Predatory Mites for Biocontrol of the Greenhouse Whitefly, *Trialeurodes vaporariorum* in Cut Roses

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Abstract

Integrated Pest Management (IPM) is successfully used on a year-round scale on only 15% of the area of roses under glass. Obstacles for further expansion of IPM practices among rose growers are the control of the spidermite *Tetranychus urticae* and the greenhouse whitefly *Trialeurodes vaporariorum*. The research stations of Naaldwijk, Aalsmeer and Boskoop have started initiatives in order to enlarge the choice of predator species available for Dutch growers. A series of greenhouse experiments were conducted to select phytoseiid mites suitable for commercial cut roses. Among ten species tested in experimental greenhouses, *Euseius ovalis* was found to be the most promising control agent of *T. vaporariorum*. Its efficacy against other pests and its compatibility with chemicals are the subject of further studies. Since *E. ovalis* is an exotic species formerly not commercially available, efforts are being made to obtain authorization for experimenting with this species in commercial greenhouses in the framework of new fauna protection regulations in The Netherlands.

INTRODUCTION

Trialeurodes vaporariorum (Westwood) is a key pest in both ornamental and vegetable greenhouse crops in the Netherlands, and in nearly all horticultural areas in the world. To control this pest, Dutch rose growers have to apply chemicals that can seriously affect predators of other pests, like spider mites. Bionomics and predation capacity of several whitefly predators have been studied in laboratories (Nomikou, 2003), but little was known about their actual performance under field conditions. From 2003 onwards, the research stations of Naaldwijk, Aalsmeer and Boskoop conducted a series of greenhouse experiment with some ten phytoseiid predatory mites (Messelink, 2005a; Pijnakker, 2005a). Their affinity with rose as a host plant and greenhouse grown cut roses as an environment were established. The potential of three selected species as control agents for greenhouse whitefly was then studied.

MATERIALS AND METHODS

The three experiments described in this paper took place in rose greenhouses at the research stations of Naaldwijk and Aalsmeer in The Netherlands. *Phytoseiulus persimilis* and *Neoseiulus californicus* were obtained from the firms Koppert and Biobest. The other species were reared in climate chambers at the research station. *Amblyseius andersoni*, *Neoseiulus cucumeris* and *Neoseiulus barkeri* were reared on *Acarus siro* as a prey, while *Euseius ovalis*, *Euseius finlandicus*, *Euseius scutalis*, *Typhlodromalus limonicus* and *Typhlodromips swirskii* were reared on Typha pollen.

Experimental Design

1. Experiment 1: Colonization of a Rose Crop by All 10 Predatory Mites. The experiment started in November 2003. Ten plots were created in a greenhouse of 300 m^2 with a three year old rose crop cv. Vendela. The plants were grown in containers with perlite at 21 ± 5 °C, 80 ± 10 % relative humidity (RH). Supplementary light (4,000 lux) was applied during 16 hours a day. CO_2 was supplied during the light period at ± 800 ppm. During the experiment, sulphur evaporators were switched off and compatible fungicides were regularly sprayed instead to control powdery mildew. Each plot consisted of a bed about 1 m wide and 10 m long. In each bed a different predator species was released several times. The first three introductions were done in the absence of prey. Introductions took place in week 50, week 2 and week 6, at a rate of 15, 10 and 15 individuals per m^2 respectively. Spider mites collected at commercial rose glasshouses were then introduced in week 8. Additional predatory mites were released in week 12 ($15/m^2$) and week 16 ($15/m^2$). In week 19, a treatment with the acaricide bifenazate (Floramite) took place. The greenhouse whitefly *T. vaporariorum* appeared spontaneously and was observed in the crop from week 18 onward.

2. Experiment 2: Evaluation of 8 Whitefly Predators on Young Rose Plants. The experiment started in December 2003. Two greenhouses of 10 m^2 per unit were divided into 8 plots of 12 rose plants cv. First Red. The plants (ca 6 months old) were grown in containers with coco peat placed on tables at 21 ± 3°C, 60 ± 20 % relative humidity. Additional light was provided by 4 high pressure lamps (10,000 lux) during 20 hours a day. The plants did not receive any chemical treatment during the experiment. They were heavily infested with adult greenhouse whiteflies originating from tomatoes. Three days after whitefly infestation, 8 species of phytoseiid mites were introduced: *E. ovalis*, *E. scutalis*, *T. swirskii* and *T. limonicus* in the first greenhouse and *A. andersoni*, *E. finlandicus*, *N. cucumeris* and *N. californicus* in the second one. Prior to their release, the predators were transferred to 96 leaf discs (10 predators per disc). On each plot, 120 females of a predatory mite species were released (10 predatory mites per plant).

3. Experiment 3: Evaluation of the Effect of 3 Selected Phytoseiids (*E. ovalis*, *A. andersoni* or *T. swirskii*) Introduced in Combination with *Encarsia formosa* in a Rose Crop. The experiment started in October 2004. Four adjacent climate-controlled 32 m^2. greenhouses housed a ten month old rose crop cv. First Red. The plants were grown on rockwool slabs at 20 ± 0.5°C, 80 ± 5 % relative humidity (RH) and received supplementary light (10,000 lux) during a maximum of 20 hours a day. CO_2 was supplied during the light period at ± 800 ppm. Adult whiteflies were introduced every two weeks between week 48 and 12 in small numbers (60 to 120 per greenhouse). Because of insufficient establishment, an inundative introduction of 1500 adults per greenhouse ($47/m^2$) was carried out in week 15. From week 50 to week 2, 200 *Encarsia formosa* adults were released weekly in all four greenhouses. From week 22, 4 weekly releases (200, 400, 400 and 400 respectively) of *Encarsia formosa* were introduced additionally in each greenhouse. In three greenhouses, a different predatory mite was introduced repeatedly in week 48, 49, 8 and 23 (1000 in each greenhouse). To avoid cross contamination between greenhouses, all human activities (flower harvest, crop maintenance, sampling) where done by two different people on two different days.

Assessments

Samples of 27 leaves per plot were regularly collected in the first experiment. Samples of 210 leaves per plot were collected ten weeks after the release of the predatory mites in the second experiment. Leaves were examined under a stereo-microscope. Mobile instars of the phytoseiids were counted. All nymphs and adult predatory mites were placed in a Marc André medium on a microscope slide. The slides were heated for a few days to clear the specimens and then identified.

In the third experiment, eleven weeks after the release of the predatory mites, the number of whitefly egg circles was counted on 90 stems per greenhouse. One sticky trap was used per greenhouse to assess the weekly infection level of the greenhouse. Predatory mites were regularly observed on 60 stems per greenhouse and identified.

RESULTS

Experiment 1: Colonization of a Rose Crop by Predatory Mites

Only *P. persimilis* and *N. californicus* responded well to the presence of spider mites. After the invasion of the greenhouse by whiteflies in week 18, numbers of *E. ovalis* started to increase (Fig. 1). In week 26, *T. vaporariorum* had reached a critical level and chemical treatments were necessary to reduce the number of whiteflies. In week 30, *E. ovalis* had colonized the major part of the crop and was found in eight of the ten plots.

Experiment 2: Evaluation of Whitefly Predators on Young Rose Plants

With abundant whitefly larvae to prey on, *Euseius ovalis* became the most numerous predatory mite (Fig. 2). No predatory mites were found on leaves with accumulated honeydew.

Experiment 3: Evaluation of the Effect of the Phytoseiids *E. ovalis*, *A. andersoni* or *T. swirskii* Introduced in Combination with *Encarsia formosa* on a Rose Crop

The number of whiteflies captured weekly on the sticky traps was assessed in each greenhouse, in the presence of either *E. formosa* alone, *E. formosa* and *E. ovalis*, *E. formosa* and *A. andersoni* or *E. formosa* and *T. swirskii*. Eleven weeks after the last introduction of the predatory mites (week 34), the number of whiteflies was the lowest in the greenhouse where *E. ovalis* and *E. formosa* were introduced. The number of whitefly egg circles on the leaves (Fig. 3) corroborated the sticky trap results.

DISCUSSION

In experiment 1 and 2, *Euseius ovalis* was found to be the most abundant predator among the phytoseiids tested. It dominated on single plants as well as under crop conditions. Its rapid installation on plants of two different cultivars of roses in the presence of whitefly, its high mobility (experiment 1) and its generalist character (Manjunatha, 2001b) suggest that *E. ovalis* is a promising biological agent in IPM programs in roses. *Euseius ovalis* is a generalist predator. It preys, among other things, on whitefly eggs and nymphs. Rangarajan and Mahadevan described it in India on chili *Capsicum annuum* L., during the winter of 1971-72. It has been recorded in Taiwan, on the Matsu Islands (China), on the Fiji Islands, on the Cook Islands, in Papua New Guinea, on Andaman Nicobar Islands, in Malaysia and on the Canary Islands. Research has been carried out on its life history on phytophagous mites, on thrips, different pollens and artificial diets (Shih Chain Ing et al., 1993, 2001; Chang et al., 1995; Manjunatha et al., 2001a).

The first experiments pursued only to find out which of the potential predators was able to colonize and to survive in the rose crop, but pest control efficacy was not studied. Despite the whole greenhouse being colonized by *E. ovalis*, whitefly infection level became too high and chemical treatments were necessary to control the pest. These observations suggest that whitefly IPM strategy should not include only mites, but also compatible chemicals or other beneficials like the parasitoid *E. formosa*. This idea seemed to be confirmed by the results of a fourth experiment (data not shown) with the rose cv. Passion, where the combined presence of *Encarsia formosa* with the mites *T. swirskii* and *E. ovalis* (all in one crop) kept a whitefly population at a very low level during several months.

This was one of the reasons that lead to experiment 3, in which we pursued just some indication of the combined predatory effect of *Encarsia* with the three mites. *E. ovalis* combined with *Encarsia formosa* gave the fastest reduction of whitefly.

At this moment, the predatory potential of *T. swirskii*, *E. ovalis* and *A. andersoni* on *T. vaporariorum* and other pests in roses and their compatibility with chemicals are being studied further with and without the presence of *Encarsia*. *T. swirskii* became commercially available in the beginning of 2005 and *A. andersoni* is expected at the end of the year. Efforts are being made to get authorization for experimenting with *E. ovalis* in commercial greenhouses in the framework of new fauna protection regulations in The Netherlands.

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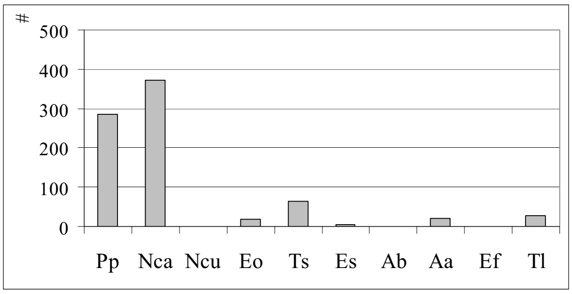
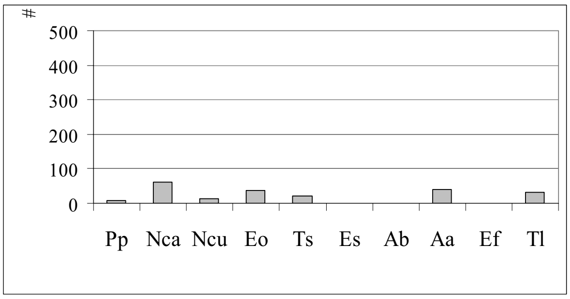
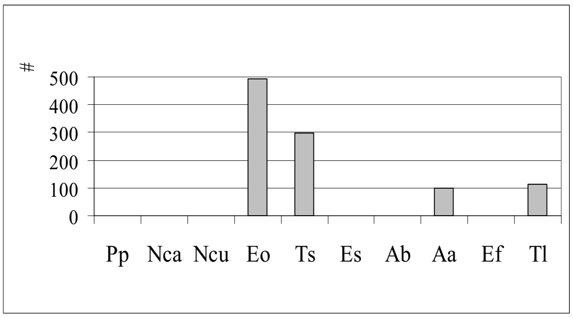
Figures



a) Week 18



b) Week 22



c) Week 30

Fig. 1. Total number of predatory mites found in the samples (270 leaves collected, 27 per plot) on different dates: a) week 18, two weeks after the second introduction of predatory mites in presence of spider mites. First whiteflies found in the crop. b) week 22, two weeks after pulverization of the acaricide bifenazate. Absence of spider mites, presence of greenhouse whitefly. c) week 30, eleven weeks after pulverization of the acaricide bifenazate. Absence of spider mites, presence of greenhouse whitefly.

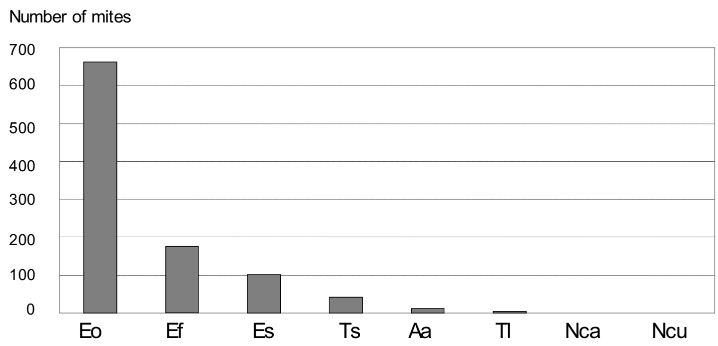


Fig. 2. Number of predatory mites collected ten weeks after release in roses infested with greenhouse whitefly *Trialeurodes vaporariorum*. Values are total number of mites on 210 leaves sampled per plot. Phytoseiid species: Eo: *E. ovalis*; Ef: *E. finlandicus*; Es: *E. scutalis*; Ts: *T. swirskii*; Aa: *A. andersoni*; Tl: *T. limonicus*; Nca: *N. californicus*; Ncu: *N. cucumeris.*

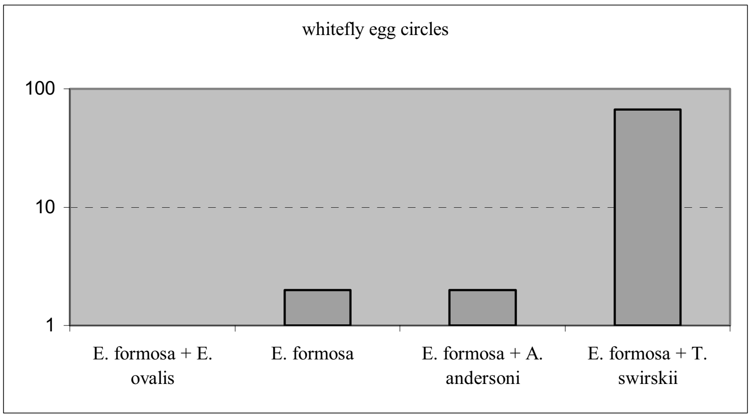


Fig. 3. Number of whitefly egg circles on the leaves of 90 rose stems 11 weeks after the release of predator combination in each greenhouse.