Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2015; 3(4): 110-113

Received: 19-06-2015
Accepted: 21-07-2015

Soon Do Bae
Department of Southern Area Crop Science, National Institute of Crop Science, Rural Development Administration, Miryang 627-803, Republic of Korea.

Hyun Ju Kim
Department of Southern Area Crop Science, National Institute of Crop Science, Rural Development Administration, Miryang 627-803, Republic of Korea.

Young Nam Yoon
Department of Southern Area Crop Science, National Institute of Crop Science, Rural Development Administration, Miryang 627-803, Republic of Korea..

Yeong Hoon Lee
Department of Southern Area Crop Science, National Institute of Crop Science, Rural Development Administration, Miryang 627-803, Republic of Korea.

In Hee Park
Department of Southern Area Crop Science, National Institute of Crop Science, Rural Development Administration, Miryang 627-803, Republic of Korea.

Hang Won Kang
Department of Southern Area Crop Science, National Institute of Crop Science, Rural Development Administration, Miryang 627-803, Republic of Korea.

Bishwo Prasad Mainali
Department of Southern Area Crop Science, National Institute of Crop Science, Rural Development Administration, Miryang 627-803, Republic of Korea.

Correspondence:
Bishwo Prasad Mainali
Department of Southern Area Crop Science, National Institute of Crop Science, Rural Development Administration, Miryang 627-803, Republic of Korea.

Yellow sticky card offers composite attractiveness to western flower thrips and greenhouse whitefly

Soon Do Bae, Hyun Ju Kim, Young Nam Yoon, Yeong Hoon Lee, In Hee Park, Hang Won Kang, Bishwo Prasad Mainali

Abstract
Studies have reported differential attractiveness of yellow, white or blue sticky cards to *Frankliniella occidentalis* (Pergande) and *Trialeurodes vaporariorum* Westwood. This study was conducted to determine whether yellow or blue sticky card is better in attracting these greenhouse pests. Laboratory study that included choice and no-choice tests followed by a glasshouse study to compare composite attractiveness of color sticky cards to the greenhouse pests was conducted. *F. occidentalis* showed higher preference to blue and yellow sticky cards in laboratory, and blue captured the greatest number of *F. occidentalis* in glasshouse test. However, while the blue sticky card captured few *T. vaporariorum*, the yellow sticky card captured the greatest number of *T. vaporariorum* in both laboratory and glasshouse tests. Since yellow sticky card received composite affinity of both pests, placement of yellow sticky card, rather than blue or yellow targeted to individual species, is recommended for monitoring greenhouse pests.

Keywords: *Frankliniella occidentalis*, *Trialeurodes vaporariorum*, visual attraction; monitoring, mass trapping, sticky cards.

1. Introduction
The sympatric greenhouse pests, western flower thrips *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) and greenhouse whitefly *Trialeurodes vaporariorum* Westwood (Homoptera: Aleyrodidae), are cosmopolitan, polyphagous insects that are known to inflict losses of several protected as well as outdoor crops [1, 2, 3, 4, 5], and are vectors of plant pathogens [6, 7, 8, 9, 10, 11].
Effective population monitoring of the pests is the first and crucial step in determining proper timing for control applications [12, 13]. Significant numbers of studies have been conducted to develop effective monitoring programs against *F. occidentalis* and *T. vaporariorum* by exploiting the visual cues [14, 15, 16, 17, 18, 19, 20, 21]. Color sticky cards are mainly used for monitoring population [22] and possibly for control [23, 24, 25]. Most of the studies opined and recommended that blue colored sticky traps captured more thrips [26, 27, 28], whereas yellow sticky cards are known to capture higher number of greenhouse whiteflies [14, 16, 18]. Although the preferential orientation of western flower thrips has been reported towards blue, but white or yellow colors also have been reported to attract more number of the western flower thrips in different studies [26, 27, 29]. In addition, Blumthal *et al*. [30] suggested that the yellow sticky cards could be more appropriate in sampling *F. occidentalis* than the blue sticky cards. In the study herein, we aim to observe the response of greenhouse pests, especially *F. occidentalis* and *T. vaporariorum*, to sticky cards with different colors in order to determine the color that offers composite attraction to both the pests.

2. Materials and methods
2.1. Laboratory evaluation
A multiple choice experiment was carried out for both *F. occidentalis* and *T. vaporariorum*. A white and a green colored papers were cut (25 × 10 cm; Samwon Paper Ltd., Seoul) and each paper was then laminated using a transparent film (100 MIC, Lami Ace Co., Kimpo, Korea). A thin layer of Tanglefoot (The Tangle foot Co., Grand Rapids, MI, USA) was applied on both sides of the laminated colored papers [20]. Commercial both sided yellow and blue sticky cards (25 × 10 cm; Koppert biological systems, Germany), and the laboratory made white and blue sticky cards were hung inside black boxes. Four cards were placed at four corners of each

Box: each card at a corner; sticky cards were illuminated by an overhead light source (20 W).Temperature of the black box ranged from 25 to 28 ^{0}C. One hundred newly emerged adult female *F. occidentalis* were collected from the lab colony and released inside a black box. In a similar fashion, a day old 100 *T. vaporariorum* adults were released inside another black box. The insects were allowed to make preferences for 48 hours. After 48 hours all the cards were taken out and captured numbers of both insects were counted visually by using an achromatic hand lens (20X).

No-choice tests were also conducted for both *F. occidentalis* and *T. vaporariorum* using the laboratory made and commercial sticky cards following the same procedure and conditions as mentioned for choice tests. Both choice and no-choice tests for each species were replicated for five times.

2.2. Greenhouse evaluation

Attractiveness of the yellow and blue color sticky cards to *F. occidentalis* and *T. vaporariorum* was evaluated in a glasshouse located at NICS, RDA, Korea, where potted soybeans (*Glycine max* [L.] Merr.) were grown on a table (3.7 × 1.6 m). Potted soybean plants were placed 25 × 15 cm apart. Each table contained at least 140 soybean plants at flowering stage.

Natural populations of *F. occidentalis* and *T. vaporariorum* had infested the potted soybean plants in the glasshouse. Prior to experimental set up, both *F. occidentalis* and *T. vaporariorum* were randomly sampled and species were confirmed under a stereomicroscope.

Commercial yellow and blue sticky cards were alternatively placed 50 × 50 cm apart facing each other in randomly chosen direction. Each table received at least nine yellow and nine blue sticky cards. Temperature of the glasshouse ranged from 20 to 30 ^{0}C. The cards were all collected after 10 d and brought into the laboratory and the number of insect pests captured was counted using an achromatic hand lens (20 X). Experiments were replicated thrice. The study was conducted from 10 November 2014 to 20 December 2014.

2.3. Statistical analyses

Data for choice tests and no-choice tests in the laboratory were analyzed using a Chi-square test of a contingency table and a post-hoc multiple comparison test analogous to the Tukey's test [31]. In glasshouse evaluation, number of insects captured in each table for yellow or blue cards was pooled and comparison was made using a pair-wise *t*-test.

3. Results

3.1. Laboratory evaluation

Blue sticky card (Choice: 25.8 ± 4.55 SD; No-choice: 31.4 ± 6.80 SD) followed by yellow sticky card (Choice: 20.4 ± 3.78 SD; No-choice: 27.6 ± 5.32 SD) captured higher number of female *F. occidentalis* in both multiple choice ($\chi2$ = 83.35, *df* = 5, $P < 0.0001$) and no-choice ($\chi2$ = 493.21, *df* = 3, $P < 0.0001$) than green (Choice: 8.0 ± 2.55 SD; No-choice: 10.8 ± 3.27 SD) or white (Choice: 9.4 ± 3.44 SD; No-choice: 13.8 ± 2.59 SD) sticky cards (Fig. 1). However, yellow sticky card (Choice: 51.0 ± 4.95 SD; No-choice: 60.8 ± 4.76 SD) captured significantly the highest number of *T. vaporariorum* in both multiple choice ($\chi2$ = 93.02, *df* = 5, $P < 0.0001$) and no-choice tests ($\chi2$ = 444.91, *df* = 3, $P < 0.0001$) than that captured by blue (Choice: 6.6 ± 2.07 SD; No-choice: 11.4 ± 3.58 SD), green (Choice: 2.4 ± 1.14 SD; No-choice: 11.0 ± 6.00 SD) or white sticky cards (Choice: 13.6 ± 3.51 SD; No-choice: 19.2 ± 2.59 SD) (Fig. 2).

3.2. Greenhouse evaluation

In the glasshouse, blue sticky card captured 1.1 times higher number of female adult *F. occidentalis* than yellow sticky card (t =7.99, *df* = 2, P = 0.015). On the other hand, the yellow sticky card captured 5.5 times more number of *T. vaporariorum* than the blue sticky card (t = 28.92, *df* =2, P = 0.001). However, no difference between the blue and the yellow sticky card in attracting the male adult *F. occidentalis* was detected (t = 0.58, *df* =2, P = 0.622). When comparison was made for the attraction of total pests that included unidentified species of aphids and leafminer other than the thrips and whiteflies, yellow sticky card captured 1.3 times more number of the pests than the blue (t = 19.99, *df* =2, P = 0.002).

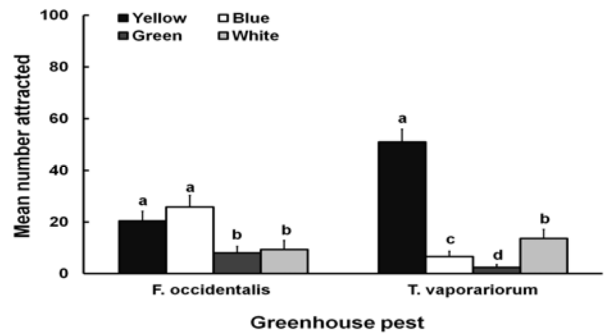

Fig. 1. Mean number (± SD) of female *F. occidentalis* and *T. vaporariorum* captured on colored sticky cards in multiple choice tests. Values with different letters are significantly different (P < 0.05). Five replications were made for testing each species.

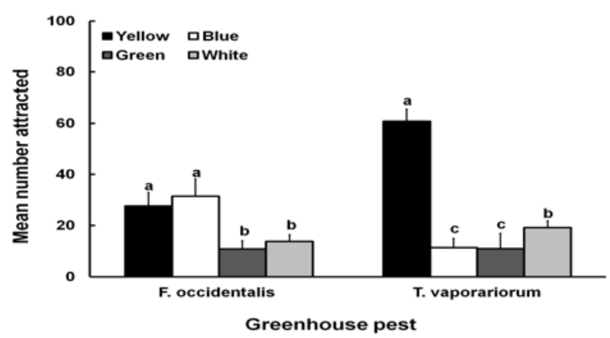

Fig. 2. Mean number (± SD) of female *F. occidentalis* and *T. vaporariorum* captured on colored sticky cards in no- choice tests. Values with different letters are significantly different (P < 0.05). Five replications were made for testing each species.

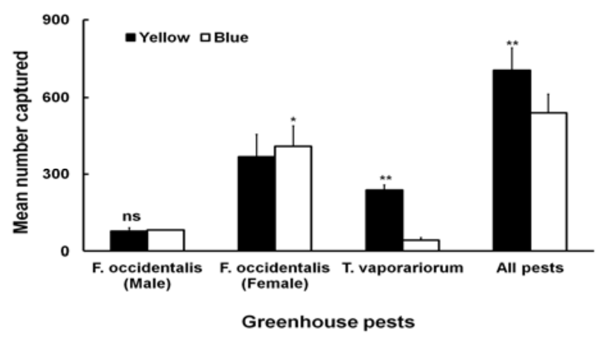

Fig. 3. Number (± SE) of male and female adult *F. occidentalis*, and *T. vaporariorum*, and all greenhouse pests captured on yellow or blue sticky cards in a glasshouse where potted soybean plants were grown on tables. Number of the insects captured either by yellow or blue sticky card in each table was pooled. ns = non-significant; *0.01<P≤0.05, from a paired *t*-test. Three replications were made.

4. Discussion

Greenhouse crops are often high-valued and perishable, and minor feeding injuries or oviposition spots may decrease the aesthetic value of the crops resulting into economic losses. Since *F. occidentalis* and *T. vaporariorum* not only causes such losses but also vectors several viral, fungal or bacterial diseases, effective monitoring for timely application of control mechanisms is crucial to minimize the losses, and for that exploitation of visual cues has been suggested as that have been reported as one of the dominant clues used by herbivorous insects for host finding [32]. Polyphagous species such as flower thrips and whiteflies have a generalized response to low UV white, yellow and blue [33]. However, color choice of *F. occidentalis* is still disputed [1, 34], and differential response of greenhouse whitefly to different UV regions has been reported [35, 36].

In our laboratory study, we found that blue and yellow colored cards had greater pest attraction compared to the other colors. Hence we investigated blue and yellow in semi-field condition. Blue has been often recommended for flower thrips attraction and yellow for whitefly. However, we did not find any difference on attractiveness of yellow or blue to *F. occidentalis* in both choice and no-choice laboratory experiments. Glasshouse study, on the other hand, revealed blue having better attractiveness to the female adult western flower thrips than the yellow. Dissimilar to our finding, Yudin *et al*. [1] found *F. occidentalis* most attracted to white in a field whereas in line with our finding Vernon and Gillespie [37] found preferential landing of *F. occidentalis* on blue. The differential attractiveness of the yellow and blue colored sticky cards between our laboratory study and glasshouse study could be attributed to the difference in availability of food source, pest population, environmental conditions and experiment period. While the ratio of attraction of *F. occidentalis* by blue was marginally (1.1 times) higher than the yellow, the yellow on the other hand captured 3.2 to 5.6 times more number of *T. vaporariorum* than the blue in laboratory and glasshouse experiments.

Furthermore, the yellow card was found to capture higher number of greenhouse pests that included winged aphids and leaf miners. So, in line with the suggestion made by Blumthal *et al*. [30] we suggest using yellow colored sticky card for optimal monitoring of important greenhouse pests that help minimize pest management cost and save time.

5. Acknowledgements

This study was carried out with the support of the Cooperative Research Program for Agricultural & Technology Development (Project no. PJ011194072015), RDA, Republic of Korea.

6. References

1. Yudin LS, Mitchell WC, Cho JJ. Color preference of thrips (Thysanoptera: Thripidae) with reference to aphids (Homoptera: Aphididae) and leafminers in Hawaiian lettuce farms. Journal of Economic Entomology. 1987; 80:51-55.
2. Byrne DN, Bellows TS. Whitefly biology. Annual Review of Entomology 1991; 36:431-457.
3. Parker BL, Skinner M, Lewis T (eds). Thrips Biology and Management. NATO ASI Series. Series A: Life Sciences, 1995, 276.
4. Daughtrey ML, Jones RK, Moyer JW, Daub ME, Baker JR. Tospoviruses strike the greenhouse industry: INSV has become a major pathogen on flower crops. Plant Disease 1997; 81:1220-1230.
5. Park JD, Kim DI, Park U. Occurrence and within-plant distribution of *Trialeurodes vaporariorum* (Westwood) and *Encarsia formosa* (Gahan) in greenhouse. Korean Journal of Applied Entomology. 1998; 37:117-121.
6. Van Lenteren JC, Noldus LPJJ. Whitefly-plant relationships: behavioural and ecological aspects. In: Gerling D. (Ed.), Whiteflies: their Bionomics, Pest Status and Management. Intercept Ltd, Hants, UK, 1990, 47-89.
7. German TL, Ullman DE, Moyer J. Tospoviruses: diagnosis, molecular biology, phylogeny, and vector relationships. Annual Review of Phytopathology 1992; 30:315-348.
8. Ullman DE, Sherwood JL, German TL. Thrips as vectors of plant pathogens. In Lewis T. (Ed.), Thrips as Crop Pests. CAB International, United Kingdom, 1997, 539-565.
9. Bi JL, Toscano NC, Ballmer GR. Greenhouse and field evaluation of six novel insecticides against the greenhouse whitefly *Trialeurodes vaporariorum* on strawberries. Crop Protection 2002; 21:49-55.
10. Hodges GS, Evans GA. An identification guide to the whiteflies (Hemiptera: Aleyrodidae) of the Southeastern United States. Florida Entomologist 2005; 88:518-534.
11. Arnó J, Albajes R, Gabarra R. Within-plant distribution and sampling of single and mixed infestations of *Bemisia tabaci* and *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae) in winter tomato crops. Journal of Economic Entomology. 2006; 99:331-340.
12. Parella MP, Jones VP. Yellow traps as monitoring tools for *Liriomyza trifolii* (Diptera: Agromyzidae) in Chrysanthemum greenhouses. Journal of Economic Entomology. 1985; 78:53-76.
13. Gillespie DR, Quiring D. Yellow sticky traps for detecting and monitoring greenhouse whitefly (Homoptera: Aleyrodidae) adults on greenhouse tomato crop. Journal of Economic Entomology. 1987; 80:675-679.
14. Dowell RV. Integrating biological control of whiteflies into crop management systems. In: Gerling D. (Ed.), Whiteflies: their Bionomics, Pest Status and Management, Intercept Ltd, Hants, UK, 1990, 315-335.
15. Vernon RS, Gillespie DR. Influence of trap shape, size, and background color on captures of *Frankliniella occidentalis* (Thysanoptera: Thripidae) in a cucumber greenhouse. Journal of Economic Entomology. 1995; 88:288-293.
16. Kim JK, Park JJ, Park CH, Park H, Cho K. Implementation of yellow sticky trap for management of greenhouse whitefly in cherry tomato greenhouse. Journal of Korean Society of Horticultural Science 1999; 40:549-553.
17. Jacobson RT. Integrated pest management (IPM) in glasshouses. In: Lewis T. (Ed), Thrips as Crop Pests. CAB International, Cambridge, 1997, 639-666.
18. Gorski R. Evaluation of the effectiveness of natural essential oils in the monitoring of the occurrence of greenhouse whitefly (*Trialeurodes vaporariorum* Westwood). Journal of Plant Protection Research. 2003; 43:393-397.
19. Mainali BP, Lim UT. Evaluation of chrysanthemum flower model trap to attract two *Frankliniella* thrips (Thysanoptera: Thripidae). Journal of Asia-Pacific Entomology. 2008; 11:171-174.
20. Mainali BP, Lim UT. Circular yellow sticky trap with black background enhances attraction of *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae). Applied Entomology and Zoology 2010; 45:207-213.

21. Mainali BP, Lim UT. Behavioral response of western flower thrips to visual and olfactory cues. Journal of Insect Behavior. 2011; 24:436-446.
22. Seo MJ, Kim SJ, Kang EJ, Kang KM, Yu YM, Nam MH *et al*. Attraction of the garden thrips, *Frankliniella intonsa* (Thysanoptera: Thripidae) to colored sticky cards in a Nonsan strawberry greenhouse. Korean Journal of Applied Entomology. 2006; 45:37-43.
23. Kawai A, Kitamura C. Studies on population ecology of *Thrips palmi* Karny. 15. Evaluation of effectiveness of control methods using a simulation model. Applied Entomology and Zoology (Jpn.) 1987; 22:292-302.
24. Lim UT, Mainali BP. Optimum density of chrysanthemum flower model traps to reduce infestations of *Frankliniella intonsa* (Thysanoptera: Thripidae) on greenhouse strawberry. Crop Protection 2009; 28:1098-1100.
25. Lim UT, Kim E, Mainali BP. Flower model traps reduced thrips infestations on a pepper crop in field. Journal of Asia-pacific Entomology. 2013; 16:143-145.
26. Matteson NA, Terry LI. Response to color by male and female *Frankliniella occidentalis* during swarming and non-swarming behavior. Entomologia Experimentalis et Applicata 1992; 63:187-201.
27. Brødsgaard HF. Monitoring thrips in glasshouse pot plant crops by means of blue sticky traps. IOBC/WPRS 1993; 16:29-32.
28. Antignus Y. Manipulation of wavelength-dependent behaviour of insects: an IPM tool to impede insects and restrict epidemics of insect-borne viruses. Virus Research 2000; 71:213-220.
29. Natwick ET, Byers JA, Chu CC, Lopez M, Henneberry TJ. Early detection and mass trapping of *Frankliniella occidentalis* and *Thrips tabaci* in vegetable crops. Southwestern Entomologist 2007; 32:229-238.
30. Blumthal MR, Cloyd RA, Spomer LA, Warnock DF. Flower color preferences of western flower thrips. Hort Technology 2005; 15:846-853.
31. Zar JH. Biostatistical Analysis. 4th edition. Prentice Hall, Upper Saddle River, NJ, 1999, 195-197.
32. Prokopy RJ, Owens ED. Visual detection of plants by herbivorous insects. Annual Review of Entomology 1983; 28:337-364.
33. Kirk WDJ. Pollen-feeding in thrips (Insecta: Thysanoptera). Journal of Zoology. 1984; 204:107-117.
34. Mateus C, Mexia A. Western flower thrips response to color. In: Parker BL, Skinner M, Lewis T (Eds.), Thrips biology and management. Plenum Press, New York, 1995, 567-570.
35. Vaishampayan S. The spectral sensitivity of the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) and its biological significance in host selection. PhD dissertation, University of Illinois, 1973, 179.
36. Vaishampayan SM, Waldbauer GP, Kogan M. Visual and olfactory responses in orientation to plants by the greenhouse whitefly, *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae). Entomologia Experimentalis et Applicata 1975; 18:412-422.
37. Vernon RS, Gillespie DR. Spectral responsiveness of *Frankliniella occidentalis* (Thysanoptera: Thripidae) determined by trap catches in greenhouses. Environmental Entomology 1990; 19:1229-1241.