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Chilli Thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) Management Practices for Florida Strawberry Crops[1]

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The main purpose of this publication is to provide current management practices for chilli thrips in both conventional and organic strawberries. The intended target audience is Extension agents and growers, for whom we hope it will serve as a helpful guide.

Introduction

Strawberry, *Fragaria× ananassa* Duchesne (Rosales: Rosaceae), production is an important industry in Florida with approximately 11,000 acres under production, generating a value of over $300 million (USDA-NASS 2019). In Florida, the winter strawberry fields are affected by several foliage-, flower-, fruit-, and root-feeding arthropods. Chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae), is one such major economically important and relatively new invasive pest of strawberry crops in Florida.

Scirtothrips dorsalis is an invasive and polyphagous pest with a wide host range of 225 plants including vegetable, ornamental, and fruit crops (Kumar et al. 2013). *Scirtothrips dorsalis* (Figure 1) is native to the Indian subcontinent and was reported to have invaded east Asia in 1981, South Africa in 1986, and Australia in 1998 (Kumar et al. 2013). Since Florida's sub-tropical climate is conducive for invasive plants and insects, it is not surprising that *S. dorsalis* could establish and become a pest here (Ferriter et al. 2006; Figure 2). According to USDA-APHIS inspectors, *S. dorsalis* was intercepted approximately 89 times at several ports between 1984 to 2002, mainly from imported plant materials such as cut flowers, fruits, and vegetables (USDA 2003). In Florida, it was first reported in Okeechobee County in 1991 and in Highlands County in 1994 (Silagyi and Dixon 2006). Since 2004, it has been reported in several counties in Florida and Texas (Kumar et al. 2013).

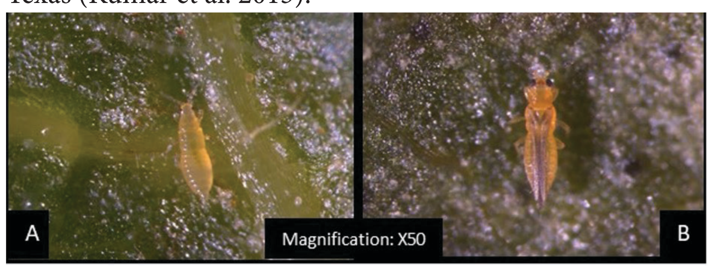

Figure 1. Larva (A) and adult (B) of *S. dorsalis* feeding on strawberry leaves.
Credits: Gagandeep Kaur

Morphology and Life Cycle

Scirtothrips dorsalis shows complete metamorphosis, with six life stages: egg, first and second instar larvae, pre-pupa, pupa, and adult stages. Females lay eggs singly by inserting their specially adapted ovipositor into the plant tissue, where the eggs remain protected from predators and insecticide application (Lewis 1973). A single female can lay an average of forty eggs during her lifespan (Tatara 1994).

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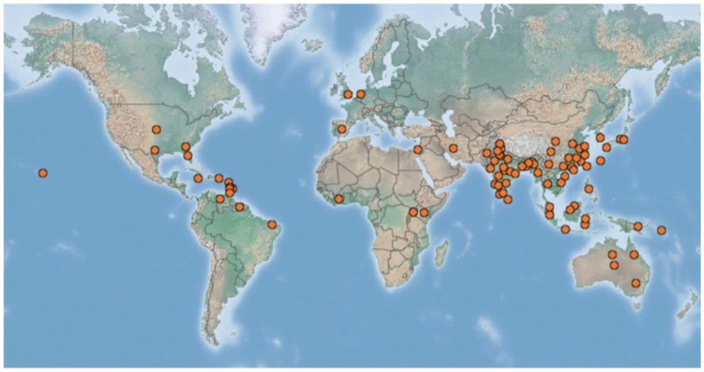

Figure 2. Worldwide distribution of *S. dorsalis*.
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Eggs are very small (0.075 mm), kidney shaped, white, and not visible to the naked eye (Seal et al. 2010). Eggs hatch in 5–8 days depending on temperature and relative humidity. Larvae and adults can typically be found at their feeding site on the mid-vein or borders of the host plant leaves. Larval stages (Figure 3A and 3B) are completed in 8–10 days whereas the pupal stage persists for 2.6–3.3 days (Kumar et al. 2013). The pre-pupa can be identified by its short wing sheaths (Figure 3C and 3D), whereas the pupa has longer wing sheaths that nearly reach the end of the abdomen (Figure 3E and 3F) (Fery et al. Krishna Kumar et al. 1996). Both the pre-pupa and the pupa are sessile, non-feeding stages, and pupae can be found in the leaf litter or in leaf curls of the damaged leaves (Moritz 1997; Kumar et al. 2013, 2014).

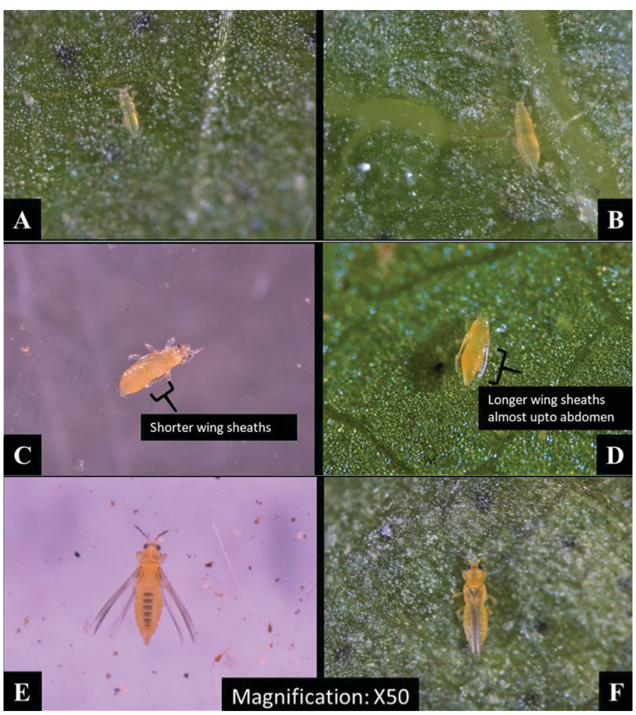

Figure 3. A & B) First and second instar larvae of *S. dorsalis*; C & D) Pre-pupa and pupa of *S. dorsalis*; E & F) Female adults of *S. dorsalis*.
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Scirtothrips dorsalis adults are very small (<2mm) and yellowish. *Scirtothrips dorsalis* adults have eight distinctive antennal segments; the head has ocellar setae between posterior ocelli; abdominal tergites have three discal setae in lateral microtrichial fields, and forewings have straight cilia (Figure 4). The wings are dark and fringed, the forewings lighter in color than the hindwings. *S. dorsalis* males are smaller than females with shorter abdomen (Kumar et al. 2013). Several morphological characteristics that help distinguish *S. dorsalis* from other thrips (EPPO 2005): pronotum covered with transverse striae, abdominal tergites laterally with many rows of minute microtrichia, sternites and metanotum with setae arising at posterior and anterior margin respectively.

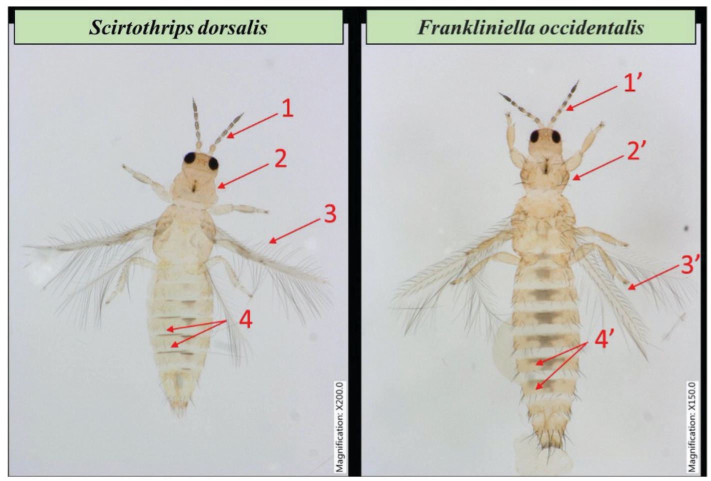

Figure 4. Distinctive antennal segments (1 and 1'), pronotum setae absent (2), present (2'), forewings with straight cilia (3), forewings cilia are not straight (3'), microtrichial comb well developed (4) and not well developed (4').
Credits: Gagandeep Kaur

The total life span of *S. dorsalis* differs depending on host plants, ranging from 11–15.8 days (Seal et al. 2010). *Scirtothrips dorsalis* is capable of both sexual and asexual reproduction, which contributes to their rapid population growth potential. Asexual reproduction in *S. dorsalis* occurs when unfertilized eggs develop into males (arrhenotokous parthenogenesis). Eggs fertilized during sexual reproduction develop into both males and females, but males are rare. The typical sex ratio is four females: one male (Dev 1964).

Crop Damage

Scirtothrips dorsalis possess piercing-sucking mouth parts and prefer to feed on younger, nutritious, softer tissues of host plants, such as on meristems or terminals. They do not feed on mature plant parts (Kumar et al. 2013). *Scirtothrips dorsalis* use their stylet-like mouth parts to penetrate into the young leaves. The wounds they make in the leaves in the process of feeding lead to necrosis and the development of brown to black color (Kumar et al. 2013; Saha et al. 2016). Severe infestation of *S. dorsalis* can result in complete host plant damage and crop loss.

In strawberries, *S. dorsalis* starts infesting plants early in the season. Heavy feeding causes reddening and darkening of leaf veins and petioles (Figures 5A, 5B, and 5C). With severe infestations, the entire leaf turns dark, crinkled, and deformed (Figures 5D and 5E). In addition, *S. dorsalis* feeding on leaves, flowers, and fruits causes leaf distortion, bronzing, and cracking of fruits, which ultimately results in reduced crop yields (Seal et al. 2006; Figures 5F, 5G and 5H).

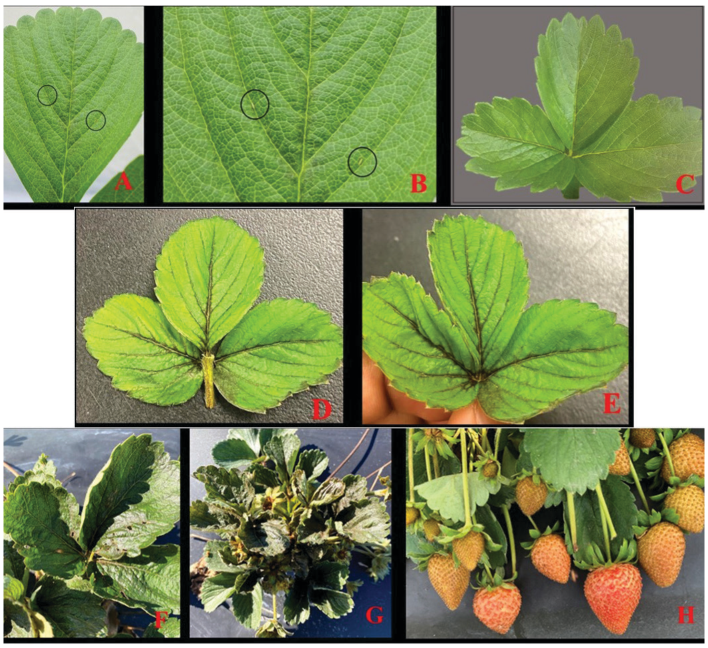

Figure 5. *Scirtothrips dorsalis* feeding on strawberry leaf veins (A and B), initial leaf symptoms of *S. dorsalis* feeding, darkening of leaf veins (C). *Scirtothrips dorsalis* feeding symptoms progress and veins get darker (D and E). Severe plant damage by *S. dorsalis* (F and G), and strawberry fruit bronzing caused by *S. dorsalis* (H).
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Management

Cultural Control

Field scouting for early detection of *S. dorsalis* is crucial for management. *Scirtothrips dorsalis* can be monitored by scouting the fields for injury symptoms. Strawberry leaf trifoliates can also be collected from the fields to count *S. dorsalis* larvae; however, enough samples should be collected to precisely estimate the *S. dorsalis* population. Allow up to two weeks to pass after initial detection of *S. dorsalis* in Florida open-field strawberries before initiating chemical control methods. *S. dorsalis* tend to aggregate around initial infestation zones within the field (Panthi et al. 2021). Other management practices include removing alternative hosts and weeds (Kumar et al. 2013).

Biological Control

Inoculative augmentation of biological control agents has emerged as a valuable tool in *S. dorsalis* management, owing to the thrips' capacity to develop insecticide resistance rapidly. For biological control of *S. dorsalis*, minute pirate bugs, *Orius* spp. (Hemiptera: Anthocoridae) and foliar-dwelling entomopathogenic nematodes, *Thripinema* spp. (Tylenchida: Allantonematidae) have been found effective under controlled conditions and can be integrated into field programs. (Kumar et al. 2013). Minute pirate bugs feed on both larvae and adults whereas entomopathogenic nematodes parasitize thrips females and make them incapable of laying eggs (Funderburk at al. 2007; Seal et al. 2010). Two phytoseiid mites, *Neoseiulus cucumeris* (Oudemans) and *Amblyseius swirskii* Athias-Henriot (Arachnida: Phytoseiidae) also provide control of *S. dorsalis*. *Amblyseius swirskii* has been found effective for *S. dorsalis* larval suppression on pepper and strawberry (Arthurs et al. 2009; Lahiri and Yambisa in press). These biological control agents are commercially available for purchase and can be hand-released.

Chemical Control

Currently, the management of *S. dorsalis* mainly relies on chemical control. Management of *S. dorsalis* can be challenging for several reasons: They can move to surrounding weed crops to take refuge and lay eggs inside the leaf tissue where the eggs remain protected from pesticide sprays because they are embedded in the leaf. Thrips hide in concealed places such as leaf curls or under fruit calyxes where they can avoid foliar or drench pesticide applications. Several conventional synthetic and OMRI-approved pesticides are labeled for thrips management in Florida strawberry (Lahiri and Panthi 2020; Lahiri and Yambisa in press). Pesticides derived from plant extracts or entomopathogens are most effective if applied 2–3 times within a 5- to 7-day interval.

It is necessary to apply insecticides in rotation to prevent resistance development in *S. dorsalis* (*UF/IFAS Vegetable Production Handbook 2019–2020*). Pesticides registered for strawberry crops in Florida should be integrated with other management strategies. Pesticides that can be applied by organic growers are listed in Table 1A; those suitable for conventional growers are listed in Table 1B.

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Table 1A. List of OMRI approved pesticides recommended for *S. dorsalis* management in strawberry crops in Florida (adopted from *UF/IFAS Vegetable Production Handbook of Florida, 2020–2021*, Chapter 16 by Whitaker et al. 2020).

Chemical group	IRAC Code	Active ingredient	Registered products	Insecticidal activity	Registered use site			Rate (Product/ Acre)	Rate per season	Min. hours to reentry	Min. hours to harvest	Residual effect in days	Remarks
					Field	Greenhouse	Nursery						
-	-	Capsicum oleoresin extract + garlic and canola oil	Captiva Prime	Repellency, anti-feeding & ovipositional deterrent	Y	Y	Y	1–2 pints	Sprays every 4–7 days	4	0	-	-
-	-	Azadiractin	Aza-Direct	Systemic & contact	Y	Y	Y	See label	-	4	0	7	-
			Neemix 4.5% EC	Systemic & contact	Y	Y	Y	4–16 fl oz	-	12	0	7	-
-	-	*Chromobacterium subtsugae* strain PRAA4-1	Grandevo	Non-systemic & stomach poison	Y	Y	Y	2–3 lb	-	4	0	-	-
-	-	*Metarhizium anisopliae* strain F52v	MET52 EC	Contact	Y	Y	Y	Drench: 40–80 fl oz/100 gal Foliar: 0.5 pint–2 quarts	-	4	0	5-7	Mix it with 5–100 gallons of water per acre.
-	-	*Isaria fumosoroseus* Apopka strain 97	PFR-97 20%WDG	Contact	Y	Y	Y	1–2 lb	Repeat applications with 3-10 days of interval	4	0	-	Do not apply along with fungicides.
-	-	*Beauvaria bassiana* strain GHA	Mycotrol ESO	Contact	Y	Y	Y	0.25–1 quart	3-5 applications	4	0	-	3–4 applications per season for effective control. See label instructions if using with fungicides.
-	-	*Burkholderia rinojensis* strain A396	Venerate	Contact and ingestion	Y	-	-	2–4 quarts	-	4	0	-	-

Table 1B. List of registered conventional pesticides recommended for *S. dorsalis* management in strawberry crops in Florida (adopted from *UF/IFAS Vegetable Production Handbook of Florida, 2020–2021*, Chapter 16 by Whitaker et al. 2020).

Chemical group	IRAC Code	Active ingredient	Registered products	Insecticidal activity	Registered use site			Rate (Product/ Acre)	Rate per season	Min. hours to reentry	Min. hours to harvest	Residual effect in days	Remarks
					Field	Greenhouse	Nursery						
Neonicotinoids	4A	Acetamiprid	Assail 30 SG, 70 WP	Systemic	Y	Y	Y	30 SG: 1.9–6.9 oz 70 WP: 0.8–3.0 oz	30 SG: 13.8 oz 70 WP: 6.0 oz	12	24		An interval of 5 days within the application is recommended.
Sulfoxaflor (neonicotinoid)	4C	Sulfoxaflor	Closer SC	Systemic	Y	-	-	4.5 oz.	17 oz.	12	1	3	At most 4 applications per year. Harmful to bees.
Butenolides	4D	Flupyradifurone	Sivanto Prime	Systemic	Y	-	-	14 oz.	28 oz./ acre	4	0	10	-
Spinosyns	5	Spinosad	Entrust SC	Systemic	Y	-	Y	4–6 fl oz	18 fl oz	4	24	5	3 applications per year are recommended, OMRI-listed.
		Spinetoram	Radiant SC	Systemic	Y	-	Y	6–10 fl oz	39 fl oz	4	24		Mix it with 5–100 gallons of water per acre.
-	6	Abamectin	Timectin 0.15 EC Ag	Systemic	Y	Y	Y	16 fl oz.	64 fl oz/ acre	12	3	7–10	Harmful to mammals and aquatic life.
-	15	Novaluron	Rimon 0.83EC	Non-systemic	Y	Y	Y	6–12 fl oz.	36 fl oz/ acre	12	1	7–14	-
-	21A	Tolfenpyrad	Apta	Systemic	Y	Y	-	27 fl oz.	81 fl oz/ acre	12	1	7–14	3 applications per year are recommended.
Diamides	28	Cyantraniliprole	Exirel	Systemic	Y	-	Y	13.5–20.5 fl oz	-	12	24	-	Label contains warnings for the protection of pollinators.
-	6+28	Abamectin+	Minecto Pro	Systemic	Y	-	-	10 fl oz.	40 fl oz/ acre	12	3	7	Harmful to mammals and aquatic life.

Chemical group	IRAC Code	Active ingredient	Registered products	Insecticidal activity	Registered use site			Rate (Product/ Acre)	Rate per season	Min. hours to reentry	Min. hours to harvest	Residual effect in days	Remarks
					Field	Greenhouse	Nursery						
Organophosphate	1B	Naled	Dibrom 8-E*	Contact & stomach action	Y	-	Y	1 pint	5 pints	48	24	-	4 applications per year are recommended. Avoid spraying when temperature is over 90°F.
	1B	Malathion	Malathion 5EC, 8F	Systemic	Y	-	Y	5EC: 1.5–3.2 pints 8F: 1.5–2.0 pints	8F: 8 pints	12	72	-	Not more than 4 applications per growing season.
Pyrethroids	3A	Pyrethrins	PyGanic EC 5.0	Non-systemic	Y	Y	Y	See label	-	12	0	-	2 applications per growing season are recommended.
		Azadirachtin & pyrethrins	Azera	Contact & ingestion	Y	Y	Y	See label.	-	4	0	-	-
		Pyrethrins & piperonyl butoxide	Evergreen EC 60-6	-	Y	Y	Y	2–16 fl oz	-	12	0	-	Repeat applications with 3–5 days of interval.