ISSN: 1511-3701
Pertanika J. Trop. Agric. Sci. **35 (1)**: 127 - 134 (2012)

Effectiveness of Sticky Trap Designs and Colours in Trapping Alate Whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae)

A. B. Idris[1]*, S. A. N. Khalid [2] and M. N. Mohamad Roff[3]
[1]Centre for Insects Systematics,
School of Environmental and Natural Resource Sciences,
Faculty of Science and Technology, National University of Malaysia,
43600 Bangi, Selangor, Malaysia
[2]Department of Biology, Faculty of Education,
Thamar University, Sana'a P.O. Box 2614, Yemen
[3]Deputy Director/ Senior Principal Research Officer,
Pest and Disease Management Programme,
Horticulture Research Centre, MARDI HQ,
P.O. Box 12301, GPO, 50774 Kuala Lumpur, Malaysia
**E-mail: idrisgh@ukm.my*

ABSTRACT

A study to determine the effectiveness of sticky trap designs with different colours for trapping alate whitefly (WF), *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) was carried out at MARDI Station, Jalan Kebun, in Klang, Malaysia from September 2004 to August 2005. Trap designs (cylindrical, horizontal, and vertical), colours (yellow, blue, green, red, white and black) and time (sampling dates) gave significantly ($P<0.05$) different effectiveness of trapping the alate WF, as well as indication of its population abundance in the field. Both vertical and cylindrical traps were the most effective traps as significantly ($p<0.05$) higher numbers of alate WF caught on these traps than on traps of other designs. Meanwhile, yellow was the most attractive colour to alate WF, regardless of the trap design as it had the highest number of alates caught compared to the other colours. Comparatively, the vertical yellow trap was the most attractive and efficient trap to use in monitoring WF.

Key Words: Alate, *Bemisia tabaci*, trap, colour, population abundance, *Capsicum annum*

INTRODUCTION

Monitoring and surveillance are basic tools for developing effective pest-management system. Several researchers have highlighted the benefits of using different trapping methods for monitoring the population of homopterous insects. For example, Berlinger (1980), Gerling and Horowitz (1984), Musuna (1986) and Venugopal Rao *et al*. (1989) reported the effectiveness of using yellow sticky trap (YST) in monitoring the population of whitefly (WF) in the field.

The first step in managing whitefly (WF) is to determine the most accurate and effective monitoring system to measure the population levels of the insects (Byrne *et al.,* 1986). Heathcote *et al.* (1969) found that the counts of both suction traps and yellow sticky traps were more efficient than crop inspection for predicting the first seasonal flight of several aphid species. Burgess *et al*. (1979), Disney *et al*. (1982) and Southwood (1978) found that cylindrical sticky traps, which were placed at the height of 157.5 - 182.9 cm, caught more aphids than those

*Corresponding Author

placed at either 55.9 - 111.8 cm or 5.1- 35.6 cm. Besides, the highest number of aphids was recorded towards the end of the growing season, where traps that were placed at the lower canopy level (5.1 - 35.6 cm) caught 65% more aphids than those placed at other levels. Heathcote (1957) also found that the traps of different colours, designs, and placements caught various numbers of aphid species.

Byrne and Bishop (1979) reported that the number of *Myzus persicae* (Sulzer) caught in the yellow water pan trap was correlated with the number of potato leaves from the adjacent potato fields. Similarly, Gerling and Horowitz (1984) found that a high number of *B. tabaci* was captured in a horizontally placed trap compared to the cross-shaped vertical trap of similar size, and the catches were greater at the ground level. Mound (1962) found that *B. tabaci* was attracted to the blue-ultra violet and yellow part of the light spectrum. Several other researchers have suggested that this insect might be attracted to coloured traps (e.g. Webb & Smith, 1980; Patti & Rapisarda, 1981; Sharaf, 1982).

The purpose of this study was to evaluate the effectiveness of the sticky traps with different designs and colours in monitoring the WF population abundance in the field. It was hope that the information generated from this study would be able to support or help farmers to reduce and manage WF infestation in their crops.

MATERIALS AND METHODS

Study Site

This study was carried out at MARDI Research Station Jalan Kebun, in Klang, Selangor, Malaysia from September 2004 to August 2005. This research station is situated in a flat peat land that lies between 3°0'N latitude and 101° 30' E longitude, and 3.1m above the sea level.

Trap Design and Experimental Layout

In this study, three sticky trap designs were used (vertical, horizontal and cylindrical traps), as shown in *Fig. 1 A-C*). The size of the vertical and horizontal traps was 6 x 27 x 1 cm (width x length x thickness), and both the traps were made of rectangular flat wood; the vertical trap was attached to an erect wooden pole, while the horizontal trap was fixed onto a wooden pole at 90° angle. The cylindrical trap was made of transparent plastic container of 4 cm diameter and 30 cm length, and attached to an erected wooden pole. Four traps (replicates) of each type were painted with ICI Dulux paint in yellow, blue, green, red, white and black to act as the treatments. The traps were arranged in a row at a distance of 1.5 m apart from each other. All the traps were placed on a wooden pole that was installed 90 cm above the ground level within chilli (*Capsicum annum*) plot measuring of 8 m x 35.5 m and separated by 2 m apart between the plots. The treatments (18) were arranged in a randomized complete block design (RCBD) with four replicates. The traps were placed randomly in each block or chilli plot. These traps were first covered with transparent polyethylene plastic and then sprayed with sticky glue (Neopace™ Agricultural Chemical Malaysia Bhd.) to trap alate WF. The traps were repainted from time to time to ensure that their colours would not fade away.

Data Collection

The sampling of WF was done on a weekly basis from 0800 to 1000 h. On each sampling day, transparent polyethylene plastics were collected and marked with Y, R, BL, G, B, and W to represent trap colours (i.e. yellow, red, blue, green, black and white) and V, H and C to represent the trap designs (vertical, horizontal and cylindrical). A new transparent polyethylene plastic, sprayed with glue, was also put on each trap as a replacement. The collected plastics were brought back to the laboratory and the numbers of WF were counted. The alate WF was counted by placing the transparent plastic on a black polyethylene chloride (PVC) sheet and viewed using a 10-x magnifying glass.

Fig. 1: Samples of the trap design used in the study (A, B and C is a vertical, horizontal and cylindrical trap, respectively)

Statistical Analysis

Data on the number of WF per trap per week were pooled to obtain the number of WF per week. These were then transformed using $\sqrt{x+0.5}$ for normalization before the analysis (Healy & Taylor, 1962). A three-way ANOVA (colours, sampling dates and trap's shape as the independent variables) was performed on the data to determine the differences in the numbers of WF caught in the different traps with different colours and at different sampling dates. When significant, the means were separated by Fisher's Protected Least Significant Difference ($p<0.05$). All the statistical analyses were carried out using SAS Institute 9.01 statistical software (SAS Institute Inc., 2002, Cary, NC, USA).

RESULTS

The interaction between trap designs, colour and sampling dates was found to be significant ($F=2.20$, df=510 and 1870, $P<0.05$) (Table 1) in catching WF. A significant interaction was also found between the trap designs and sampling dates ($F=13.59$, df=102 and 1870, $P = 0.05$), between the trap colour and sampling dates ($F=11.30$, df=255 and 1870, $P<0.05$), and between the trap colour and trap designs ($F=105.39$, df = 10 and 1870, $P<0.05$) (Table 1 and *Fig. 2*). The WF catches were significantly ($P<0.05$) higher in both the vertical and cylindrical yellow traps compared to other treatments (*Fig. 2*).

The mean number of WF caught in the traps with different colours, irrespective of trap

TABLE 1
Three-way ANOVA statistics for the mean number of alate whiteflies caught on different sticky trap designs and colours.

Source	*df*	*Sum of square*	*F- value*	*P - value*
Colour	5	563.97	905.70	<0.0001
Time	51	627.94	98.86	<0.0001
Shape of Traps	2	122.01	489.85	<0.0001
Colour x shape	10	131.25	105.39	<0.0001
Colour x Time	255	358.98	11.30	<0.0001
Shape x Time	102	172.57	13.59	<0.0001
Colour x shape x Time	510	139.71	2.20	<0.0001
Error	1870	232.89		

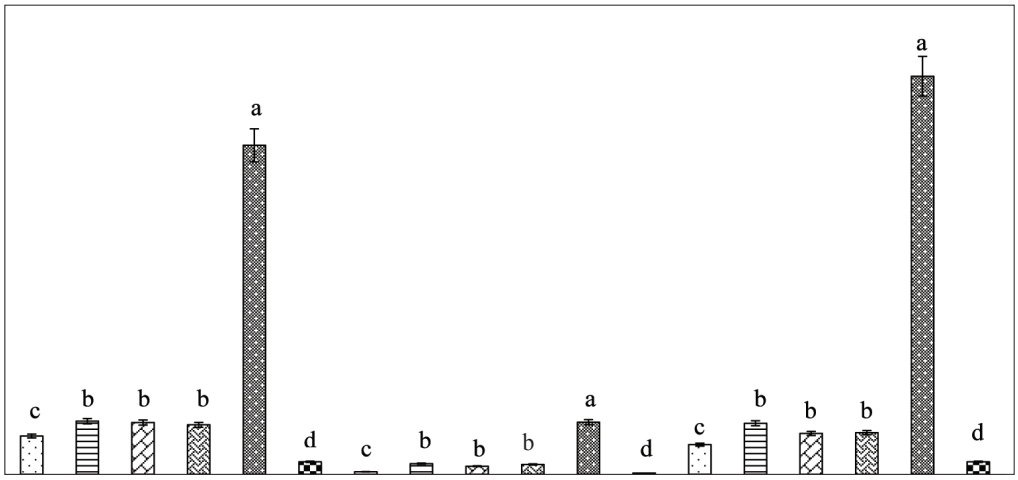

Fig. 2: Mean numbers of alate WF for different shapes and colours of traps from 1st September 2004 to 30th August 2005. Bars with different letters differ significantly at P<0.05.

designs, differed significantly (F=905.70, df=5 and 1870, P<0.05) (*Fig. 3*). In more specific, the yellow traps had significantly (P<0.05) higher number of WF caught compared to the other colour traps, whereas the mean number of WF caught was the lowest in the black traps (*Fig. 3*). Catches were intermediate for the traps of other colours.

The mean number of WF caught in the different trap designs, irrespective of the colours of the trap, was significantly (P<0.05) higher in both the vertical and cylindrical traps as compared to the horizontal ones (*Fig. 4*). However, the number of WF caught on the vertical trap did not differ significantly (P>0.05) with that of the cylindrical trap.

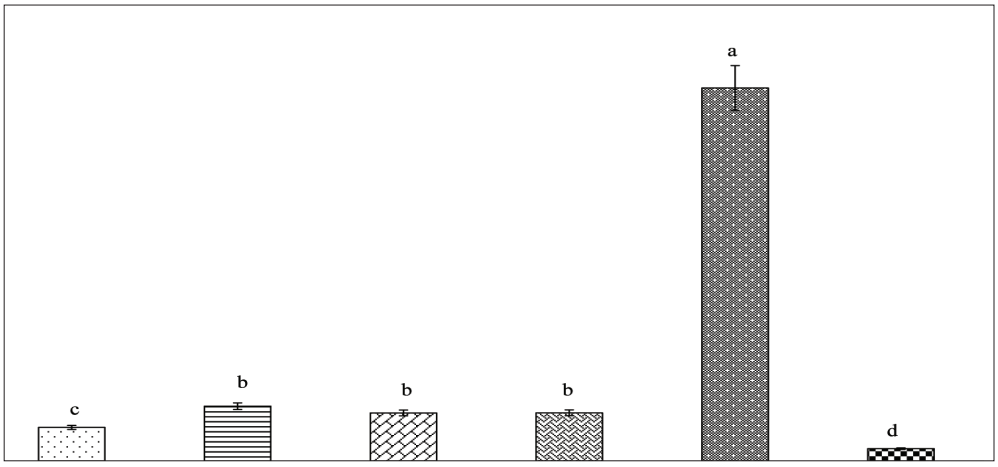

Fig. 3: The mean number of alate WF catches in different coloured traps from 1st September 2004 to 30th August 2005. Bars with different letters differ significantly at P<0.05.

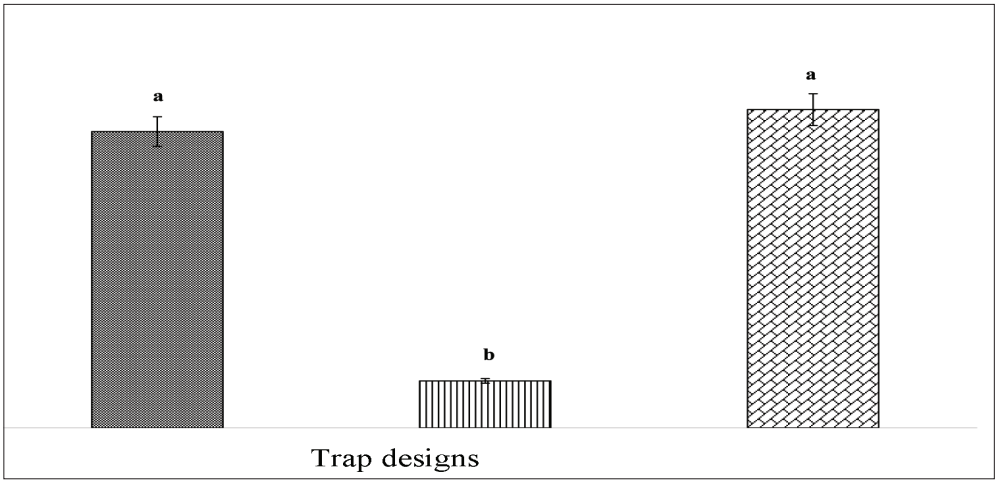

Fig. 4: A comparison of the total mean number of alate WF catches on the vertical, horizontal, and cylindrical traps from 1st September 2004 to 30th August 2005. Bars with different letters differ significantly at P<0.05.

DISCUSSION

The results showed that the WF catches in the yellow trap was the highest, and this was followed by red, green, blue, white, and black traps (*Fig. 3*). This is not surprise because a positive response to yellow colour is common to most foliage-seeking insects (Prokopy & Owens, 1983). Vaishampayan *et al*. (1975) and Southwood (1978) reported that yellow was found to be an efficient colour used in trapping insects such as Homopteran, Hymenopterans, Dipteran, and Thysanopteran compared to other colours. Furthermore, Venugopal Rao *et al*. (1991) reported that alate WF caught was highest in yellow sticky trap than those in the red, green, blue, black , yellow + red, yellow + green, yellow + white and yellow + blue (50:50) in the cotton field. Similar results were also reported

by Kirk (1984) who found that the numbers of flower thrips, glasshouse thrips and predatory flies caught were significantly higher in yellow traps than those of other colours. The possible reason is that the yellow traps create a contrast between the trap and the field background. This affects the optomotor of the insects' eyes and influences the landing response of the flying insects (Smith, 1976). The positive response to yellow pigment may be the characteristic of the majority of foliage-seeking insects, although there may be some variations (Greany *et al*., 1977) or exceptions (Saxena & Goyal, 1978). These insects may have mechanisms that enable the discrimination of foliage-like clues (which peak at 500 - 580 nm) (Kennedy *et al*., 1961). Yellow also reflects UV light, as well as other long wave and short wave lights (Halgren, 1970a, 1970b; Prokopy, 1972). The short wave light (500 - 580 nm) has been known to arrest the flying insects including WF (Halgren 1970a, 1970b; Prokopy, 1972). A lower number of catches by the traps of other colours (*Fig. 3*) indicated that WF responded weakly to these colours. This suggests that yellow is a good tool for sampling the WF population in chilli field. However, traps that were exposed for more than one day are often unreliable because of the dust and dirt coverage on the sticky material, and thus, a frequent replenishing is needed.

This study also indicated that the number of WF trapped in the vertical and cylindrical sticky traps was higher than in the horizontal traps (*Fig. 4*). Butler *et al*. (1986) and Youngman *et al*. (1986) also stated that vertical and cylindrical traps were more efficient in trapping insects than traps of other designs. However, Meyerdirk *et al.* (1986) reported that traps with horizontal surface attracted more WF than those with a vertical surface. Meanwhile, the lower number of WF caught in the horizontal trap in this study congruent with the report of Byrne *et al.* (1986). The high number of WF caught in both the vertical and cylindrical traps in this study might be due to the constant height of traps, which was placed at 90 cm above ground level. On the contrary, Byrne *et al*. (1986) placed the traps at ground level, i.e. 50 cm and 100 cm from the ground level. This result, nonetheless, differs from that of Gerling and Horowitz (1984) where the horizontal traps were found to have caught WF as low as the cylindrical trap.

The traps, regardless of its design (*Fig. 2*) and colour (*Fig. 3*), caught different numbers of WFs, indicating that the proximity of the open field generally has limited influence on the activity of WFs, even within the immediate surroundings. This finding is supported by Blackmer and Byrne (1993b), who reported that the resident populations of WF were found in the close proximity to their hosts, and rarely needed to move more than a few meters. Similar results were also reported for WF in cassava, whereby they were predominantly trapped in the crop canopy (Legg, 1994). This result is consistent with WFs being weak fliers with an estimated flight speed of only 0.2 ms^{-1} (Yano 1987) and a maximum climb rate of approximately 0.037 ms^{-1} (Blackmer & Byrne, 1993a). Two main flight activity categories have been suggested for WF. The first is trivial short heights, which occurs within and slightly above the plant canopy and is associated with 'vegetative' behaviours such as searching for mates, feeding and oviposition sites (Byrne *et al.*, 1996). The second type is the long-distance movement which occurs when alates WF leave the crop and are carried over by the wind (Blackmer & Byrne, 1993a; Southwood, 1978).

Hence, it can be stated that both the vertical and cylindrical yellow traps are the most effective tool for monitoring the WF population in the chilli field. Although WF is a very weak flier and always in the field feeding on the plants, it cannot be assumed that the surrounding vegetations and the abiotic factors do not have any influence on the alate WF flight activity. Thus, this needs further investigation.

ACKNOWLEDGMENTS

We would like to thank the authority of Seed Unit, MARDI for providing facilities to conduct this study. We are grateful to Mrs. Fathmah

Mokhtar and Mrs. Robiah Binti Mat Saat, Research Assistant for their technical assistance throughout the study period. This study is part of a PhD dissertation by the second author and was supported by the Malaysian National Scientific Research Council under the Intensive Research in Priority Areas (IRPA: 09-02-02-0063- EA163) grant and general fellowship programme of the Sana'a University, Republic of Yemen.

REFERENCES

Berlinger, M. J. (1980). A yellow sticky trap for whiteflies, *Trialeurodes vaporariorum* and *Bemisia tabaci* (Aleyrodidae). *Entmologia Experimentalis et Applicata, 27*, 98-102.

Blackmer, J. L., & Byrne, D. N. (1993a). Flight behaviour of Bemisia tabaci in a vertical flight chamber: effect of time of day, sex, age and host quality. *Physiological Entomology, 18*(3), 223-232.

Blackmer, J. L., & Byrne, D. N. (1993b). Environmental and physiological factors influencing phototactic flight of Bemisia tabaci. *Physiological Entomology, 18*(4), 336-342.

Burgess, N. R. H., Shuttleworth, A. E., & Chetwyn, K. N. (1979). Adhesive panels as a control method of the common cleg *Haematopota pluvialis* L. (Deptera: Tabanidae). *Journal of the Royal Army Medical crops, 125*, 156-161.

Butler Jr, G. D., Henneberry, T. J., & Wilson, F. D. (1986). Bemisia tabaci (Homoptera: Aleyrodidae) on Cotton: Adult Activity and Cultivar Oviposition Preference. *Journal of Economic Entomology, 79*(2), 350-354.

Byrne, D. N., & Bishop, G. W. (1979). Relationship of Green Peach Aphid Numbers to Spread of Potato Leaf Roll Virus in Southern Idaho. *Journal of Economic Entomology, 72*(6), 809-811.

Byrne, D. N., Von Bretzel, P. K., & Hoffman, C. J. (1986). Impact of Trap Design and Placement When Monitoring for the Bandedwinged Whitefly and the Sweetpotato Whitefly (Homoptera: Aleyrodidae). *Environmental Entomology, 15*(2), 300-304.

Byrne, D. N., & Bellows, T. S. (1991). Whitefly Biology. *Annual Review of Entomology, 36*(1), 431-457.

Byrne, D. N., Rathman, R. J., Orum, T. V., & Palumbo, J. C. (1996). Localized migration and dispersal by the sweet potato whitefly, *Bemisia tabaci*. *Oecologia, 105*(3), 320-328.

Disney, R. H. L., Erzinclioglu, Y. Z., deC. Henshaw, D. J., Howse D., Unwin D. M., Withers P., & Woods, A. (1982). Collecting methods and the adequacy of attempted founa surveys, with refrence to the Deptera. *Field Studies, 5*, 607-621.

Gerling, D., & Horowitz, A. R. (1984). Yellow traps for evaluating the population levels and dispersal patterns of *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae). *Annals of the Entomological Society of America, 77*, 753-759.

Greany, P. D., Agee, H. R., Burditt, A. K., & Chambers, D. L. (1977). Field studies on color preferences of the Caribbean fruit fly. *Anastrepha suspensa* (Diptera: Tephritidae). *Entomologia Experimentalis et Applicata, 21*(1), 63-70.

Halgren, L. A. (1970a). Take off behavior of greenbug, *Schisaphis graminum*, in the laboratory. *Annals of the Entomological Society of America, 63*, 712-715.

Halgren, L. A. (1970b). Flight behavior of greenbug, *Schisaphis graminum*, in laboratory. *Annals of the Entomological Society of America, 63*, 716-720.

Healy, M. J. R., & Taylor, L. R. (1962). Tables for power-low transformations. *Biometrika, 44*, 557-559.

Heathcote, G. D. (1957). The comparison of yellow cylindrical, flat and water traps, and of Johnson suction traps, for sampling aphids. *Annals of Applied Biology, 45*, 133-139.

Heathcote, G. D., Palmer, J. P., & Taylor, L. R. (1969). Sampling for aphids by traps and crop inspection. *Annals of Applied Biology, 63*, 155-166.

Kennedy, J. S., Booth, C. O., & Kershaw, W. J. S. (1961). Host finding by aphids in the field. *Annals of Applied Biology, 49*(1), 1-21.

Kirk, W. D. J. (1984). Ecologically selective coloured traps. *Ecological Entomology, 9*, 35-41.

Legg, J. P. (1994). *Bemisia tabaci*: The whitefly vector of cassava mosaic geminiviruses in Africa: an ecological perspective. *African Crop Science Journal, 2*, 437-448.

Meyerdirk, D. E., Coudriet, D. L., & Prabhaker, N. (1986). Population dynamics and control strategy for Bemisia tabaci in the imperial valley, California. *Agriculture, Ecosystems & Environment*, *17*(1-2), 61-67.

Mound, L. A. (1962). Studies on the olfaction and colour sensitivity of Bemisia tabaci (Genn.) (Homoptera, Aleyrodidae). *Entomologia Experimentalis et Applicata, 5*(2), 99-104.

Musuna, A. C. Z. (1986). A Method for Monitoring Whitefly, *Bemisia tabaci* (Genn.), in Cotton in Zimbabwe. *Agricultural Ecosystem and Environment, 17*, 29-35.

Patti, L., & Rapisaarda, C. (1981). Findings on the morphology and biology of aleyrodids injurious to cultivated plants in Italy. *Belletino di Zoologia Agraia e di Eachicolura, 16*, 135-190.

Prokopy, R. J. (1972). Response of apple maggot flies to reactangles of different colours and shade. *Environental Entomology, 1*, 720-726.

Prokopy, R. J., & Owens, E.D. (1983). Visual Detection of Plants by Herbivorous insects. *Annals Review of Entomology, 28*, 337-364.

Saxena, K. N., & Goyal, S. (1978). Host-plant relations of the citrus butterfly *Papilio demoleus* L.: Orientation and ovipositional responses. *Entmologia Experimentalis et Applicata, 24*, 1-10.

Sharaf, N. (1982). Parasitization of the tobacco whitefly, *Bemisia tabaci* Genn. (Homoptera: Aleyrodidae) on *Lantana camara* L. in the Jordan Valley. *Zeitscbrift fur Angewandte Entomologie, 94*, 263-271.

Smith, J. G. (1976). Influence of crop background on aphids and other phytophagous insects on brussel sprouts. *Annals of Applied Biology, 83*, 1-13.

Southwood, T. R. E. (1978). *Ecological methods with particular reference to the study of insect populations. 2nd Edition*. London, UK: Chapman and Hall.

Vaishampayan, S. M., Kogan, M., Waldbauer, G. P., & Woolley, J. T. (1975). Spectral specific responses in the visual behavior of the greenhouse whitefly *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae). *Entomologia Experimentalis et Applicata, 18*(3), 344-356.

Venugopal Rao, N., Reddy, A. S., & K. Tirumala Rao (1989). A method to monitor whitefly (*Bemisia tabaci*) in cotton (*Gossypium hirsutum*). *Indian Journal of Agricultural Science, 59*, 459-461.

Venugopal Rao, N., Reddy, A. S., & K. Tirumala Rao. (1991). Monitoring of cotton whitefly, *Bemicia tabaci* Genn. with sticky traps. *Madras Agricultural Journal, 40*(1), 1 - 7

Webb, R. E., & Smith, F. F. (1980). Greenhouse whitefly control of an integrated regimen based on adult trapping and nymphal parasitism. *IOBC/ WPRS Bulletin, 3*(3), 235- 246.

Yano, E. (1987). Quantitative monitoring techniques for greenhouse whitefly. *IOBC/WPRS Bulletin, 10*, 198-202.

Youngman, R. R., Toscano, N. C., Jones V. P., Kido K., & Natawick E. T. (1986). Correlations of seasonal trap counts of *Bemisia tabaci* (Homoptera: Aleyrodidae) in South-Western Californa. *Journal of Economic Entomology, 79*, 67-70.