Thirty Years of Advances in Arthropod Management in Florida's Commercial Strawberries

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Abstract

Florida produces more than 3000 ha. of fresh-market, winter-grown strawberries annually. That production environment is conducive to development of arthropod pests of strawberries such as twospotted spider mite, flower thrips, melon aphid, various noctuid moth larvae, *Drosophila* sp. fruit fly, sap beetles and others. Before 1978 these pests were controlled in the most part, with broad-spectrum pesticides applied on a regular basis with little regard for the ecological status of the arthropod community. About that time, scouting to assess the ecological condition of the strawberry fields was introduced and pesticide use began to be determined accordingly. By the 1990s, *Phytoseiulus persimilis* predators were being introduced on some farms for control of spider mites along with reduced use of ecologically disruptive pesticides. As more farmers adopted the practice over the next few years a new awareness of the ecological damage in the crop from broad-spectrum pesticides emerged. New pesticides with better target-pest specificity and other favourable environmental qualities replaced many of the more harsh early pesticides. Today many Florida strawberry farmers rely on biologically and ecologically based plans of arthropod pest management and are seeking new biological controls for aphids, thrips and other pests in addition to spider mites. During this 30-year transition, the strawberry industry in Florida has expanded and has become an uncommon example of an annual, field-grown, horticultural crop produced with an applied biological component of pest management.

INTRODUCTION

Florida produces over 3000 ha. of fresh-market strawberries for winter sales along the USA east coast. The crop is grown under the plastic mulch, annual hill system of culture, with about 50,000 bare-root transplants per ha. sourced from northern or high altitude regions and planted mostly during October. Fruits are harvested from late November until April, when prices fall as more abundant Californian berries are shipped eastward, but peak production occurs in January and February. Almost the entire crop is grown in west-central Florida near Plant City, about 28°N latitude.

The regional sub-tropical climate presents an environment favourable for numerous nematode, weed, microbial, and arthropod pests (Howard et al., 1985). Fungal diseases constitute the most destructive pests of the crop in Florida, but arthropods contribute considerable threat and require effective management. The principal arthropod pests include the twospotted spider mite (*Tetranychus urticae* Koch), southern and fall armyworms (*Spodoptera eridania* (Cramer) and *S. frugiperda* (J.E. Smith)), *Frankliniella*

bispinosa flower thrips, melon aphid (*Aphis gossypii*), a *Drosophila* sp. fruit fly, and three or more species of sap beetle (Nitidulidae), although several other arthropods occasionally reach economic pest status (Table 1).

This paper discusses the major changes in approaches to arthropod pest management that have occurred in Florida strawberry production during about the past 30 years.

Pre-1978

Immediately before 1978 the strawberry industry in Florida managed arthropod pests effectively, in the most part, with regular applications of relatively inexpensive, broad-spectrum organophosphate, chlorinated hydrocarbon, and other synthetic organic pesticides developed in the post-World War II era. The authors cannot locate records of the pesticide complement available to Florida strawberry production 30 years ago, but those available in 1982 are likely similar, and are presented in Table 2. The list includes methoxychlor, toxaphene, carbofenothion, demeton, ethion, fonofos, methyl parathion, parathion, mevinphos and others. In 1978, mevinphos commonly was applied every second week throughout the season to control twospotted spider mites as well as other arthropods.

1978-1990

By 1978 the University of Florida trained local agriculturists engaged in the tomato industry in innovative, pilot integrated pest management programs based on scouting. Scouting systems for strawberries, based on that model, soon developed to reveal ecological parameters within the crop that would suggest timing and choice of interventions. As a result, insecticide and miticide applications declined and broad-spectrum pesticide use also declined in favour of more target-specific materials. For instance, *Bacillus thuringiensis* rather than methomyl, was often selected to manage noctuid larvae. A few pioneering, young agriculturists formed small companies to provide scouting and limited consulting services. The early predominant leader serving the strawberry industry in that innovation was Gordon DeCou of Agri-Tech Services, Inc. (Bradenton, FL). His company still contributes to the strawberry industry today.

1990-Present

The use of predatory mites to control spider mites in Dutch cucumber greenhouses began in the early 1960s, and the system was well developed and very economical by the late 1980s (Huffaker and Messenger, 1976; Malis and Ravensberg, 2003). The senior author invited Marinus van de Vrie, an accomplished economic acarologist from The Netherlands, to cooperate in transferring what was known about biological control of spider mites in greenhouse cucumbers, to Florida's field-grown strawberries (van de Vrie and Price, 1994). They secured support from Koppert B.V. of The Netherlands, and proposed schemes for *P. persimilis* releases and management in the crop. Gordon DeCou enlisted some of his pioneering and venturesome grower-clients to test the ideas. Alan Williford was one of the earliest and most aggressive of Decou's grower-clients to evaluate schemes for the biological control of twospotted spider mites. As Williford and other clients of DeCou achieved success in biological control (DeCou, 1994), other farms adopted the technique until annually 25% - 40% of the Plant City acreage was under biological management of twospotted spider mites.

Adoption of *P. persimilis* control of spider mites required growers to use even lower inputs of some disruptive pesticides. Growers found that the reduced use of disruptive pesticides resulted in more active natural control of pests such as spider mites, aphids and noctuid larvae. This stimulated grower interest in employing target-specific, less ecologically disruptive pesticides. Interest among growers in chemicals with these properties and pressures from federal regulators have resulted in a modern complement of pesticides much different to that available in the early 1980s.

The information in Table 2 indicates that among what would be regarded as harsh, broad-spectrum insecticides and miticides (largely the carbamates, chlorinated hydrocar-

bons, organophosphates and pyrethroids), two chlorinated hydrocarbon and nine organophosphate insecticides and miticides have been lost to Florida strawberry growers. One carbamate, one organophosphate and two pyrethroid insecticides and miticides have been gained since 1982 for a net loss of seven. Among the ecologically more favourable biologically derived insecticides and miticides, none have been lost during that period, but eight have been gained. The trend away from ecologically disruptive, broad-spectrum pesticides toward the less disruptive biologically derived pesticides over the past few decades, represents an important shift toward an agricultural environment that can support additional achievements in biological control.

CONCLUSIONS

The strawberry industry in Florida has expanded greatly over the past 30 years and represents a unique example in that State of an annual, field-grown horticultural crop produced with an applied biological component of pest management. There has been an intensive effort by the present authors over the past 3 years to deliver programs of biological control for additional pests of Florida's strawberry crop (Rondon et al., 2003). Success in that is likely to continue. At the close of three decades of progress in management of arthropod pests in Florida strawberries, a system of protection will exist that is overwhelmingly different from that employed at the beginning of the period, one that is certainly much more sustainable.

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Tables

Table 1. Arthropods that may require management intervention in commercial strawberry crops in Florida.

Common Name	Scientific Name
Cyclamen mite	*Phytonemus pallidus* (Banks)
Fall armyworm	*Spodoptera frugiperda* (J.E.Smith)
Field crickets	*Gryllus* spp
Flower thrips	*Frankliniella* spp.
Fruit fly	*Drosophila* sp.
Leaf tiers and rollers	*Cambidae* and *Tortricidae*
Lesser cornstalk borer	*Elasmopalpus lignosellus* (Zeller)
Melon aphid	*Aphis gossypii* Glover
Mole crickets	Gryllotalpidae
Pamera bugs	*Pamera* spp.
Plant bugs	Miridae
Sap beetles	Nitidulidae
Southern armyworm	*Spodoptera eridania* (Stoll)
Strawberry root aphid	*Aphis forbesi* Weed
Tumid spider mite	*Tetranychus tumidus* Banks
Twospotted spider mite	*Tetranychus urticae* Koch

Table 2. Insecticides and miticides for use against arthropod pests of Florida strawberry not available in 1982, but available in 2004 (gained), and available in 1982 but not available in 2004 (lost), or available over the entire period.

Pesticide Group	Since 1982		Available the Entire Period
	Gained	Lost	
Biologically derived	Abamectin Azadirachtin *Bacillus thuringiensis* *Beauveria bassiana* Neem oil Pyrethrins Spinosad POBs of NPV of *H. zea*	(None)	(None)
Carbamate	Methomyl	(None)	Carbaryl
Chlorinated Hydrocarbon	(None)	Methoxychlor Toxaphene	Dicofol Endosulfan
Organophosphate	Chlorpyrifos	Azinphosmethyl Carbophenothion Demeton Ethion Fonofos Methyl parathion Mevinphos Oxydemetonmethyl Parathion	Diazinon Malathion Naled
Pyrethroid	Bifenthrin Fenpropathrin	(None)	(None)
Other	Bifenazate Fenbutatin-oxide Hexythiazox Imidacloprid Insecticidal soap Petroleum oils	Cryolite Cyhexatin	Propargite