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DEVELOPMENT OF LIGHT-EMITTING DIODE (LED) EQUIPPED INSECT TRAPS FOR MONITORING PEST INSECTS IN GREENHOUSES AND FIELDS, 2001 – 2004

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ABSTRACT: We equipped yellow sticky card (YC) and CC traps with 530 nm lime green light-emitting diodes (LED-YC and LED-CC) and blue sticky card (BC) traps with 470 nm blue LEDs (LED-BC) to increase trap catches of several pest insects. The LED-YC traps caught 1.3, 1.4, 1.8, and 4.8 times more adult *Trialeurodes vaporariorum* (Westwood), sweetpotato whitefly *Bemisia tabaci* (Gennadius) biotype B, *Aphis gossypii* (Glover), and *Bradysia coprophila* (Lintner), respectively, compared with YC traps in greenhouse studies. The LED-YC traps did not catch more *Eretmocerus* spp. than the standard YC traps. The LED-CC traps caught 6.1 times more *B. tabaci* compared with unlit CC traps. The LED-CC traps caught few *Encarsia erimicus* (Rose and Zolnerowich) and *Encarsia formosa* (Gahan) compared with YC traps. The LED-BC traps caught 8.1 times more adult *Franklinella occidentalis* (Pergande) compared with the unlit BC traps in field studies.

INTRODUCTION

A LED consists of a semi-conductor chip housed in an epoxy case. When connected in a circuit, the LED emits light specific to the semi-conductor material (usually a combination of gallium, arsenic, and phosphorus). The recent development of the "cold" generation of LED light leads to high efficiency (15-20%) to convert electrical energy into light making the possible of using LEDs in plant production (Fang and Jao 2004).

Insect traps are vital component for detection and monitoring of insect populations. We equipped yellow sticky card (YC) and blue sticky card (BC) traps with 530 nm lime green and 470 nm blue LEDs (LED-YC and LED-BC) to increase trap catches of several pest insects. We also equipped a CC trap (= plastic cup trap) with a 530 nm LED for monitoring sweetpotato whitefly populations in the greenhouses and fields. We reported here our recent studies using LED technique to increase the trap catches of YC, BC, and CC traps in greenhouses with the LED lights. Details of the studies were reported elsewhere (Chen et al., 2004a, 2004b, Chu et al., 2003, 2004, Simmons et al., 2004).

MATERIALS AND METHODS

The design of a LED clamp is shown in Figure 1. Figure 2 shows the arrangement of LED-YC and unlit YC to test their efficacies in a commercial poinsettia greenhouse in 2002. Figure 3 shows a close-up of the YC trap equipped with a LED clamp. Figure 4 shows the standard CC developed in 1996 for monitoring whiteflies in the field and greenhouses. Figures 5 and 6 show the design of a LED-CC trap and a LED-CC trap in use for in a greenhouse study. Figure 7 shows a BC traps equipped with a 470 nm blue LED clamp.

Experiments below were conducted using a randomized complete block design with 4-10 replicates:

Darkroom study. Treatments were lime green LED and white LED CC traps. The unlit CC traps were controls.

Research greenhouse studies. (1) Treatments were sticky clear plastic card traps equipped lime green LED. The unlit clear plastic card traps were controls. (2) Treatments were lime green LED-YC traps. The unlit YC traps were controls. (3) Treatments were lime green LED equipped and Tanglefoot coated CC traps. The unlit Tanglefoot coated CC traps were controls. (4) Treatments were lime green LED equipped CC traps. The unlit YC traps were controls. (5) Treatments were blue LED-BC traps. The unlit BC traps were controls.

Commercial greenhouse studies. Treatments were lime green LED-YC traps. The unlit YC traps were controls.

Field studies. Treatments were LED-BC traps. The unlit BC traps were controls.

RESULTS AND DISCUSSION

Lime green LED-CC traps caught more *T. vaporariorum* and *B. tabaci* compared with white LED-CC and unlit CC traps (Table 1), indicating the two whitefly species were more attracted to the lime green colors.

The study on Tanglefoot coated clear plastic traps verified the color attraction of the whitefly species. In addition, more *Bradysia coprophila* were attracted to clear plastic traps equipped with lime green color compared with unlit clear plastic card traps (Table 2). YC traps equipped with lime green LED also caught more *B. tabaci, T. vaporariorum, B. coprophila, and A. gossypii.*

The LED-CC traps caught six times *B. tabaci* compared with Tanglefoot-coated CC traps in a greenhouse study (Table 3). The LED-CC traps did not catch significantly fewer *Bemisia tabaci* compared with unlit YC traps. Both studies showed that the traps equipped with LED caught fewer parasitoids except that LED–CC caught more *E. eremicus* and *E. formosa* compared with tanglefoot coated traps.

The study in a commercial poinsettia greenhouse showed that LED-YC traps caught more *B. tabaci* compared with unlit YC traps. This study and the study in a commercial gerber greenhouse showed that there were no differences in the catch of *F. occidentalis* and, but more catches in *B. coprophila* (Table 4).

More *B. tabaci* were caught on LED-YC traps in a research greenhouse planted with collard and melon but the differences in the catches of *F. occidentalis*, *E. eremicus*, and *D. catalinae* were not significant, except LED-YC caught more *D. catalinae* compared with unlit YC traps (Table 5).

LED-BC caught more *F. occidentalis* compared with unlit BC in greenhouse planted with potted bloomingdale ranunculus.

The LED-YC traps caught 1.3, 1.4, 1.8, and 4.8 times more adult *T. vaporariorum Bemisia tabaci, Aphis gossypii* and *Bradysia coprophila*, respectively, compared with unlit YC traps in greenhouse studies. The LED-YC traps did not catch more *Eretmocerus* spp. than the unlit YC traps. The LED-CC traps caught 6.1 times more *B. tabaci* compared with unlit CC traps. The LED-CC traps caught few *E. erimicus* and *Encarsia formosa* compared with YC traps. The LED-BC traps caught 8.1 times more *Franklinella occidentalis*. The lime green LED-YC traps caught more adult greenhouse whiteflies, sweetpotato whiteflies, cotton aphids, and *B. coprophilas* but not more *Ertmocerus remicus* compared with unlit YC traps in greenhouses. The lime green LED-CC traps caught more *T. vaporariorum* and *B. tabaci* but

fewer parasitoids *Ertmocerus eremicus* and *Encarsia formosa* compared with unlit clear plastic traps in greenhouses.

Results indicate that LED-YC trap has potential for insect detection, monitoring, and control outside of greenhouses. LED-CC trap is compatible for use in combination with releases of *Eretmocerus* or *Encarsia* sp. for whitefly nymph in biological control greenhouses. Both LED-YC and LED-BC traps have potential for insect and monitoring in greenhouses and fields.

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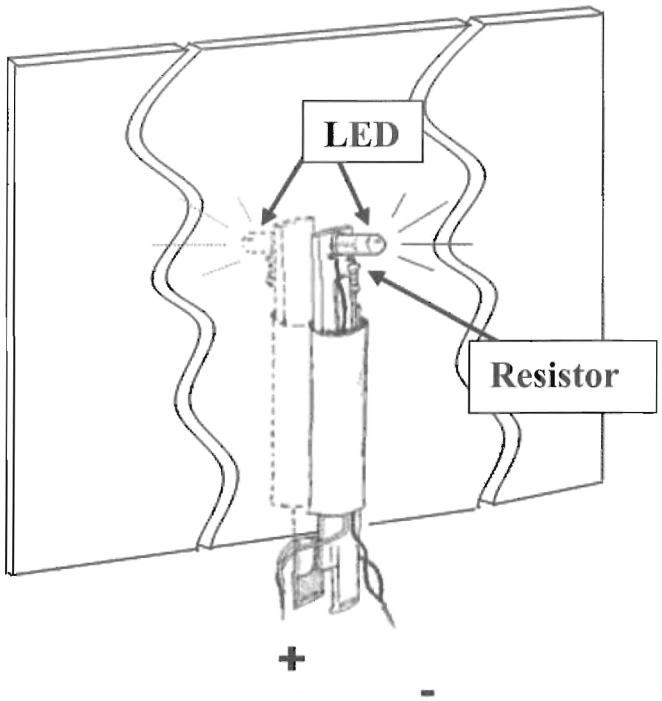

Figure 1. The design of a yellow sticky card trap equipped with a light-emitting diode clamp.

Figure 2. Arrangement of LED-YC and unlit YC to test their efficacies in a commercial poinsettia greenhouse in 2002.

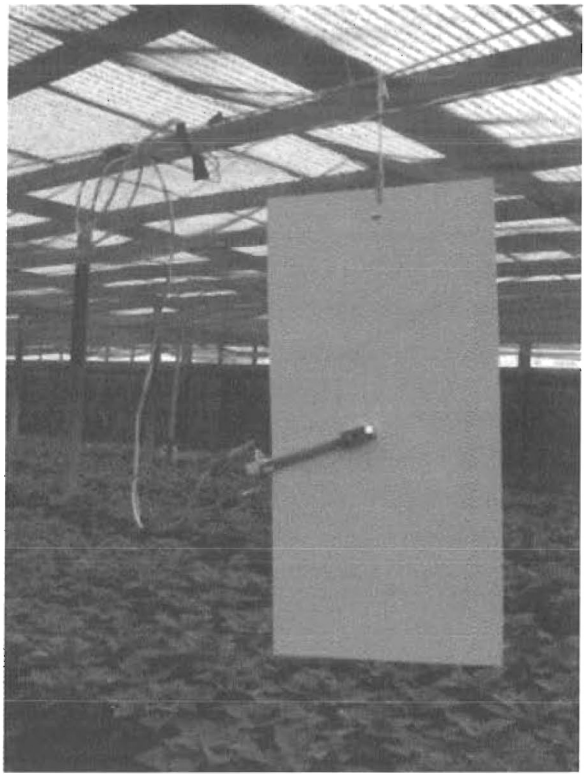

Figure 3. A close-up view of a yellow sticky trap equipped with a lime green light-emitting diode shown on one side of the trap in a commercial poinsettia greenhouse in 2002.

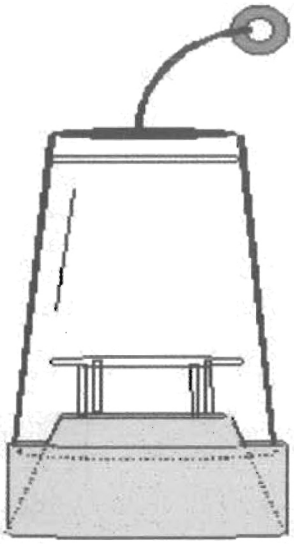

Figure 4. A standard CC trap for monitoring *Bemisia tabaci* populations in the field and greenhouses.

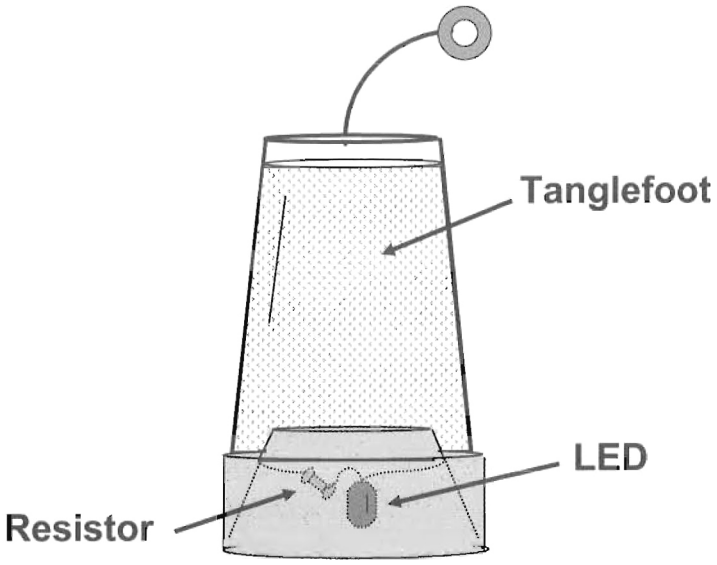

Figure. 5. The design of a CC trap equipped with a 530 nm green light-emitting diode.

Figure 6. A CC trap equipped with a 530 nm lime green light-emitting diode for trapping insects in greenhouses.

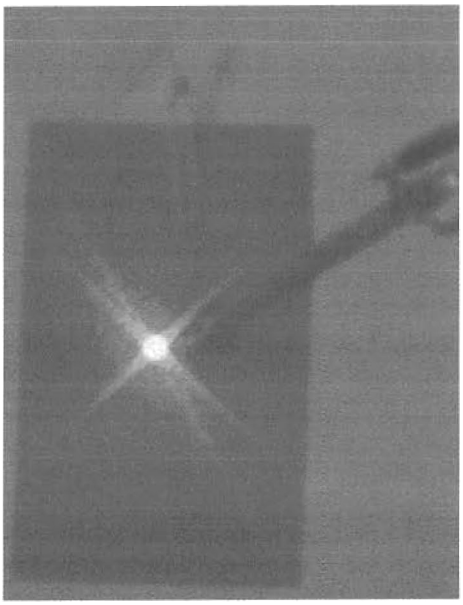

Figure 7. A blue sticky card trap equipped with a 470 nm blue clamp.

Table 1. Mean numbers of *Trialeurodes vaporariorum* and *Bemisia tabaci* caught in CC traps equipped with light emitting diodes (LED).

		No. adults/trap/day	
LED type	Lumens	*T. vaporariorum*	*B. tabaci*
No	2.2	10.0b[a]	91.3b
White	2.6	24.3b	52.6b
Lime green	2.6	138.1a	270.1a

[a] Means in a row not followed by the same letters significantly different, Tukey's test, $P = 0.05$.

Table 2. Mean numbers of *Trialeurodes vaporariorum*, *Bradysia coprophila*, *Bemisia tabaci*, and *Aphis* gossypii caught in traps equipped with light emitting diodes (LED).

		No. adults/100 cm2/day	
Trap type	Insect species	LED	Unlit
Clear plastic	*B. tabaci*	74.3a[a]	13.3b
	T. vaporariorum	7.4a	3.9b
	B. coprophila	4.0a	0.8b
Yellow card	*B. tabaci*	388.3a	274.5b
	T. vaporariorum	85.4a	65.3b
	B. coprophila	6.2a	1.3b
	A. gossypii	23.0a	12.7b

[a] Means in a row not followed by the same letter were significantly different, *t – test*, $P = 0.05$.

Table 3. Mean numbers of *Bemisia tabaci*, *Eretmocerus*, and *Encarsia formosa* caught in traps equipped with light emitting diodes (LED).

		No. adults/100 cm2 or trap/day[a]	
Trap type	*B. tabaci*	*E. eremicus*	*E. formosa*
Test 1			
Coated-CC	497.7b[a]	1.8b	0.0a
LED-CC	3,055.3a	33.4a	0.2a
Test 2			
YC	232.4a	39.2a	81.6a
LED-CC	189.2a	2.8b	5.3b

[a] Means in a column of a test not followed by the same letter were significantly different, *t – test*, $P = 0.05$.

Table 4. Mean numbers of *Bemisia tabaci*, *Franklinella occidentalis* and *Bradysia coprophila* caught in traps equipped with light emitting diodes (LED).

	No. adults/100 cm2/ week		
Trap type	*B. tabaci*	*F. occidentalis*	*B. coprophila*
Poinsettia			
YC	246.3b[a]	2.2a	8.0b
LED-YC	347.5a	2.5a	44.1a
Gerbera			
YC	-	7.3a	1.0b
LED-YC	-	8.4a	2.4a

[a] Means in column in a crops species not followed by the same letter are significantly different, *t* - test, $P = 0.05$.

Table 5. Mean numbers of *Bemisia tabaci*, *Franklinella occidentalis, Eretmocerus ermicus*, and *Delphastus catalinae* caught in traps equipped with light emitting diodes (LED).

	Mean no. adults/100 cm2/6 d			
Trap type	*B. tabaci*	*F. occidentalis*	*E. eremicus*	*D. catalinae*
Collard				
YC	19.4b[a]	33.5a	5.4a	1.1b
LED-YC	23.6a	35.1a	5.6a	1.5a
Melon				
YC	6.3b	5.6a	1.1a	0.2a
LED-YC9.	5a	6.1a	1.0a	0.4a

[a] Means in column in a crops species not followed by the same letter are significantly different, *t* - test, $P = 0.05$.

Table 6. Mean numbers of *Frankliniella occidentalis* caught in traps equipped with light emitting diodes (LED).

LED on blue card	No. *F. occidentalis* adults/4 wk
Yes	38.3a[a]
No	4.6b

[a] *t*- test, $P = 0.05$.