Banker plants facilitate biological control of whiteflies in cucumber

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Banker plants, *Lapsana communis* and *Chelidonium majus*, were utilized to rear the whitefly *Aleyrodes proletella*. The parasitic wasp *Encarsia formosa* was reared on this host in order to facilitate biological control of glasshouse whitefly, *Trialeurodes vaporariorum* on cucumber. Banker plants with *E. formosa* showed to be a good alternative to weekly introductions of *E. formosa*. Moreover, banker plants were refugia for *E. formosa* between two crops. Another parasitic wasp *Eretmocerus eremicus* was unable to reproduce on *A. proletella*. However, during the summer *E. eremicus* supplemented control of glasshouse whitefly by *E. formosa*.

Keywords: *Trialeurodes vaporariorum*, *Aleyrodes proletella*, *Encarsia formosa*, *Eretmocerus eremicus*, *Lapsana communis*, *Chelidonium majus*

Whiteflies are important pests in glasshouse horticulture. The larvae and the adults suck fluids from the plants and a surplus of sugar contents is excreted as honeydew. Honeydew is an excellent medium for the growth of sooty mould fungi, which may result in complete collapse of plants. Moreover, whiteflies are potential vectors of virus.

At present, cucumber crops are planted three times per year in Dutch commercial glasshouses. Glasshouse whitefly, *Trialeurodes vaporariorum* Westwood may easily get out of hand, because cucumber is a very attractive and excellent host-plant. Woets (1978) developed a scheme for introduction of the whitefly parasitoid *Encarsia formosa* Gahan in tomato. However, in cucumber it is clearly more difficult to achieve control of whitefly. At the time of replanting the risk is even higher, because the whiteflies concentrate on the small leaf area of the young crop. This may result in sticky plants and the growth of sooty mould. Removal of the old crop results in a gap in biological control, because parasitized pupae are removed from the glasshouse. Adult parasitoids, that are still present in the glasshouse are unable to parasitize or to conduct host-feeding, because there are no whitefly larvae available. Banker plants could serve as refugia for parasitoids during the process of removing the old crop and replanting the new crop. One of the indigenous whiteflies that is a candidate for a banker plant system is the cabbage whitefly, *Aleyrodes proletella*. Suitable host-plants are Nipplewort, *Lapsana communis* (Asteraceae) and Greater Celandine, *Chelidonium majus* (Papaveraceae) (Bink *et al.*, 1980). *A. proletella* is fairly easy to rear and it is a host for *E. formosa*. A preliminary test showed that *E. formosa* reared on *A. proletella* readily accepts the glasshouse whitefly again. In addition to *E. formosa*, the parasitoid *Eretmocerus eremicus* (Rose & Zolnerowich) is now being introduced commercially for control of whiteflies.

An experimental alternative for replanting the cucumber crop is growing the plants in a layering system at a high wire. The advantage of this method is that the crop stays in the glasshouse. However, in an experimental layered crop, the oldest leaves were removed before *E. formosa* was able the hatch from the black pupae. This also resulted in poor control of whiteflies. A banker plant system would also be necessary with this method of cucumber growing, if this method is commercially adopted in the future.

In order to investigate the possibility of facilitating whitefly control, the development of both pest and parasitoids was followed in glasshouses with either weekly introductions of parasitoids or with a banker plant system.

MATERIALS AND METHODS

In each of four compartments planted with cucumber, a different treatment was carried out (Table 1). The first planting was mid-February, the second in July and the third in early October.

Table 1. Treatments with *Encarsia formosa* and *Eretmocerus eremicus* in four cucumber glasshouses with or without banker plants

Treatment	Number of plants	Area (m^2)	Introduced *E. f.*/m^2/week
1. Weekly introduction of *E. formosa*	180	107	1.2
2. Banker plants with *E. formosa*	240	153	
3. Weekly introduction of *E. formosa* and *E. eremicus*	256	160	0.8
4. Banker plants with *E. formosa* (and *E. eremicus*)	304	189	

Introductions of parasitoids started on 12 March and continued until December. The rate of released *E. formosa* was estimated with the help of a reference card. One reference card per week was reared in the laboratory to check the number of *E. formosa* that emerged from this card. In glasshouses were *E. eremicus* was introduced the rate was 1.5 *E. eremicus* per m^2. *E. eremicus* was released as adults and counted before each weekly introduction. The introductions of parasitoids on the banker plants were stopped after the banker plants had become self-supporting. In the glasshouses without banker plants weekly introductions of parasitoids continued.

The banker plants comprised of Nipplewort (*L. communis*) with the cabbage whitefly *Aleyrodes proletella*. Two of these plants were planted weekly in the banker plant glasshouses until their total number was ten. In summer and autumn Greater Celandine (*C. majus*) were also utilized as banker plants. When a banker plant had senesced, it was replaced with a fresh plant. *A. proletella* is a recognized host for *E. formosa*, but *E. eremicus* had not previously been tried on this host. Plantings were delayed because natural infestation of whiteflies did not occur. The first attempt to deliberately introduce whiteflies on 9 April failed, so another introduction was made on 29 April.

To get a good impression of the numbers of pupae per plant and the rate of parasitism, unparasitised and parasitised pupae were counted weekly on five individually labelled plants. Assessments during the first planting were done in May and June, during the second planting in August and September and during the third planting in November. Although plantings were later than in commercialglasshouses, it was still considered valuable to compare parasitoid performance in cucumbers with and without banker plants.

RESULTS AND DISCUSSION

Although *A. proletella* did lay some eggs on cucumber sporadically, it was evident that the larvae did not survive. The total number of pupae, unparasitised plus parasitised, are given in the Figs. 1, 3, 5 and 7. The rates of parasitism by *E. formosa* and *E. eremicus* are given in Figs. 2, 4, 6 and 8. In September assessments were not possible because of a high density of cotton aphids, *Aphis gossypii*, and sooty mould. A natural infection of *Verticillium lecanii* occurred so abundantly on the whitefly infestation, that counting pupae was impossible.

In glasshouse 1 (weekly *E. formosa*) the total number of pupae was in the order of hundreds in the first and third crop and up to 8800 per plant in the second crop. At a density of thousands of pupae per plant the plants became sticky whitefly honeydew. In August and September assessments were not possible, because of high densities of cotton aphids. The mean rate of parasitism was approximately 50% and reached a maximum of 70%. During the summer *E. eremicus* occurred naturally in this glasshouse and supplemented control by *E. formosa*. In September the whitefly became infected with *V. lecanii*. During the third planting parasitism was less than 7%.

In glasshouse 2 (with banker plants) the maximum number of pupae was tens to hundreds per plant. The rate of parasitism by *E. formosa* was between 30 and 85%. In the third planting the parasitism was almost nil. The number of pupae rose to 10000 per plant, possibly due to a high infestation pressure from a nearby glasshouse.

In glasshouse 3 (weekly *E. formosa* and *E. eremicus*) the total number of pupae was between tens and hundreds per plant. The rate of combined parasitism by *E. formosa* and *E. eremicus* was from 17 to 75%. Parasitism during the third planting was 15% at most.

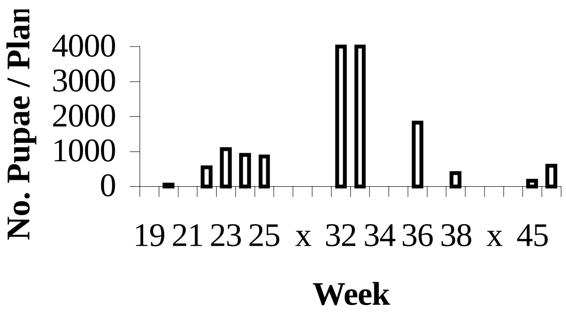

Figure 1. Weekly introductions of *Encarsia formosa.* Total number of pupae (unparasitised and parasitised). x = change of crops. Numbers in week 32 and 33, respectively 5000 and 8800

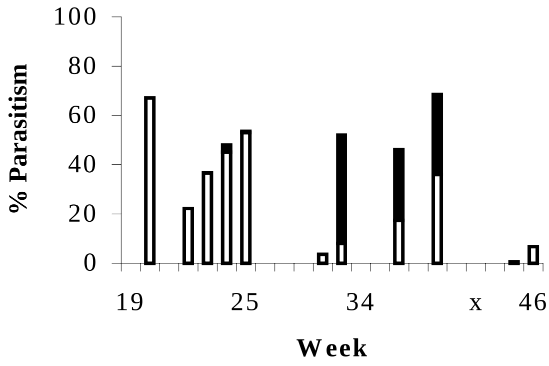

Figure 2. Weekly introductions of *Encarsia formosa*. Parasitism (%) of *Encarsia formosa* (white) and spontaneous *Eretmocerus eremicus* (black)

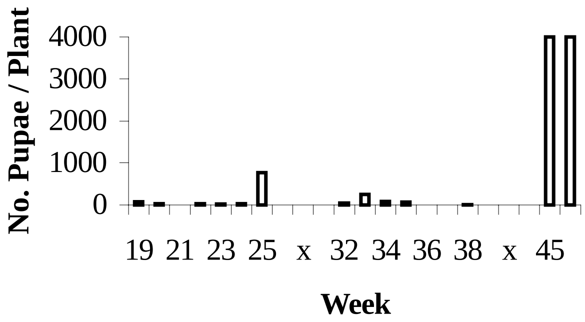

Figure 3. Banker plants. Total number of pupae (unparasitised and parasitised). x = change of crops. Number in week 45 and 46, respectively 4200 and 10700

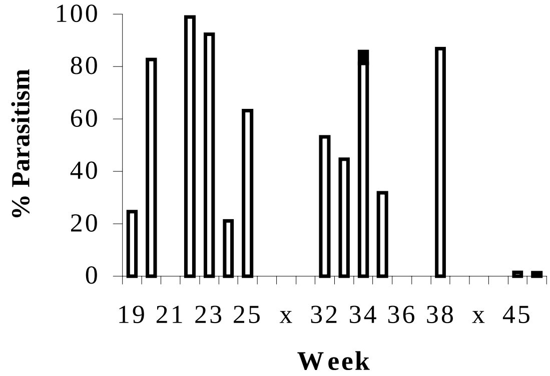

Figure 4. Banker plants. Parasitism (%) of *Encarsia formosa* (white) and spontaneous *Eretmocerus eremicus* (black)

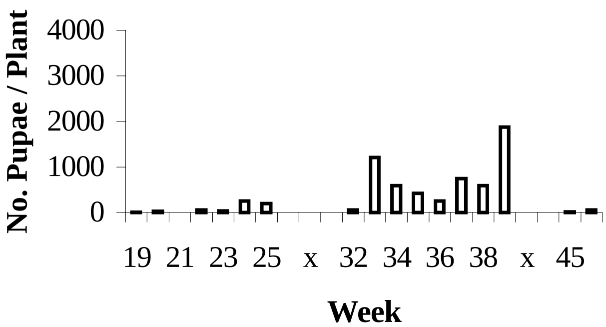

Figure 5. Weekly introductions of *Encarsia formosa* and *Eretmocerus eremicus.* Total number of pupae (unparasitised and parasitised). x= change of crops

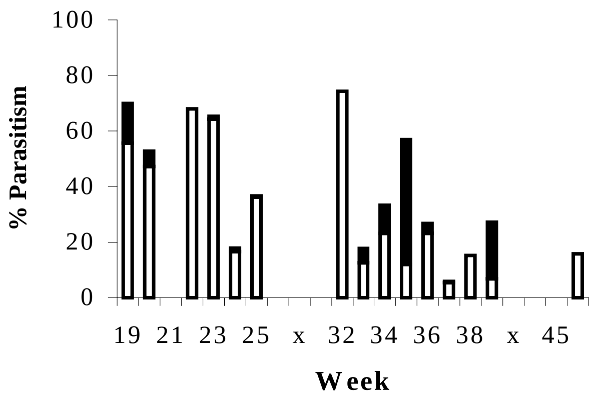

Figure 6. Weekly introductions of *Encarsia formosa* and *Eretmocerus eremicus.* Parastitism (%) of *Encarsia formosa* (white) and *Eretmocerus eremicus* (black)

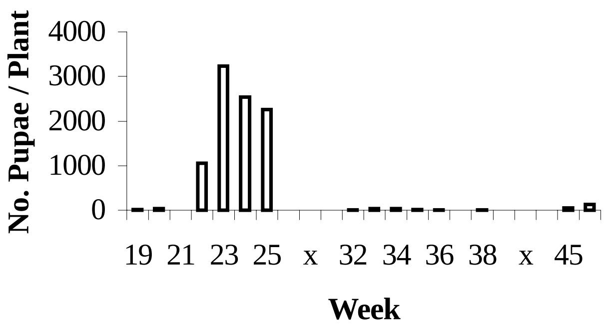

Figure 7. Banker plants. Total number of pupae (unparasitised and parasitised). x = change of crops

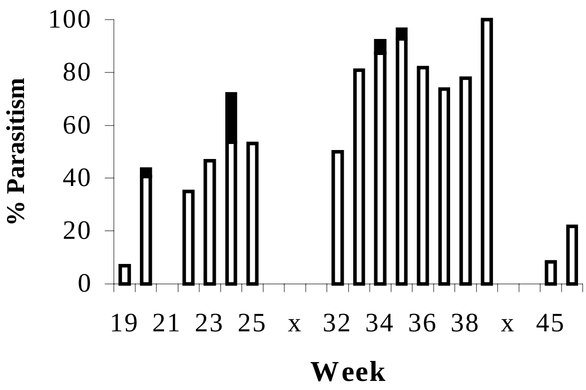

Figure 8. Banker plants. Parasitism (%) of *Encarsia formosa* (white) and early introduction of *Eretmocerus eremicus* (black)

In glasshouse 4 (with banker plants) the total number of pupae rose above 3000 in the first planting, but in the second and third planting tens per plant at most. The rate of parasitism by *E. formosa* during the first planting was 35 to 55%, during the second planting 50 to 100% and during the third planting 20% at most.

The banker plants served as a reservoir of *E. formosa*, making extra parasitoid introductions unnecessary. Replacing senescing banker plants with fresh ones maintained *E. formosa* populations. It is possible that *E. formosa* emerging from the banker plants were more viable than those emerging from commercially produced cards and this should be further investigated.

Aleyrodes proletella proved to be an unsuitable host for *E. eremicus*. However, it is worth trying to find another host for this parasitoid, because a banker plant system for this parasitoid would be a valuable supplement to that for *E. formosa* during the summer. Both *E. formosa* and *E. eremicus* can kill large numbers of whitefly larvae by host-feeding, but this has not been quantified in this study.

In autumn the rate of parasitism of *E. formosa* decreased dramatically and *E. eremicus* disappeared completely, so glasshouse whitefly had the opportunity to increase in numbers. The third crop was planted at the beginning of October, which is much later than the last planting in commercial glasshouses. Results from this crop clearly demonstrated that biological control of whitefly is more difficult during the autumn. Less solar radiation is likely to result in less activity of the adult parasitoids. Likewise, both *A. proletella* and *E. formosa*, became less active on the banker plants during autumn. To keep biological control going as long as possible the rate of parasitism should be high and the whitefly density low.

For further improving whitefly control, tests with the mirid bug *Macrolophus caliginosus* on *L. communis* with *A. proletella* were carried out. Results showed that *M. caliginosus* could be reared on *L. communis* with *A. proletella* from May to December. Banker plants could potentially be used as a reservoir of both parasitoids and predators.

Cotton aphids, *Aphis gossypii*, were a nuisance during this study. *Aphidius colemani* and *Aphidoletes aphidimyza* were released for their control. *A. aphidimyza* was regularly found predating on the different stages of whiteflies on cucumber and on the banker plants. Western flower thrips, *Frankliniella occidentalis* increased during the summer, followed by high numbers of naturally occurring *Orius laevigatus*. In one of the glasshouses very high numbers of *Amblyseius limonicus* also occurred naturally and to a lesser extent, *Amblyseius degenerans* and *Amblyseius cucumeris*. Caterpillars of *Chrysodeixis chalcites* were controlled with *Bacillus thuringiensis* and in one of the glasshouses four insectivorous birds (*Alcippe brunnea*) were released in autumn. The control of caterpillars was most effective in the glasshouse with birds where the crop was kept free from further caterpillar damage. Mildew was controlled chemically without noticeable effect on the biological control.

CONCLUSIONS

- Banker plants did not pose a risk for cucumbers, because *A. proletella* did not reproduce on cucumber.
- Banker plants with *A. proletella* were shown to be a possible alternative for weekly introductions of *E. formosa* on cards.
- Banker plants made it unnecessary to re-introduce *E. formosa* after planting the next crop.
- In general *E. formosa* was dominant, but *E. eremicus* was a welcome addition for the biological control of whiteflies in summer.
- In autumn parasitism decreases and whitefly has the opportunity to increase.

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