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Greenhouse Whitefly (*Tialeurodes vaporariorum* Westwood) Control By *Encarsia formosa* Gahan And Its Color Preference In Commercial Gerbera Greenhouses In Iran

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ABSTRACT

Whiteflies (Homoptera: Aleyrodidae) are one of the most important key pests of many crops throughout the world. In this examination, the effective at weekly releases of Encarsia formosa Gahan for greenhouse whitefly control, Trialeurodes vaporariorum Westwood in commercial gerbera greenhouses, on three colours: yellow, white and pink was determined. Parasitoids were released in one, two and three ratio per each pot and compared with control treatment. Released parasitoids in two and three ratio treatments could decrease population of greenhouse whitefly under the economic damage threshold and no meaningful difference observed, and these treatments had a significant difference with treatments one and control. This shows that treatment one couldn't decrease pest population under the economic damage threshold. In addition, the pest population on yellow flowers were more than other colours and had a significant difference with them.

Keywords: Biological control, Commercial greenhouse, *Encarsia formosa*, Whitefly, Gerbera, Color.

INTRODUCTION

Whiteflies (Homoptera: Aleyrodidae) are one of the most important key pests of many crops, which attack more than 500 species of food, fiber and ornamental plants such as gerbera and cause crop losses that total to hundreds of millions of dollars [14]. Whiteflies can damage the plant directly and indirectly. They suck the plant sap and this leads to lessen plant 's vitality, productivity and causes plant damage [2]. They damage by secreting honeydew, which leads to growth of sooty mold fungi, and this affect the process of the plant physiology [7], also they transmit the plant viruses [26].

If it left uncontrolled large populations of whiteflies can develop on greenhouse crops over a production season [24], and it can have a large effect on plant growth and yield [31].

Osman (1996) found that color is one of the most important factors for whiteflies in selecting the host plant, where whitefly attracts to short wavelengths with migratory behavior and long wavelengths that attract them to host plants. *Trialeurodes vaporariorum* made a response to the yellow-green color in large numbers with a wavelength ranging from 520 to 610 nm [32].

In integrated pest management (IPM), there are different ways to control whiteflies, which include: cultural and physical control, host-plant resistance, chemical control and biological control [17].

Using *E. formosa* for biological control of greenhouse whitefly introduced in 1920 in Europe [35], and it was an effective and appropriate method to the environment. *E. formosa* is used worldwide for commercial greenhouse crops [36, 37]. Inundative releases of *E. formosa* have been vastly used in commercial greenhouses to suppress populations of *T. vaporariorum* worldwide [4], and due to the architecture of different leaf surfaces, have had been varying degrees of success [34, 23, 9, 12, 3].

Principal greenhouse crops in which *E. formosa* is used to, include tomato (*Lycopersicon esculentum* Mill) and cucumber (*Cucumis sativus* L.) [37]. The parasitoid is also used, or being tested, to a lesser extent on eggplant (*Solanum melogena var. esculenta*) and gerbera (*Gerbera jamesonii* L.) [33], poinsettia (*Euphorbia pulcherrima*) [18, 25, 29], marigolds (*Tagetes erecta* L.) [16], and strawberry (*Fragaria X ananassa* Duch) [11].

E. formosa parasitizes at least 15 hosts in eight aleyrodid genera [30].

In this study, we tried to determine the suitable rate of releasing *E. formosa* to control *T. vaporariorum* on gerbera greenhouses in Iran condition.

MATERIALS AND METHODS

Insects

Adult insects of greenhouse whitefly (*Terialeurodes vaporariorum* Westwood) were collected from the Pakdasht Gerbera greenhouses of Tehran Province, Iran. They maintained on sunflower, tobacco plants in the laboratory at 26$^{°C}$ under a 14h light: 10h dark (LD 14:10) photoperiod.

Adult insects of Aphelinid parasitoid wasp, *Encarsia formasa* Gahan was collected from the Shahryar sunflower's field of Tehran province, Iran. *E. formosa* maintained on whiteflies nymphs and pupa in the laboratory at 26$^{°C}$ under a 14h light: 10h dark (LD 14:10) photoperiod.

Encarsia Cards

Parasitized pupae of whitefly were collected from leaves. They were transferred to special cards and stored at -4$^{°C}$ for future usages.

Treatments

The examination was conducted in cages placed in a greenhouse during three-month periods from 1 April to the end of June 2011. Three gerbera colors: yellow, white and pink were used for the test. The pots of flowers in cages (150×150×150cm) were 1^{m} above the floor, and each cage included nine pots. Cages were covered with screens with 23×13 meshes (wrap and woof per cm^2).

Ten adults greenhouse whitefly per gerbera pots were released three times to contaminate them. The examination was done at 28±2$^{°C}$ temperature and %67±5 relative humidity. *E. formosa* cards introduced by the cards that were contained parasitized pupa of greenhouse whiteflies into the cages. Treatments included one, two and three parasitoids per pots. One cage assumed as control, which was no parasitoid release on it.

Table 1. Analysis of varience table (Partial sum of squares)

Source	Sum of Squares	DF	Mean Square	F Value	Prob> F	
Model	25823.89	35	737.83	467.73	<0.0001	**significant**
A	16684.82	3	5561.61	3525.66	<0.0001	
B	578.72	2	293.86	186.29	<0.0001	
C	2764.58	2	1382.29	876.27	<0.0001	
AB	586.18	6	97.70	61.93	<0.0001	
AC	4669.13	6	778.19	493.32	<0.0001	
BC	149.76	4	37.44	23.73	<0.0001	
ABC	288.74	12	24.06	15.25	<0.0001	
Pure Error	112.00	71	1.58			
Cor Total	**25935.89**	**106**				

Sampling

Sampling started one week after the first releases of parasitoids. Then sampling was done every three days. On each sampling date, 10 gerbera leaves were chosen randomly on plants from each cage. The leaf was turned over and the number of live pupa in third-instar and parasitized pupa of greenhouse whitefly, under the leaves were counted.

Data analysis

The experiment was analyzed with Design expert 6 in Three- factor factorial Completely Randomized Design (CRD). Factors were consisted of colors (Pink, yellow and white), Time of the sampling (at the start, mid and last of sampling) and different rates of releasing per pots (one, two, Three and control). Experiment was done in three replications.

RESULTS

Data analysis of first sampling shows that the population of live pupae in one, two and three ratio per pots didn't have a significant difference (Table 1).

There was a significant difference among control and other treatments. The population of live pupa on white and pink flowers had no significant difference in the treatments but had a meaningful difference with control. In the control cage, there was a significant difference among yellow color and the other colors (Figure 1).

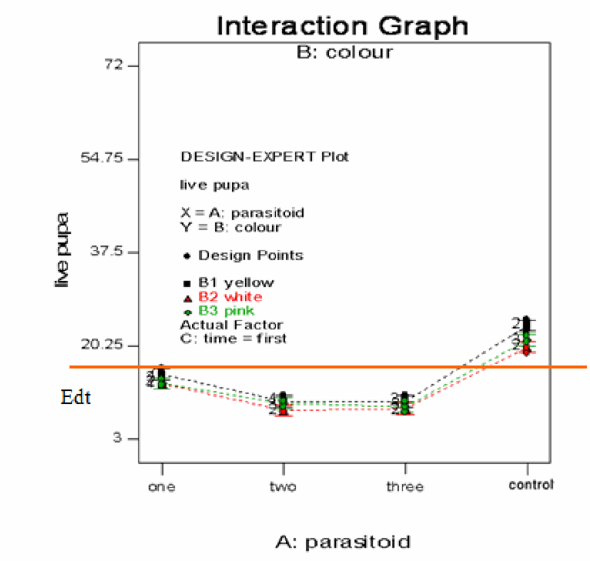

Figure 1. Mean of live pupa in different colors and different treatments at the first time of examination

In the second sampling, there weren't observed any significant difference between live pupa in the treatments two and three, whereas they had a meaningful distinction between them and treatment one. There was also a difference between treatment one and the control. Treatment one and the control were more than the economic damage threshold. In this stage, color also were effective to attract greenhouse whiteflies and there was a significant difference among yellow color with the other colors in the live pupae in treatment one and the control but not in treatments two and three (Figure 2).

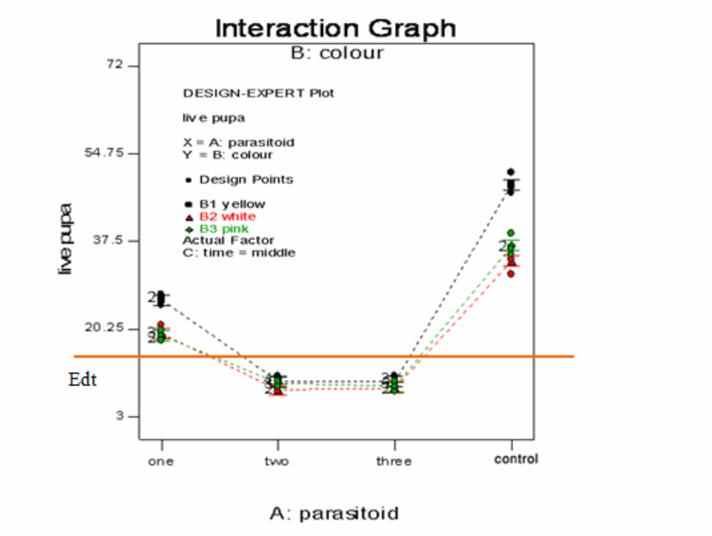

Figure 2. Mean of live pupa in different colors and different treatments at the middle of time of the examination.

In the third sampling which was done 38 days after the first release, weren't observed any significant difference between treatments two and three, but a high consequential difference was observed among these treatments with treatment one and the control which were upper than the economic damage threshold. The difference of colors effects were like the last stage (Figure 3).

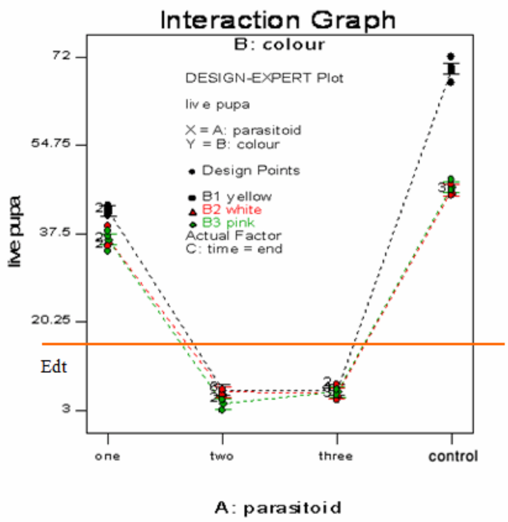

Figure 3. Mean of live pupa in different colors and different treatments at the end of time of the examination.

CONCLUSION

Encarsia formosa parasitizes several whitefly species and is a valuable biological control agent for the greenhouse whitefly, *Trialeurodes vaporariorum* [19, 20].

Results of this experiment showed that release of one *E. formosa* can't control whitefly damages and lessen it under the economic damage threshold. Two parasitoid of *E. formosa* per gerbera pots which had no significant difference with three release parasitoid in decreasing of pest population can decrease the population of greenhouse whitefly, *T. vaporariorum*, and keep it under the economic damage threshold. So using two parasitoids per gerbera pots is recommended to control *T. vaporariorum*. Benzuii et al. (1990) showed ten times release weekly of *E. formosa* at rate the 9.64 parasitoid pupa per square meter of poinsettia greenhouses also made successful results.

Eggenkamp-Rotteveel Mansveld et al. (1982) introduced 27.5 *E. formosa* pupae per m^2 in the 6-week period. In small experimental greenhouses at Cornell University, life-table analyses showed that *E. formosa* released at 3 and 1 wasp/plant/week as high and low release rate, respectively exerted a suppressive effect on *B. argentifolii* population growth on poinsettia [20].

Hulspas-Jordaan et al. (1987) reported that 4 introductions with a total of 20.6 *E. formosa* adults per m^2 in a period of 6 weeks will be effective. One of the crucial factors that helps the insect in identifying its food supply is phototropism and color vision [15, 21].

Insects use the different colors to differentiate between the host and the environment [5]. As the examination process indicated gerbera colors can be one of the most important factors, which affected pest population. There weren't observed any significant difference between pink and white color during the test, Whereas there was a difference among yellow gerbera color with the other colors. So that yellow color can attract more whiteflies which the other colors can't. Affeldt et al. (1983) found that the highest number of *T. vaporariorum* was on traps reflecting radiation with wavelength between 500 - 600 nm. They also responded more positively to yellow with a peak reflectance at 600 nm [13]. Chu et al. (2000) also had proven that the most attractive colors in a wavelength range between 490 to 600 nm for *Bemisia argentifolli* were yellow-green, yellow and spring green respectively. They have said that when using nine different colors, yellow, green and orange with wavelength range between 490 to 600 nm will be the most attractive for the whitefly respectively. These colors consider the primary colors in attracting insects, as its wavelength similar to the reflected light waves from the underside of the lush green leaves. Mutwiwa and Tantau (2005) also reported that the greenhouse whitefly, *T. Vaporariorum*, attracted to lamps of the yellow color.

As a result separating this color with the other colors in commercial gerbera greenhouses is preferable because this can decrease *T. vaporariorum* population. Because the effect of two parasitoids and three parasitoids are approximately the same and there is no significant difference between them in decreasing the pest population using two parasitoids is more economical.

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