformed fruit (Kakkar et al., 2012a). *F. schultzei* has been found to be most abundant in south on cucumber followed by tomato (Kakkar et al., 2012b). Together with *T. palmi*, *F. schultzei* poses a serious economic threat to cucumber and other vegetable crops in the region.

Insecticides are a primary mode of controlling thrips infesting various field crops (Bao et al., 2014; Morse and Hoddle, 2006; Seal and Kumar, 2010). However, the use of insecticides may not be the best solution to thrips problem owing to its high costs, rapid selection for resistance by rapidly reproducing thrips and adverse effects on natural enemies and environment (Herron et al., 2007; Jensen, 2000). Nevertheless, insecticides have been widely used for control of *T. palmi* in the region and the recent reports suggest reduced susceptibility to a wide range of chemical insecticides (Seal et al., 2013). There is very little known about the effectiveness of control tactics other than insecticide use for managing *F. schultzei* in cucumber in Florida. However, biological control of thrips in peppers and potential compatibility with insecticides has been well documented (Srivastava et al., 2014).

In the last two decades, predatory mites belonging to the family Phytoseiidae have received much attention as biological control agents of various vegetable pests including whiteflies, broad mites, thrips, etc. *Neoseiulus cucumeris* (Oudemans) (Mesostigmata: Phytoseiidae), a phytoseiid mite has been reported as an effective predator of several thrips species under greenhouse conditions, including onion thrips (Gillespie, 1989; Van Houten and Van Stratum, 1993) flower thrips (Jacobson, 1997; Jacobson et al., 2001; Van de Veire and Degheele, 1995) and chilli thrips (Arthurs et al., 2009). In recent years, another predatory mite species within this genus, *Amblyseius swirskii* (Athias-Henriot), has been reported in Florida as an effective predator of chilli thrips (Dogramaci et al., 2011) and *Frankliniella occidentalis* (Pergande) (Xiao et al., 2012). Considering the success of phytoseiid mites in regulating various thrips species (Brodsgaard and Stengaard Hansen, 1992; Messelink et al., 2005, 2006), we evaluated the role of *N. cucumeris* and *A. swirskii* as potential predators of *F. schultzei* and *T. palmi* inhabiting different microhabitats of the same crop. The specific objectives of this study were to (a) assess the potential of *N. cucumeris* and *A. swirskii* to control *F. schultzei* and *T. palmi* in laboratory, shade house and field, (b) compare two rates of mite application for control of thrips complex in the field, (c) investigate the persistence of predacious mites on leaves and flowers of cucumber in the field.

2. Materials and methods

2.1. Arthropods

For laboratory and shade house studies, *T. palmi* and *F. schultzei* were obtained from a commercial cucumber field infested with the two thrips species at Homestead, Florida. *A. swirskii* and *N. cucumeris* were obtained from Koppert Biological Systems Inc. (Romulus, MI). Upon arrival, mites were stored at the most for 24 h in a growth chamber maintained at 11 ± 2 °C, RH 60 ± 5%, and 14:10 h L:D until the day of release. For mite release in the field experiment, volume of bran that contained desired number of mites (20 mites/plant or 40 mites/plant) was quantified. The quantified volume was standardized by repeatedly (10 times) drawing bran from the product received from the company and counting predatory mites under a stereoscopic microscope. Individual estimates were made for *N. cucumeris* and *A. swirskii*.

2.2. Laboratory bioassay

A no-choice leaf disc bioassay was conducted following protocol of Arthurs et al. (2009) to investigate potential of two phytoseiid mites to act as predators of the two thrips species. The experimental arena consisted of a 9 cm diameter Petri dish lined on the bottom with a thin layer of moist cotton wool. A 2 cm diameter cucumber leaf disc was placed in the center of the Petri dish onto which a single female mite individual and 15 s instar larvae of one or the other of the thrips species were released. Dishes covered with thrips-proof screen (No-Thrips Insect Screens, BioQuip Products, USA) lid were placed at 25 ± 2 °C, L16: D8, and 65–70% R.H for 24 h, after which treatments were evaluated by recording the number of dead larvae. There were 6 replicates per treatment and the bioassays were repeated 5 times.

2.3. Shade house study

The study was conducted in spring 2010 to assess the biocontrol potential of two predatory mites in an open shade house that was pest free at the beginning of the study (20 ± 3.5 °C, and 75–82% R. H). Cucumber plants (*var.* 'Vlaspek') were grown from seeds in 3.8 l plastic pots. Plants were irrigated twice a day and fertilized weekly with 20-20-20 (N:P:K). Once flowering began, pots were moved adjacent to an experimental cucumber field to become infested with a naturally occurring thrips population. After 10 days, pots were brought back to the shade house and predatory mites were released on the thrips-infested plants. Treatments were *N. cucumeris* (20 adults/plant), *A. swirskii* (20 adults/plant based on preliminary data) and control (no mites). Each treatment had five replicates with each replicate comprised of five plants. Plants were assessed at the interval of five days by sampling five leaves and five flowers (one/plant) for a period of 20 days. Leaves and flowers were collected and placed by replicates in separate Ziploc bags (17 × 22 cm). Bags were transported to the Vegetable IPM laboratory, TREC, Homestead where flower samples were placed in a one-quart plastic cup with 75% ethanol for 30 min to dislodge various life stages of thrips. Thrips were extracted from the alcohol by sieving through a 25 μm grating, USA Standard Testing Sieve (W. S. Tyler, Inc.) as per Seal and Baranowski (1992). The residue in the sieve was washed off with 75% alcohol into a Petri dish and checked under a dissecting microscope at 12× to record number of thrips larvae, mites (nymphs and adults) and their eggs.