POTENTIAL FOR BIOLOGICAL CONTROL OF THE GREENHOUSE WHITEFLY IN THE FIELD WITH *ENCARSIA FORMOSA*: THE STRAWBERRY EXPERIENCE

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ABSTRACT

The greenhouse whitefly is a new pest in strawberries on the central coast in California. Damage by this pest includes reduction in yield due to feeding, and the production of honeydew, which supports the development of sooty mold. Stickiness due to honeydew can also interfere with harvest. We evaluated the potential of inundative field releases of the parasitoid *Encarsia formosa* which is used worldwide for greenhouse whitefly suppression, but primarily in greenhouses. We released 30,000 / acre per release early this year in three central coast strawberry fields, and repeated the releases 4 times 10 - 15 d apart. The parasitoid was recovered at all three sites where releases were made. Overall we observed 47.6 % reduction in adult whitefly population in the release plot compared with the control. There was 53.2 % parasitism of whitefly pupae on leaves collected around release points at the three sites. Our results suggest that *E. formosa* has potential for reduction of greenhouse whitefly populations in strawberries in winter. However, the impact of this parasitoid under warmer conditions later in the year needs to be determined. Further research is also needed on release strategies to improve parasitoid efficacy, and on possible integration with other control tactics for effective suppression of the greenhouse whitefly in strawberries.

INTRODUCTION

The greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) (Homoptera: Aleyrodidae), is an emerging pest in strawberries on the central coast in California. While whiteflies have always been present in low numbers in strawberry fields, the species that have been observed in the past include primarily the iris whitefly, *Aleyrodes spiraeoides* Quaintance (Homoptera: Aleyrodidae), and, to a lesser extent, the strawberry whitefly, *Trialeurodes packardi* (Morrill) (Homoptera: Aleyrodidae) (UCIPM 1994). Populations of these species are usually kept below damaging levels by naturally occurring beneficial insects. The reasons for the sudden appearance in recent years of high populations of the greenhouse whitefly in certain restricted areas on the central coast are unknown. Perhaps the use of pyrethroids, which are known to have negative impacts on beneficial insects, in strawberries for suppression of other pests could be one factor responsible for whiteflies becoming a pest in strawberries (Udayagiri *et al.* 2000).

Whiteflies can reduce yield directly through their feeding on leaf tissue, which removes plant sap and stunts plant growth. They also produce sticky honeydew excreted during feeding. The honeydew may cover plants and support the development of black sooty mold fungus. In addition, honeydew can interfere with picking due to stickiness. When adult populations are high, strawberry pickers experience breathing problems.

Few options exist for control of whitefly populations in strawberries. In 1999, the carbamate methomyl was applied in fall at several locations on the central coast. This resulted in temporary reduction in whitefly populations but subsequently whitefly populations increased and adults migrated to adjacent new plantings of strawberries. In addition, application of methomyl resulted in large outbreaks of the two-spotted mite that could not be suppressed. Hence, an alternative, safe, and less disruptive strategy is needed for whitefly control.

We are evaluating the potential for greenhouse whitefly suppression through inundative releases of *Encarsia formosa* Gahan (Hymenoptera: Aphelinidae). This parasitoid is used worldwide to control *T. vaporariorum* on vegetable crops in greenhouses (van Lenteren *et al.* 1996). Females lay eggs into whitefly larvae of all stages though the third and fourth instars are preferred. Parasitized larvae turn black and are easily recognized in the field. *E. formosa* is also known to host feed, and this facilitates suppression of whitefly populations.

While *E. formosa* is primarily used on vegetables and ornamentals in greenhouses (Hoddle *et al.* 1998), its potential for use on outdoor crops such as strawberries is unknown. It prefers cool environments from 60 to 85□F and hence we speculated that it was likely to be effective on the central coast in California where temperatures are mild even during summer. Hence, earlier this year, we evaluated inundative releases of *E. formosa* in strawberry fields on the central coast and here we present results from the trial.

MATERIALS AND METHODS

Parasitoids: Parasitoids were received as pupae within host pupae from Novartis BCM North America (Oxnard, CA). Parasitoids were released either attached to cards placed in paper containers with a mesh top or in vials. For protection from rain in the field, a waxed paper covering was placed over each release container.

Parasitoids were released @ 1000 per vial and 30 vials were placed at random locations in the field. Releases were commenced at the end of January and four releases were made 10-15 d apart.

Experimental set-up: The experiment was conducted at three sites, one each in Salinas, Elkhorn and Castroville. Releases were made in one acre-sized plots within large strawberry fields. Similar sized plots at least 200 ft away were set up as controls where no parasitoids were released.

Sampling: Prior to parasitoid releases, whiteflies were sampled on a weekly basis. Once parasitoid releases commenced, five young leaflets were selected from 12 random locations, and numbers of whitefly adults on the undersurfaces of the leaflets were recorded in each release and control plot. Success with *E. formosa* has been achieved primarily in greenhouses. This was the first attempt at its evaluation in strawberries. Hence, to maximize our chances of obtaining parasitoid recoveries, we collected 25 older leaves in the vicinity of the release points. These were returned to the laboratory and the numbers of blackened pupae, which are indicative of parasitism by *E. formosa*, were recorded. In addition, to determine the numbers of whiteflies that escaped parasitism, we recorded the numbers of whitefly pupae with emergent holes as these are cohorts from the same generation as the pupae that were parasitized.

Data Analysis: To evaluate the impact of the parasitoid, we determined percent parasitism on old leaves collected for the release plots. Percent parasitism was calculated as (Number of blackened pupae / (Number of whitefly pupae with emergence holes + Number of blackened pupae))* 100. We also compared populations of adult whiteflies in release and control plots to determine the impact on adult emergence in the next generation.

RESULTS

Whitefly adult populations were first observed on newly planted strawberries in mid December when sampling commenced. Both adults and eggs were observed on plants that were less than 2 months old. There was a gradient in infestation levels based on distance from the field of second year strawberries (Fig. 1).

Examination of the release vials indicated that majority of the parasitoids had emerged and dispersed. Collection of rainwater in release vials resulted in < 5% parasitoid mortality. Blackened pupae were first recovered in mid March, and parasitoids were recovered at all three release sites. Parasitized pupae were maintained till adult emergence to confirm that the pupae were parasitized by *E. formosa*. In addition, we recovered two other parasitoid species that are in the process of being identified.

We observed 53.2 % parasitism of whitefly pupae on leaves that were collected from areas around release points in the release plots (Fig. 2). There was 47.6% reduction in number of adult whiteflies in the release plots compared with the control plots (Fig. 3 A, B).

DISCUSSION

The greenhouse whitefly has potential for causing considerable damage to strawberries on the central coast in California. For the past two years, growers in the area have observed whitefly populations in fall on strawberry plants planted the previous year. In addition, sampling in December 1999 indicated that, new plantings of strawberries in fields adjacent to strawberries planted the previous year were infested with adults and eggs. Our data indicated that there was a gradient in infestation level based on distance from the field of second year strawberries suggesting that the latter is the source of infestation for the young plantings.

Insecticide control of whiteflies in winter is not possible due to rain, and due to the early stage of development of the plants which makes adequate coverage difficult. Development of a control strategy that is effective over winter is critical to prevent build up of whitefly populations later in the year. Biological control through parasitoid releases would be beneficial at this time of the year.

Encarsia formosa is considered to be an effective biological control agent for the greenhouse whitefly in greenhouses, but has not been recommended for use under field conditions. This is the first study where recoveries of *E. formosa* have been obtained after release in strawberries. Our results are encouraging In an earlier study by Phillips *et al.* (1999) the parasitoid *Eretmocerus emericus* Rose & Zolnerowich (Hymenoptera: Aphelinidae) was released in strawberries for evaluation against the greenhouse whitefly but not a single parasitoid was recovered. In the present study, *E. formosa* was recovered from all three sites where it was released. We focussed our sampling efforts in areas around the release sites to determine whether *E. formosa* had any impact at all. As a result, parasitism levels observed need to be viewed with caution. However, adult whiteflies were sampled using normal sampling techniques. Several factors could be responsible for success with recovery of *E. formosa* in the present study. Whitefly infestation levels at the three release sites were low to moderate. In addition, temperatures were cool during this study and this may have facilitated parasitism by *E. formosa*.

Our results provide evidence that *E. formosa* has potential for use outdoors in crops such as strawberries. Further research is needed to determine whether whitefly suppression is possible with an increase in the number of

release points for improvement in coverage and with lower release rates. In addition, the impact of this parasitoid later in the year, under warmer conditions, also needs to be determined. It is likely that integration with other control tactics will be needed for effective greenhouse whitefly suppression in strawberries on the central coast.

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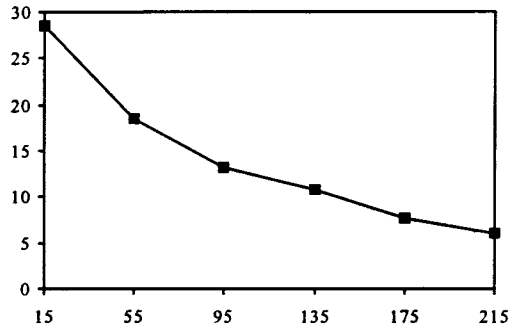


Fig. 1. Mean numbers of adult whiteflies on strawberry leaflets collected in winter from three central coast fields at various distances from adjacent fields of second year berries.

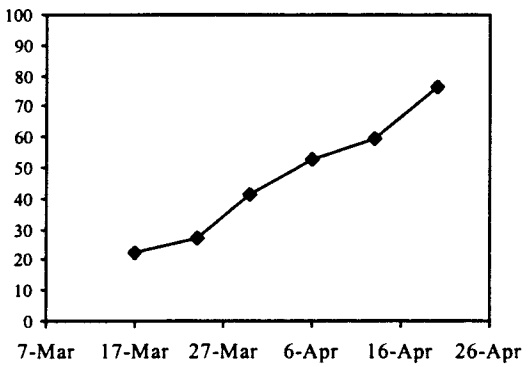
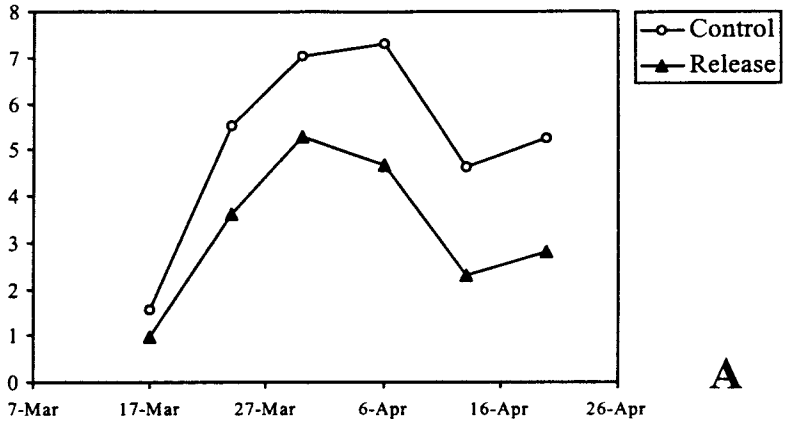


Fig. 2. Mean percent parasitism of whitefly pupae on strawberry foliage collected from three central coast fields where *E. formosa* was released. Twenty-five leaflets were collected from strawberry plants around release points at each release site. Percent parasitism was calculated as (Number of blackened pupae/ (Number of whitely pupae with emergence holes + Number of blackened pupae))* 100.



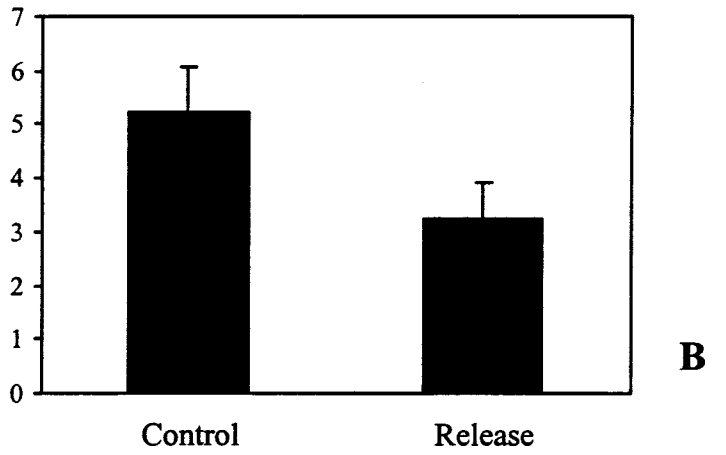


Fig. 3. Mean number of whitefly adults on strawberry foliage collected from three central coast fields where inundative releases of *Encaria formosa* were made. A. Average weekly populations of adult whitefly on 60 young leaflets / acre. B. Average numbers of whitefly adults on 60 young leaflets / acre collapsed over 8 weeks.

ACKNOWLEDGEMENTS

We are thankful to Novartis BCM North America for donating *E. formosa* for the trial, and to cooperators Thom Flewell, Martin Rubio, Laurence London and Joe Valdez for permitting the experiments on commercial strawberry ranches. We also thank Cathy Carlson for help with development of the release containers, and Kathleen Walker for reviewing the manuscript.