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# Efficacy of different light-emitting diodes (LEDs) attached to yellow sticky cards to capture the whitefly *trialeurodes vaporariorum*

Eficacia de diferentes diodos emisores de luz (LEDs) unidos a trampas adhesivas amarillas para la captura de la mosca blanca *Trialeurodes vaporariorum*

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## RESUMEN

Teniendo en cuenta que algunos adultos de insectos muestran preferencia a ciertas longitudes de onda, se ha considerado este comportamiento para desarrollar herramientas de monitoreo y estrategias de control de insectos plaga. Como ejemplo de ello, las tarjetas adhesivas amarillas han sido ampliamente usadas para monitorear población de moscas blancas a campo como invernadero. Este estudio tuvo como objetivo evaluar la efectividad de trampas adhesivas amarillas provistas con luces emitidas por diodos (LEDs) para el trampeo de adultos moscas blancas *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae). Los ensayos se llevaron a cabo en la EEA INTA Concordia en condiciones de umbráculo, donde se ubicaron jaulas de cría con plantas de tabaco, *Solanum tabacum* (L.) y poroto, *Phaseolus vulgaris* (L.) desde Junio hasta Julio del 2013. Las trampas adhesivas amarillas tuvieron una superficie de 64cm$^2$ provistas con (LEDs) de diferentes longitudes de onda promedio (525 nm verde y 380 nm UV) y sin LED como testigo. Los ensayos mostraron que los adultos de mosca blanca fueron significativamente ($\alpha$ >0.05) más atraídos por las trampas equipadas con LED 525 nm verde (134 ± 7.4 adultos/tarjeta) comparadas con trampas equipadas con LED 380 nm UV (105 ± 7.4 adultos/tarjeta) y trampas sin LED (85.17 ± 7.4 adultos/tarjeta). Estos resultados muestran que los adultos de *T. vaporariorum* son atraídos a trampas dotadas con LED verde, las cuales podrían tener un promisorio uso en invernadero como detección, monitoreo y control de mosca blanca.

**Palabras clave**: trampas; aleyrodidae; longitud de onda; tarjetas adhesivas amarillas

## ABSTRACT

Since adult insects respond to particular wavelengths, some investigations have proposed to use such behavior as potential target for novel monitoring and pest control tools.Yellow sticky cards have been commonly used for monitoring whiteflies population in open-fields as well as in greenhouses. However, the attractiveness depends on various factors such as the reflected intensity (brightness) and the hues of yellow color (wavelength) of the trap surface, which is often influenced by environmental conditions and may sometimes affect the capture of white flies.There fore, the use of light emitting diodes (LEDs) can be a significant complementary tool to strengthen attractiveness and the selectivity of these cards. This research was carried out to investigate the efficacy of the yellow sticky traps equipped with LEDs in the capturing mechanism of adult whiteflies *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae). This study has taken place in a glass little greenhouse at the Argentine Agricultural Experiment Station (EEA) of the National Institute for Agricultural Technology (INTA) of Concordia, Province of Entre Rios (Argentina), where rearing insect cages were placed together with tobacco plants, *Solanum tabacum* L. and beans *Phaseolus vulgaris* L. from June to July, 2013. The yellow sticky traps covered an area of 64cm$^2$and were supplemented with LED sof different wavelengths, namely green LEDs (525 nm), UV (380 nm) and without LED sas control treatment. The trials showed that adults of *T. vaporariorum* on average preferred ($\alpha$>0,05) traps equipped with green LEDs (525nm),which could have a promising use in greenhouses for the identification, monitoring and control of whiteflies.


**Keywords**: LED traps, aleyrodidae, wavelength,yellow stickycard

## INTRODUCTION

The horticultural activity in Argentina is wellknown for its wide geographical distribution and the variety of crops grown in the area. This is a fundamental socio-economic sector that provides daily food for the population living in this region, satisfies the domestic demand and contributes to the GDP (11, 6% out of the Agricultural GDP). This sector also provides employment to 350,000 people approximately, mainly people from family farmers, in a horticultural area of 600,000 hectares resulting in an annual production of 10,500,000 tons (Colamarino *et al*., 2006). In Entre Ríos, the most important developed horticultural areas can be found in the cities of Federation, Paraná, Concordia and Colón that represent 83% of the total horticultural areas within the Province of Entre Rios (CNA, 2002). About 550 farmers grow vegetables in these fields covering a productive area of 1,300 hectares, out of which 80 are developed in greenhouses. The most important vegetables grown in this area include leafy vegetables (lettuces), fruits from vegetables (tomatoes, peppers), sweet potatoes, onions and squashes. With reference to main greenhouse crops in the city of Chajarí, it has been observed that a large number of polyphagous arthropods affecting such crops leads toboth direct and indirect damage, which creates significant economic loss due to the reduction of yield within this quality.

Among these agricultural pests, certain types of whitefly, including the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae), are important pests that produce significant economic damages. White fly adults and nymphs white flies in greenhouse commercial crops cause the reduction in yield due to the water extraction, photosynthates and amino acids in the plant (Mound and Halsey, 1978). Furthermore, whiteflies excrete sticky honeydew that leads to the growth of sooty mold and can transmit plant viruses that belong to the family of Geminiviridae as in the case of tomato plants (Polston *et al*., 1999).

Chemical control has been traditionally the main control treatment in the Province of Entre Ríos for *T. vaporariorum*. However, the application of chemical pesticides has not been completely effective to some extent because of the presence of the serosity produced by the pest. The serosity avoids the chemical contact with the different stages of nymphs and pupa which remain immobile (Gerling, 1990). Additionally, the habitual use of excessive chemical products has led adults and nymphs to develop resistance against pesticides resulting in new outbreaks of pest (Palumbo *et al*., 2001). The repeated applications of chemical products also lead to reduce the natural enemies of *T. vaporariorum* (González-Zamora *et al*., 2004). However, despite the activity of natural enemies as the sole pest management strategy, this control method would not be sufficient to avoid crop loss in case of high infestation by *T. vaporariorum*. Thus, this situation has led to seek new efficient alternatives for management of whiteflies. LEDs are emissions from solid-state material, semiconductor light sources, of small size, with particular properties, high mechanic stability, high reliability, long lifetime and at low cost (Schubert, 2003). LEDs have been used for some applications such as remote controls, numeric screens, state indicators, flat screens, optical communications, among others (Schubert and Yao, 2002). Few studies have been carried out to investigate how insects respond to LEDs. Based on the fact that yellow sticky cards (YSC) are commonly used for monitoring changes in the population of aphids, leafminers, and other pest insects (Qui and Ren, 2006; Gu *et al*., 2008)as well as whiteflies (Riley and Ciomperlik, 1997), the greenhouse white flies have played a key role for the integrated pest management of particular pests (Kaas *et al*., 2005; Park *et al*., 2011). Considering that adults of *Bemisia tabaci* are attracted to green light in the wavelength range of 530nm corresponding to the highest spectral reflectance of healthy green leaves, Chu *et al*. (2004)reported that thewhitefly *T. vaporariorum*is attracted to two wavelength ranges between blue/ultraviolet 400-490 (migration) and yellow 500-600 (selection of host plant). The aim of this research was to determine the improvement of the efficacy of adult whiteflies capture through the use of LEDs with two wavelengths attached to YSC.

## MATERIALS AND METHODS

The main whitefly *Trialeurodes vaporariorum* colony free from viruses used for trials was collected at Villa Zorraquin, City of Concordia. This colony was maintained on tobacco plants *Nicotiana tabacum* L. (Solanacea) variety Virginia and beans, *Phaseolus vulgaris* L. (Leguminosae) over the last three years without exposure to chemical pesticides in cages covered with *voile* (80cmx80cmx80 $cm^3$) to avoid other insects. A portion of this colony was transferred to another 4 cages with tobacco and beans. These colonies were reared in individual cages ina glass little greenhouse with windows equipped with air conditioned devices, at a temperature ranging from 25 ± 5 ºC, relative humidity ranging from 65 ± 10% and a photoperiod (16: 8) (L: O) supplemented by 40W fluorescent tube light bulbs.

**Yellow Sticky Cards and LEDs.** The research was carried out in a little glass greenhouse from June to July, 2013. The attractiveness of white flies was determined by using three types of traps: (1) a yellow sticky card supplemented with green LEDs (530nm, 36.80 lumens, 90ºC, NºXL503320UBGC525), (2) a yellow sticky card supplemented with UV (380 nm, 36.80 lumens, 20º, NºXL503320UV380) (SHENZEN SEALAND OPTOELECTRONICS CO., LTD) each of them connected to a 220 ohm resistance and energized with a light source of 6V constant current (CC)/ 220V alternating current (AC) and(3) a yellow sticky card without LEDs,all of them with the same area of 64 $cm^2$.The LEDs were attached to yellow sticky traps through a LEDs holder fitted on the upper sticky part of the traps.

**Capture of adults of *Trialeurodes vaporariorum.*** The study was designed as a randomized complete block design (RCBD) with 4 cages (80 x 80 x 80 $cm^3$) that represented each unit (block). Within each cage, three traps (treatments) attached to a vertical wire support system on the top of 15 tobacco and beans plants infested with adult whiteflies (n ~1000) were randomly placed in a triangular arrangement at the same time. This trial was replicated 6 times on 6 different days. The number of adult whiteflies for each tramp was counted after a 24-hour exposure under a stereo magnifier (Figure 1). The average number of adults caught in each trap in each cage was analyzed using ANOVA. Further testing was made using Tukey's method with a significance level of 5% (Figure 2).All of the calculations were performed using InfoStat/Professional software, version 1.1, 2004.

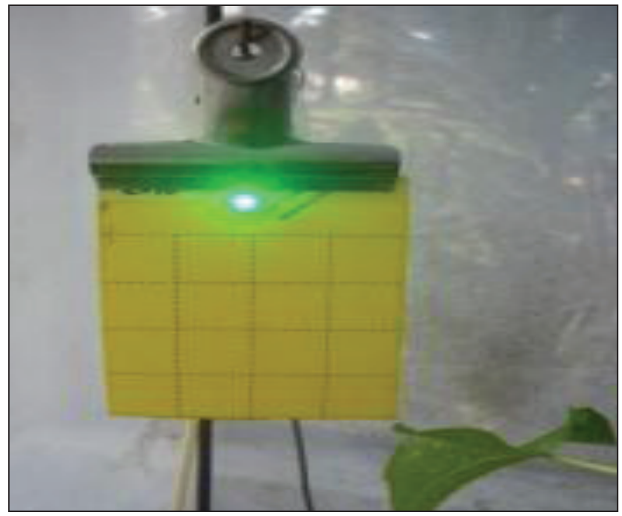

**Figure 1**. -Green LEDs attached to yellow sticky card

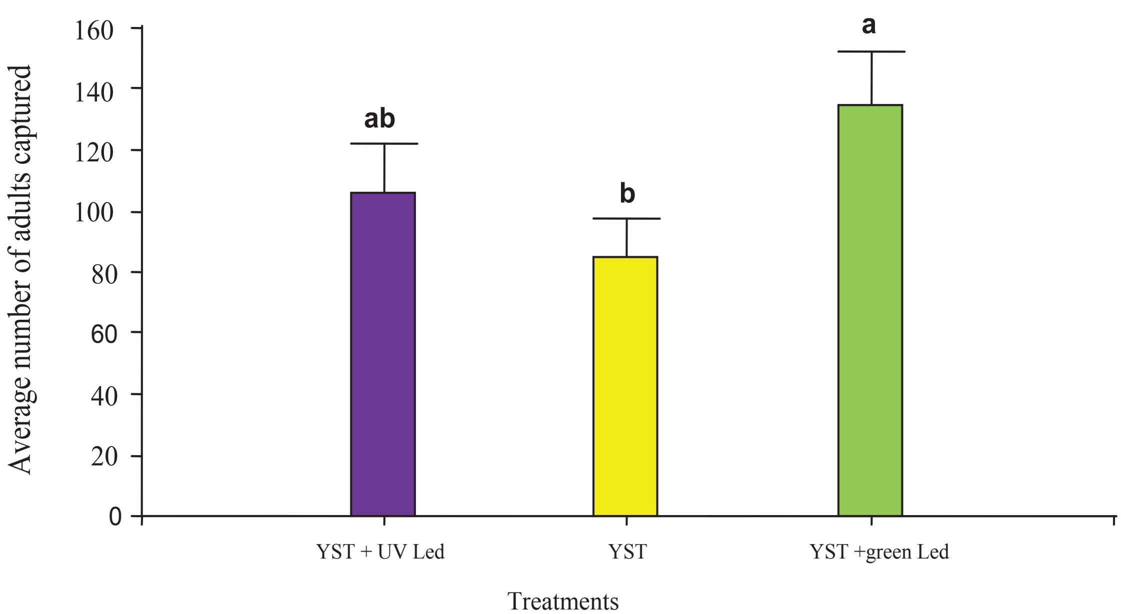


**Figure 2**. -Average number of adult whiteflies *T. vaporariorum*caught in cages with LED traps (YSC + green LEDs, YSC + UV LEDs) and ayellow sticky card without LEDsin 8 weeks in the little greenhouse. Vertical bars represent standard errors. Different letters above bars indicatethat the treatments are significantly different ($p < 0.05$).

## RESULTS AND DISCUSSION

The results showed that in all of the cages where the trials were conducted during the trial period, the average number of adult whiteflies caught in these different treatments (YSC + green LEDs / YSC + UV LEDs / YSC) had significant differences ($F_{treatment}$ =11.44; df=2; P= 0,003). Consequently, a Tukey's test showed that the total average number of adults caught in YSC with green LEDs was significantly higher compared to YSC with UV LEDs and YSC (Figure 2). In addition, at the end of the 6 trial dates, a total average of (134.96 ± 7.4 whiteflies/trap with green LEDs), compared to (105.79 ± 7.4 whiteflies/YSC with UV LEDs and (85.17 ± 7.4 whiteflies /YSC) has been observed.

The above results are supported by Mutwiwa *et al*., (2005) who reported that *T. vaporariorum* adults were more attracted to areas with a maximum refraction or transmittance in the green–yellow area (520-610nm) than to 360-380nm ultraviolet. Based on the different response of *T. vaporariorum* to the wavelength in the UV and yellow area Coombe (1982) and Mellor *et al*., (1997), the results also showed the positive response of greenhouse adult whiteflies to green areas of visible spectrum (550 nm). However, Mound (1962) noted that, in the case of *T. vaporarioum*, there is a balance between the migration behaviour influenced by the ultraviolet (UV) and their landing on yellow areas influenced by the sensitivity to yellow. Taking into consideration such balance, Coombe (1982) explained that *T. vaporariorum* adults fly toward a visual stimuli of 400 nm (Zenith lighting) rather than one of 550nm; however, during the flight this last visual stimuli was the most important signal for identification of host and subsequent landing on it. Moreover, Blackmer *et al*., (1995) showed that the migration flight of *B. tabaci* came to an end after their attraction to the visual stimuli of 550nm typical of the refraction of plants.

## CONCLUSIONS

*T. vaporariorum* adults were attracted in greater number by the visual stimuli coming from the yellow sticky card supplemented with green LEDs. These studies contribute to the design of methods for monitoring and identification of *T. vaporariorum* in order to provide information about the presence and evolution of pest. This information is important to determine a better control strategy and timing for such control. This investigation line will continue to reduce and improve the effectiveness of chemical pesticides with an aim to avoid the conflict between the need to increase food production and protect the environment.

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