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Full Length Research Paper

Aleytrap: An instrumentation to handle adult whitefly, *Bemisia tabaci*, Gennadius

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Whiteflies are fast flying, minute insects in the suborder Homoptera of the Hemiptera; family Aleyrodidae. They are reported to transmit viral diseases in various, economically important agricultural crops. Based on their small size (average wing spans of about 3 mm), whiteflies are difficult to count on plants or capture through insect nets and other tools. Therefore, we developed a feasible and effective method to capture adults and estimate the population size using a new device named "aleytrap". The device took less time to count whiteflies and was found significantly superior over other conventional methods when used in tomato (*Lycopersicon esculentum* Mill.), chili (*Capsicum anuum* L.), brinjal (*Solanum melongena* L.), okra (*Abelmuscus esculentus* L. Moench), cotton (*Gossypium hirsutum* L.), black gram (*Vigna mungo* L., Hepper) and green gram (*Vigna radiata* L., Wilczek).

Key words: Aleytrap, sampling, whitefly, adults, leaf turn method, capture.

INTRODUCTION

Observations on an insect pest in scientific studies under natural conditions involve counting and catching of the individuals on their respective niches. This effort is greatly affected by the flight capacity and behavior as well as size of the concerned insect pest. Counting or catching can be done very easily on weak flying and large size insects as compared to minute and fast flying insects viz., whiteflies and hoppers. Whiteflies and its biotypes are polyphagous pests of great significance in agriculture worldwide (Kontsedalov et al., 2012). It belongs to the family Aleyrodidae from the suborder Homoptera of the order Hemiptera, having 1,556 extant species in 161 genera (Martin and Mound, 2007) and associated with 160 host plant species from 42 families of 113 plant genera of field and fruit crops, ornamentals and forest trees including weeds (Parveen et al., 2010). Hardly exceeding 1.0 mm in length, the adults are of snow-white color which is attributed to the secretion of wax on its body and wings. Adult as well as immature stages inhabit and feed on the lower surface of leaves reducing plant vigor by depletion of plant sap (Bethke et al., 1991). Foliage becomes contaminated with excreted honeydew on which black sooty mould grows thereby reducing the photosynthetic area and lowering the aesthetic appearance of ornamentals. Adults of a small number of species, most notably *Bemisia tabaci* (Gennadius), are important as vectors of many viral diseases than as direct pests and the severe infestation of such viral diseases may cause total yield loss (Gupta and Pathak, 2009). In order to overcome the whitefly menace, an excessive use of pesticides has been done (Roditakis et al., 2005) which led to the development of resistance (Prabhakar et al., 1992). This escalation of problems has prompted many researchers to become involved in management studies of whiteflies and the viruses they are capable of transmitting.

The small size of whiteflies and attraction towards yellow color, natural tendency of upward (Rangaraju

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Table 1. Literature on whitefly counting methods.

Reference	Host	Method of observation
Dharne and Kabre, (2009)	Chili	TMB (leaf turn method)
Zabel et al. (2001)	Tomato	NDM
Gencsoylu (2009)	Cotton	TMB (leaf turn method)
Ali et al. (2004)	Brinjal	TMB (leaf turn method)
Manzano et al. (2003)	Snap bean	Cotyledonary leaf (leaf turn method)
Akhtar et al. (2004)	Cotton	TMB (leaf turn method)
Sanchez-Pena et al. (2006)	Brinjal	NDM
Gupta and Pathak (2009)	Black Gram	NDM
Byrne (2010)	Poinsettia	Leaf turn method
Pasian et al. (2000)	Chrysanthemum and Gerbera	Entire plant counting
Castle et al. (2009)	Melon vine	Fifth terminal leaf (leaf turn method)
Lee et al. (2002)	Tomato	NDM
Sequeira and Naranjo (2008)	Cotton	Abaxial side of single leaf (leaf turn method)
Alicai (1999)	Sweet potato	NDM
Leite et al. (2003)	Brinjal	TMB (leaf turn method)
Nombela et al. (2001)	Tomato	Counting on all leaves of each plant
Mallah et al. (2001)	Cotton	TMB (leaf turn method)
Muniz et al. (2002)	Tomato and Pepper	TMB (leaf turn method)
Muqit et al. (2008)	Tomato	NDM
Rafiq et al. (2008)	Araceae, Asteraceae, Brassicaceae, Cucurbitaceae, Chinopodiaceae, Malvaceae, Meliaceae, Papilionaceae and Solanaceae	NDM
Leite et al. (2005)	Okra	TMB (leaf turn method)
Naranjo et al. (2003)	Cotton	NDM

*TMB- Top, middle and bottom, **NDM- No defined method.

and Chenulu 1980) and towards light orientation (positive photo-taxis) (Holmer et al., 1998; Ahmad et al., 2010) have however made the counting a hectic and trouble-some task. The whitefly adults are active fast fliers, gets away with a slight disturbance and that may be one of the reasons for not mentioning the capture and handling method of adult whiteflies in research papers (Gupta and Pathak, 2009) by the concerned authors. Rangaraju and Chenulu (1980) initiated the efforts to overcome this problem, describing an effective method to count adult whiteflies on crops under field conditions by covering the sample plant with a bell jar of a height according to the respective crops, however, the time consumption is too much in this method.

Apart from the bell jar and leaf turn method, the yellow sticky traps (Lloyd, 1921), muffin fan traps (Byrne et al., 1996) and CC-Trap consisting of transparent disposable cup (Chu and Henneberry, 1998) have also been developed but none of these can be used in counting per plant population in scientific experiments.

Some attempts made by different authors to count adult whiteflies by employing various methods on different host plants are listed in Table 1.

As the table shows, in most of the cases, counting adults was usually based on the leaf turn method involving random selection of a number of leaves (Zanic et al, 2008) or upper, middle and lower leaves (Shirale and Bidgire, 2009). Considering the fragility of whitefly, the leaf turn method could not be considered as an accurate method to count the per plant population of whitefly adults. Therefore, it was felt germane to develop such technology which could be most efficient, less time consuming and relatively more accurate one. In this endeavor, a new device (prototype) named “Aleytrap” after the family “Aleyrodidae”, has been formulated and described.

Structure of the device

Galvanized tin (2 mm thickness) and a transparent glass (10 mm thickness) were used as materials to fabricate the device. The first lower half of the device is of cube shape, facilitated with a small window (facilitated with a lid to close and open) to provide extra brightness during evening time and cloudy weather (open only when required) (Plate 1) otherwise it will interfere with orientation of whitefly adults towards the light. The remaining upper half (trapezium) with tapering walls holding a transparent glass was erected over the lower half square. It is divided into four equal squares, additionally facilitated with clothed sleeve in the company

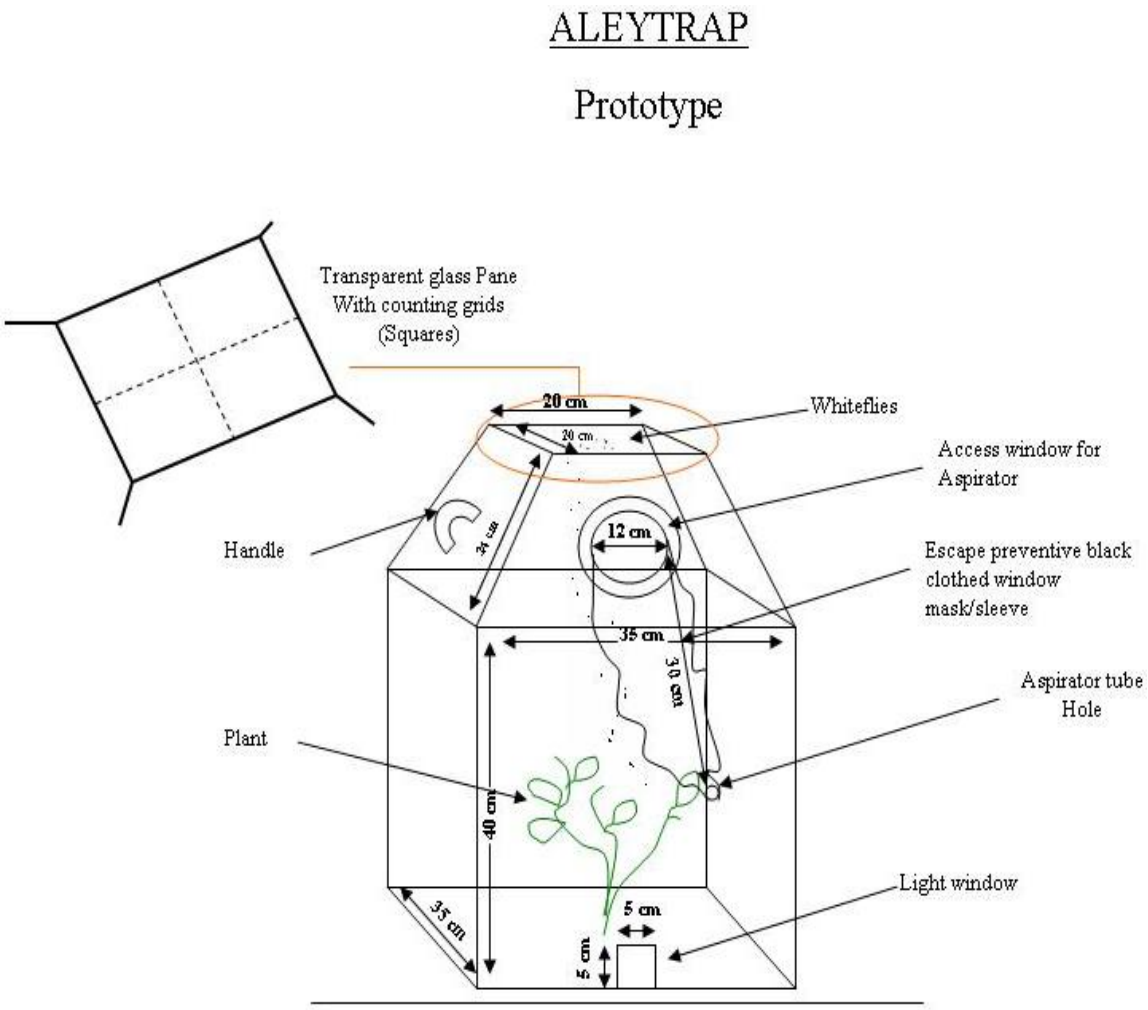

Plate 1. Sketch of Aleytrap.

of a small access hole at its lower end to capture the whitefly adults. Height and width of the device may vary depending upon the canopy of the host plant for population count.

To assure the visibility of adult whiteflies the device was painted in and outside with black color except for the transparent glass (Plate 2). For transportation of the device from the laboratory to the experimental site, a tin handle was provided opposite to the capture sleeve beneath the joint of lower square and upper trapezium. The overall manufacturing cost was estimated at 8-10 $ US, depending upon availability of material in the market and price fluctuation.

Working concept of the device

This device utilizes the phototaxis character (orientation towards light) of the aleyrodid adults (whitefly) (Holmer et al., 1998; Ahmad et al., 2010) to count and capture them. When the device was inverted over the target plant, the adult aleyrodids resting over the plants got oriented towards the source of light and accumulate in clusters underneath the glass pane and hence can easily and clearly be glanced by the device user. For the observation, the user will have to wait (approximately 30 s) for the settlement of all the adult aleyrodids. Sometimes, few adults may remain sitting at the lower internal portion of the device, in this situation, the user is advised to hit the lower portion of device by his/her finger which creates a noise and shake and ultimately will force the adults to settle underneath the glass pane.

The adult population of whiteflies (up to 15) can easily be counted simply by observing the top of the counting desk (glass pane), but in case, the population exceeds over said numbers, the counting desk can be divided into four equal parts and the number observed in that quarter desk can be multiplied by four thus providing a round estimate of whitefly adults present on the host plant. It can be utilized for tomato (*Lycopersicon esculenum* Mill.),

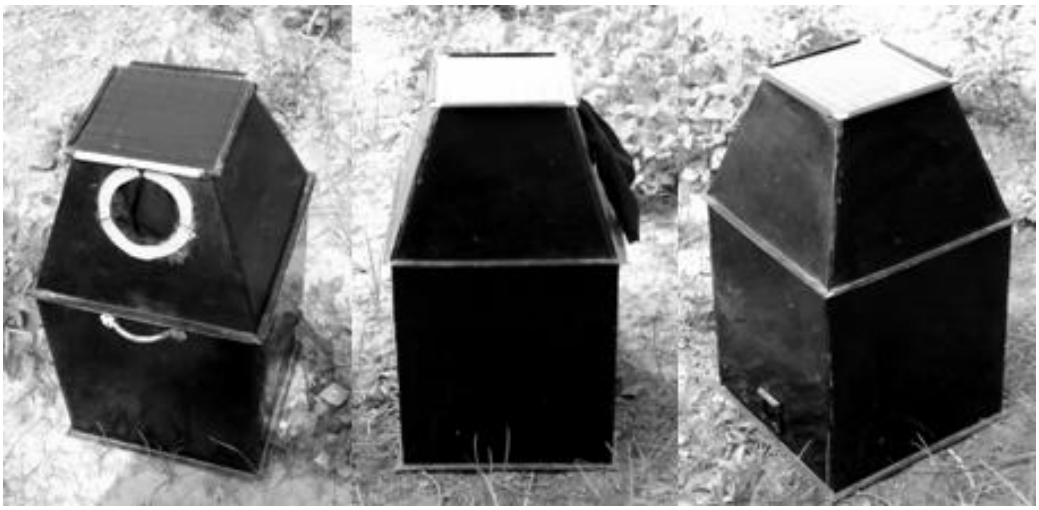

Plate 2. Aleytrap.

Chilli (*Capsicum anuum* L.), brinjal (*Solanum melongena* L.), okra (*Abelmuscus esculentus* L. Moench), cotton (*Gossypium hirsutum* L.,), black gram (*Vigna mungo* L., Hepper) and green gram (*Vigna radiata* L., Wilczek) and many other height-resembling plants.

All the adult insects waiting at the lower side of the counting desk can also be captured simply by inserting the aspirator tube through the hole of access window holding clothed sleeve at lateral side of trapezium. The size and capacity of the aspirator may vary in accordance with the users need.

MATERIALS AND METHODS

Performance of Aleytrap against whitefly on different host plants

To prove the efficacy of this device, seven host plants viz., tomato, chili, brinjal, okra, cotton, black gram and green gram were grown at the experimental fields of Department of Plant Protection, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh, India. Under field conditions, all the hosts were found to be naturally infested with one or combination of whitefly species, that is, *B. tabaci* and *Trialeurodes vaporariorum* (Westw.). For comparative efficacy of traditional 'leaf turn counting' method and 'aleytrap' device, a control was standardized by using transparent polythene bags (1.0 x 1.0 m). The host plants were covered with these polybags, ensuring the capture of all the adults, anesthetizing them with alpha isomer of allethrin (obtainable from the market under the trade name of "HIT" (Godrej consumer products limited, Mumbai, India) followed by shaking the whole plant inside the poly-bag. This exact amount of aleyrodid adults bagged with poly-bags was taken as control and used to compare the population observed through manual/leaf turn and aleytrap method of counting. Counting of adult aleyrodids in all the methods was made on separate plants of separate plots for each of the tested host. A total of ten counting attempts through each method with ten replications were made on each host plant separately between 10.00-11.00 AM in 2008-09. In aleytrap counting, a population of more than 15 adult aleyrodids was counted by dividing the counting desk (glass pane) into four equal parts (square made with white color paint) and multiplying the population of a square by four. The time spared in counting the whitefly from each of the methods was also recorded using a stop watch and the comparative time consumption was also evaluated.

Statistical analysis

The mean data obtained in each of the counting attempt from the experiments was analyzed using Minitab version 10 and SIGMA PLOT version 10.0 for ANOVA (analysis of variance) and graphical presentation of the findings was made with the help of Microsoft Excel version 2007. The time consumption (in seconds) in counting the adults was also analyzed for analysis of variance (ANOVA). Tukey's HSD test was used to compare the mean of observations of different experiments.

RESULTS

A close parallel relation (*df*-9, 99 and $p<0.05$) between poly-bag capture and aleytrap counting is clearly inferred from the findings on all the host plants whereas leaf turn method of adult counting on all the host plant was found to fall under irregular pattern and show less number of whitefly adults (*df*-9, 99 and $p<0.05$) in most of the attempts (Figure 1). Only two attempts (sixth and ninth) on tomato, the population count through leaf turn method was observed non-significantly at par (*F*-1.61, *p*-0.25, *df*-9, 99 and f-1.39, p-0.30, df-9, 99) with poly-bag and aleytrap counting method. Similar fashion adult population (*df*-9, 99 and $p<0.05$) counted through poly-bag and aleytrap was recorded on chili whereas fifth attempt of leaf turn method of counting on chili exhibited a significant superiority (*F*-5.06, *p*-0.038 and *df*-9, 99) over poly-bag and aleytrap counting attempts. No significant difference was observed among all the counting methods on the eighth (*F*-2.30, p-0.163, df-9, 99) and ninth (*F*-3.06, p-0.103 and df-9, 99) attempt of

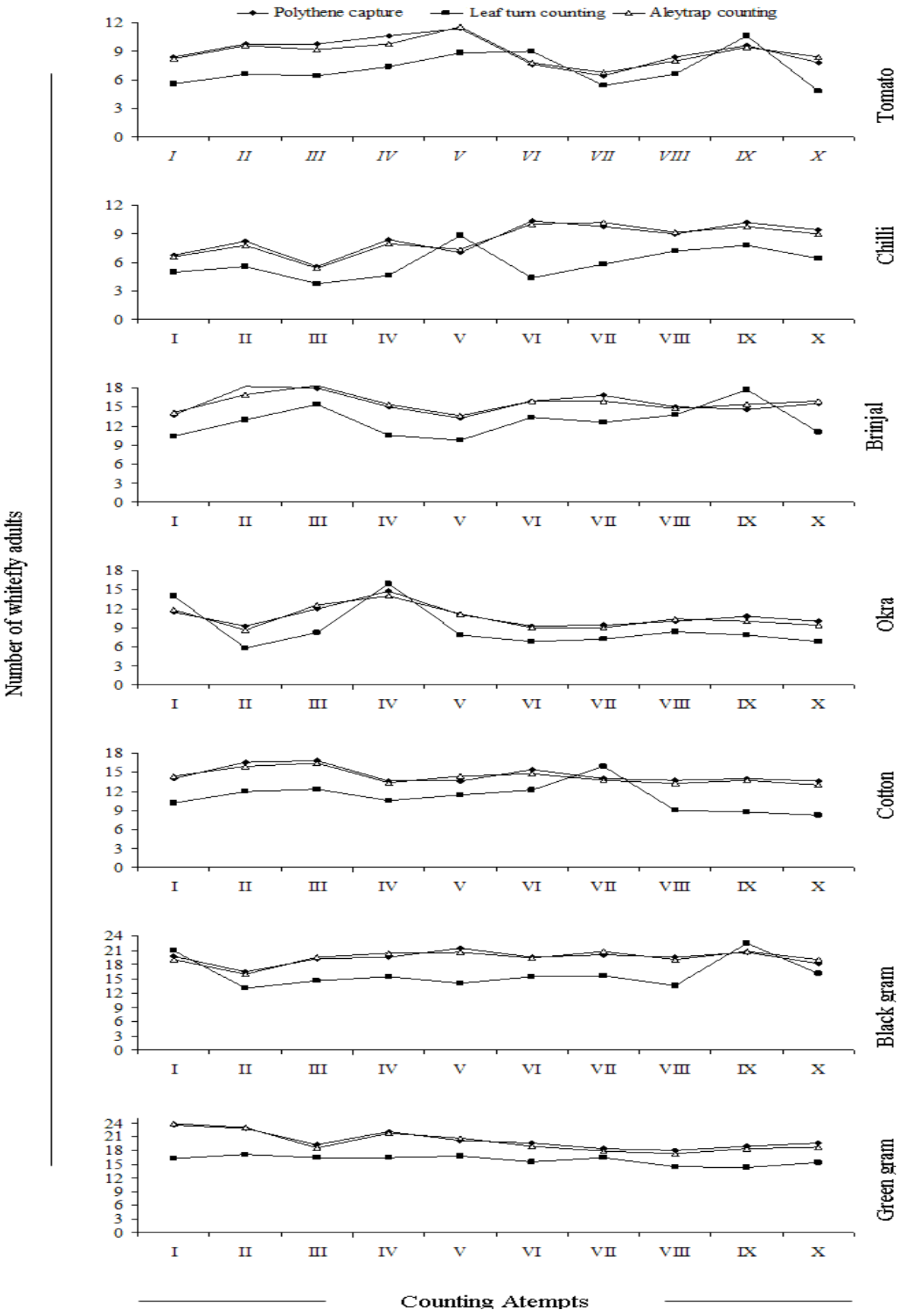

Figure 1. Comparative performance of leaf turn and aleytrap counting method on different host plants.

Table 2. Performance of leaf turn and aleytrap counting technique with respect of time consumption (in seconds) on tomato, chili, brinjal, okra, cotton, black gram and green gram.

Host	Whitefly adult	Time consumption	
		Leaf turn method	Aleytrap counting
Tomato	10.375±2.56[b]	171.37±6.52[a]	35.50±3.89[a]
Chilli	7.00±2.00[a]	171.00±4.92[a]	35.00±5.68[a]
Brinjal	16.87±3.13[d]	276.75±6.18[c]	73.37±5.50[b]
Okra	10.37±2.20[b]	224.75±3.84[b]	81.12±4.91[c]
Cotton	13.00±1.85[c]	272.62±7.76[c]	90.62±5.23[d]
Black gram	17.00±2.45[d]	326.12±6.96[d]	102.00±4.27[e]
Green gram	20.12±2.03[e]	326.50±7.11[d]	102.12±5.59[e]
f-value	35.24	819.52	256.56
p-value	0.00	0.00	0.00

*Means followed by the same letters (within a column) showt non-significant difference.

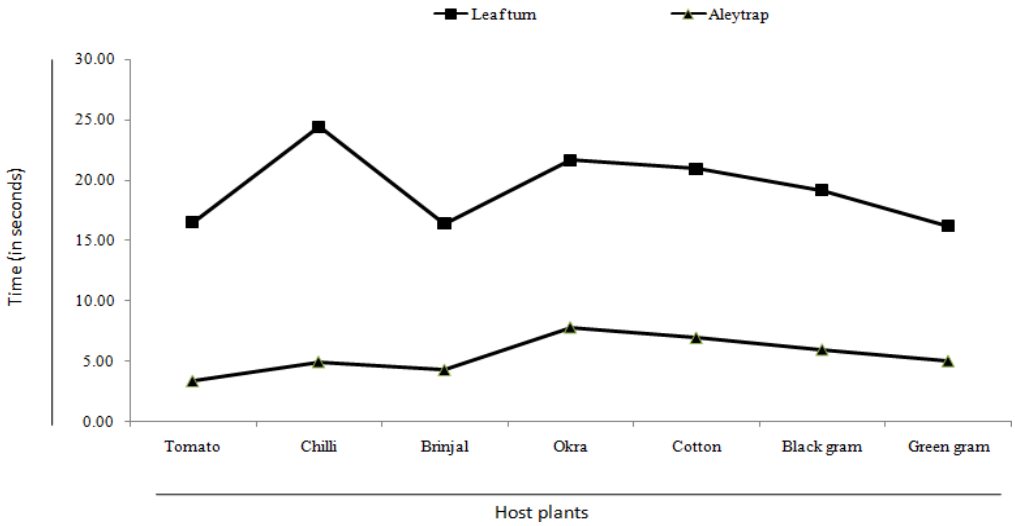

Figure 2. Time consumption throuh leaf turn and aleytrap method on single whitefly adult.

counting through leaf turn method in the case of brinjal, fourth attempt on okra (*F*- 0.75, *p*- 0.502 and *df*- 9, 99), seventh attempt on cotton (*F*- 1.46, *p*- 0.288 and *df*- 9, 99), first and ninth attempt on black gram (*f*-1.09, *p*- 0.382, *df*- 9, 99 and *f*- 0.76, *p*- 0.497, *df*- 9, 99) whereas in these attempts the leaf turn method showed a non-significant superiority over poly-bag and aleytrap counting (Figure 1). The proximity in number of whitefly adults counted through poly-bag and aleytrap counting methods and superiority of aleytrap counting over leaf turn method clearly indicate the effectiveness of aleytrap.

Time consumption

It is inferred from the present findings that aleytrap did consume significant less (*F*-256.56, p-0.00 and df-7, 42) time to count the adults whiteflies than leaf turn method (Table 2). Approximately, a similar duration of time (35.50±3.89 and 35.00±5.68 seconds) was spent to count the whitefly adults through aleytrap on tomato (10.37±2.56 adults/plant) and chili (7.00±2.00 adults) while leaf turn method has utilized relatively much more time on tomato (171.37±6.52 s) and chili (171.00±4.92 seconds) (Table 2). In the case of black gram and green gram, aleytrap has utilized a greater but almost similar time (102.00±4.27 and 102.12±5.59 seconds) to count the adults (17.00±2.45 and 20.12±2.03 adults/plant). When time consumption for a single whitefly adult was analyzed from Table 2, the lowest duration was observed on tomato followed by brinjal and highest on okra (Figure 2).

Justification

The whitefly population prefers lower surface of leave for their rest and feed. Under natural condition, whitefly population is always found to vary from plant to plant thus difficult to count without disturbing the plant. Adults are very agile and sensitive to leave the resting place with a slight disturbance. In the present investigation, poly-bag counting method was considered to compare the efficiency of aleytrap and leaf turn method of whitefly adult counting. The population count on plant basis was found to vary with each other and the performance of poly-bag and aleytrap count was recorded more or less statistically on par as comparison to leaf turn method. The significant variation with respect to aleytrap and poly-bag count, which was recorded rarely, may be attributed to the variation in population of adults on the tagged plants along with the spatial distribution and or migration and immigration from nearby plants. Employing leaf turn method in chili proved to be difficult for adult count on account of small size of leaves. Aleytrap and poly-bag method were found to be convenient and more feasible. Aleytrap nevertheless showed the best performance.

Gusmao et al. (2005) opined that the beating method was significantly superior over the leaf turn method for outdoor tomato crops, but the method is not as cost effective as the device is and in case where one has to assess the residual persistence through bioassay method, it would be inappropriate to beat the leaves and kill the adult whiteflies.

The poly-bag capture was found to be most effective in counting the adult aleyrodid, but to observe the local dynamics and population fluctuation, it cannot be applied as it kills the natural population, indirectly disturbing the natural presence of aleyrodids. Yellow sticky trap (Chu and Henneberry, 1998) and muffin fan trap (Byrne et al., 1996) are also in use but they help only in providing the information on natural occurrence of aleyrodid adults in a particular cultivated area, besides yellow sticky traps which also capture other insects having fondness of yellow color (Chu and Henneberry, 1998). Chu and Henneberry (1998) has developed a new trap (CC Trap) consisting of transparent disposable cup and proved its superiority over yellow sticky trap but these traps cannot count the per plant population of whitefly adults on their respective host plants. Here this device can be considered superior over yellow, muffin fan and CC traps by getting quick information on population count; however it cannot be used to predict the natural occurrence of whitefly as has been observed through yellow sticky, muffin fan and CC traps. The other advantage with this new device is that the sex ratio can be determined by collecting adult through aspirator.

The device is effective in counting adult whiteflies leading to accurate ecological, bio-assay experiments and other studies evolving capture of whitefly adults. On the other hand, it can only be used for low height crops like tomato,chilli, brinjal, black gram and green gram etc. The crops having the height more than one meter *viz*., papaya, pigeon pea and mature cotton cannot be assessed for counting of whitefly adult population using aleytrap. Sometimes, the insects of other groups, having bigger size also get trapped in the device and disturb the cluster settlement of adult whiteflies under the glass pane but they can be removed using clothed sleeve.

In the present findings, the device has been used solely against the adults of the family *Aleyrodidae* family, but possibly it can also be used against other small and fast flying insects having the phototactic character and fondness towards yellow color.

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