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Evaluation of moving yellow sticky traps for monitoring and management of whitefly, *Bemisia tabaci* infesting cotton

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ABSTRACT

Yellow sticky traps (YSTs) are commonly used for monitoring whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), and are usually installed in the crop fields as a stationary unit. In the present investigation YSTs were evaluated as moving unit in association with intercultural operations for their efficacy in monitoring as well as management of whitefly under field conditions. YSTs were moved by different methods in the field along with various intercultural operations such as movement of YSTs attached by rod on either side of the power weeder so as to move just above the crop canopy, movement of YSTs behind two people who would move a rope through the plant rows so as to dislodge sucking pests making the adults stick to the YSTs, YSTs stuck on the pants of the plough operator in the portion just outer to the thigh, and movement of badminton racket covered with YST on both sides between two rows. These methods were compared with YSTs installed as stationary unit, chemical control as well as untreated control. Results of this study suggested that, among all the methods, YSTs installed as stationary unit trapped maximum number of adult whitefly (342±209/trap 24 h after installation) followed by YSTs attached by a rod on either side of the wheels of a plough so as to move just above the crop canopy (236. 95 ±111whitefly adults/trap). No significant correlation between whitefly populations observed on the plants and trapped on the YSTs. Minimal impact on the population dynamics of adult whiteflies was recorded, as YSTs were not able to significantly suppress the population of adult whiteflies when compared with the chemical control. However, YSTs were helpful in early detection of the infestation and minimizing population numerically in comparison to the control plot. Moving YSTs only gave additional advantage of being synchronized with the intercultural operations in cotton.

Key words: Cotton, Intercultural operations, Whitefly, Yellow sticky trap

Whitefly, *Bemisia tabaci* (Gennadius) damage cotton through feeding, development of sooty mold on its honeydew secretion; transmission of plant-pathogenic viruses, and inducing plant physiological disorders (Jones 2003). Over 900 host plant species (Rathore and Tiwari 2014) have been recorded as alternate hosts of *B. tabaci.* During 2015 crop season severe outbreak of *B. tabaci* was witnessed in North Indian cotton growing states Punjab, Haryana and Rajasthan (Anonymous 2015). In haste, farmers used several sprays of chemical insecticides with many direct and indirect consequences on the environment (Ren *et al.* 2001). So, it becomes imperative to explore some non-chemical methods to control this pest. Among the various methods of Integrated Pest Management, attraction of whitefly adults to yellow color had been exploited as mechanical method and documented by Lloyd, in 1921 and subsequently confirmed by many workers (Mound 1962, Gerling & Horowitz 1984, Hill & Hooper 1984, Chandler 1985, Meyerdirk & Oldfield 1985).

Monitoring of the pest population at the beginning is important (Gillespie and Quiring 1987) and to monitor insects, various sampling methods are being employed, among them; sticky traps are widely used to monitor harmful and beneficial insects (Ladd *et al.* 1984, Meyerdirk and Moreno 1984, Chandler 1985, Byrne *et al.* 1986). Furthermore, attempts have also been made to use YSTs for the control of some of the pests, especially whitefly. Under greenhouse conditions, combinations of YSTs and biological control agents (parasitoids) have proven to be an effective method for the control of *B. tabaci* (Shen and Ren 2003, Gu *et al.* 2008). Placement of YSTs at particular height is important for monitoring and mass trapping of insect populations (Ladd *et al.* 1984, Meyerdirk and Moreno 1984, Chandler 1985, Byrne *et al.* 1986). Under field

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Table 1 Treatment detail and observations protocol

Treatment	Abbreviation used in text	No. of YSTs installed or moved/treatment	Observation protocol
Yellow sticky trap (YST) as stationary units at recommended rates being replaced at recommended intervals, standard methods of YST usage	YSTst	4	Average whitefly counts from both sides of all traps
YST attached by a rod on either side of the power weeder so as to move just above the crop canopy while ploughing the fields at normal speed,	YSTrw	2	Whitefly counts from single sides of both the trap
Moving YST behind two persons who will move a rope between two plant rows so as to dislodge sucking pest facilitating adults stick to the YST	YSTpr	2	-do-
YST stuck on the pants of the plough operator in the portion just outer to the thigh	YSTot	2	-do-
Movement of badminton racket covered with YST on both sides between two rows	YSTbr	2	
Recommended chemical control without any use of YST where insecticides applied based on the pest situation	YSTcc	-	Whitefly counts per plant through manual scouting
Untreated control with manual scouting	YSTuc	-	-do-

conditions, the stationary installation of YSTs encounters adverse climatic conditions due to monsoon rains and storms during the crop season and also as a hurdle in intercultural operations etc. It was felt necessary to evaluate efficacy of YSTs as moving unit in association with intercultural operations for monitoring as well as management of whitefly under field conditions.

MATERIALS AND METHODS

The study was conducted under field conditions during 2014 and 2015 between July–September.

Whitefly susceptible *hirsutum* L. cotton genotype was sown in the month of May during both the years. Necessary agronomic practices were followed to grow the crop as desired under unprotected conditions. Total plot size was fixed at 100 sq m. Each treatment had three replications. There were total six rows (67.5 cm row to row and 30 cm plant to plant spacing), of 30 m in each treatment.

Preparation of yellow sticky trap: The YSTs supplied by Pest Control India were made of art paper (33 × 22 cm) by painting with lemon yellow colour on both sides. These were sealed with a thin transparent plastic cover, and smeared with sticky glue.

Treatment details: Trapping trials were conducted on naturally multiplied population of whitefly on cotton growing in the field. The experiment was planned in randomized block design by employing seven treatments based on moving and stationary installation of YSTs. One of the treatments was taken as chemical control. The rationale behind comparison of different YST usage methods with chemical control is to study their efficacy on whitefly population reductions as insecticides are being trusted as the most reliable method of whitefly reduction by the farmers. To avoid lengthy detail of each treatment in results and discussion, the treatments were abbreviated as under and details of the treatments are as follows.

Experimental detail: For YSTst, YSTs were uniformly hanged in selected rows @ 40 traps /acre. The recommended rates in case of stationary installation are as high as 40/acre advised not only for monitoring but for the management of whitefly. In other treatments the movement of YSTs was executed thrice between the two rows. There were no traps in YSTcc and YSTuc. During the trials no insecticides were applied in fields except in the treatment YSTcc where the insecticidal interventions were planned.

Data recording: In YSTst, numbers of whitefly trapped were recorded after 24 h of installation from both sides of single YST but were removed from fields after every seven days and replaced by new ones. In YSTrw, YSTpr, YSTot and YSTbr number of whitefly trapped on YSTs were recorded immediately after operations and time taken in treatment was recorded. To maintain parity with the YSTst, whitefly adults were counted from the single side of two YSTs' used in each operation in treatments YSTrw, YSTpr, YSTot and YSTbr. In YSTcc, population of whitefly was recorded prior to the spray application and 24 hours after the application (Total 30 plants were selected i.e. 5 plants in each row). In YSTuc, population of whitefly was recorded at each operation of YST. For each operation counting of whitefly population from 3 leaves each of 30 tagged plants were done manually to study the impact on whitefly dynamics.

Data analysis: Randomized Block Design was used to arrange three experimental replications of different treatments in fields. Data from each treatment taken at 24 h interval were averaged. One way ANOVA was applied for analysis of data after appropriate transformations.

RESULTS AND DISCUSSION

Population dynamics of adult whiteflies: The data recorded on whitefly population dynamics in all the treatments showed clear difference on population dynamics. During 2014-15, whitefly population recording started from 11 July, 2014 and initial population of whitefly recorded from 30 plants in each treatment ranged between 9.26–10.87/3

Table 2 Pooled mean of whitefly adults population before and after operation of Yellow Sticky Trap

Treatment	Average whitefly adults population/3 leaves on tagged cotton plant before and after yellow sticky traps operations and other treatments*			
	2014-15		2015-16	
	Pre-Treatment	Post- Treatment	Pre-Treatment	Post- Treatment
YSTst	16.59 (24.0)	16.16 (23.4)	47.39 (42.7)	50.65 (44.9)
YSTrw	16.64 (24.1)	16.34 (23.9)	50.70 (44.6)	50.11 (44.8)
YSTpr	16.63 (24.3)	17.54 (24.6)	45.30 (41.5)	47.40 (42.7)
YSTot	16.73 (24.3)	17.86 (25.0)	50.55 (44.4)	50.11 (44.3)
YSTbr	17.29 (24.6)	17.64 (24.9)	53.54 (46.2)	50.79 (45.4)
YSTcc	13.81 (23.0)	11.29 (20.9)	49.05 (45.7)	39.31 (40.2)
YSTuc	17.43 (24.7)	18.71 (25.6)	54.56 (45.9)	57.64 (44.7)
CD		0.92		2.65
CV		12.09		12.42

* Data in parenthesis are angular transformation.

YSTst- Yellow sticky trap (YST) as stationary units at recommended rates being replaced at recommended intervals, standard methods of YST usage, YSTrw- YST attached by a rod on either side of the power weeder so as to move just above the crop canopy while ploughing the fields at normal speed, YSTpr- Moving YST behind two persons who will move a rope between two plant rows so as to dislodge sucking pest facilitating adults stick to the YST, YSTot- YST stuck on the pants of the plough operator in the portion just outer to the thigh, YSTbr-Movement of badminton racket covered with YST on both sides between two rows, YSTcc- Recommended chemical control without any use of YST where insecticides applied based on the pest situation, YSTuc- Untreated control with manual scouting.

leaves. The maximum whitefly populations recorded in each treatment was on 18 July 2014 ranging from 21.56–25.03/3 leaves. The lowest count of adult whitefly was recorded in the YSTcc, where chemical interventions were applied based on the population of nymphs as well as adults. The average whitefly based on six observations recorded prior to the moving of YSTs ranged between 13.81–17.20/3 leaves. Whereas, the population recorded post movement varied between 11.29–18.72/3 leaves (Table 2, Fig. 1**).** The significantly lowest counts were recorded in YSTcc. However the populations in the all other treatments were not significantly but numerically lesser than the control treatment.

During 2015-16, an outbreak of the whitefly was experienced in the North Cotton Growing Zone of the country. The whitefly population was above ETL throughout the season during the year. The whitefly population ranged between 17.82–20.15/3 leaves at the beginning of the season on 14 July 2015. The highest population of the whitefly recorded during this season ranged between 67.45–76.18/3 leaves during 27 July 2015. The average population of whitefly in all the treatments ranged between 45.30–54.60/3 leaves and 39.31–57.60/3 leaves prior to and after operations of yellow sticky trap or any other interventions (Table 2, Fig 1). However significantly low population was recorded in the treatment of recommended chemical control over all other treatments.

Yellow sticky traps operation: YSTs had impact on the dynamics of adult whiteflies in the field. The whitefly adult trapping capacity of sticky trap varied with method of operation. The trapping efficiency of the trap either installed or moved between rows depended on the availability of

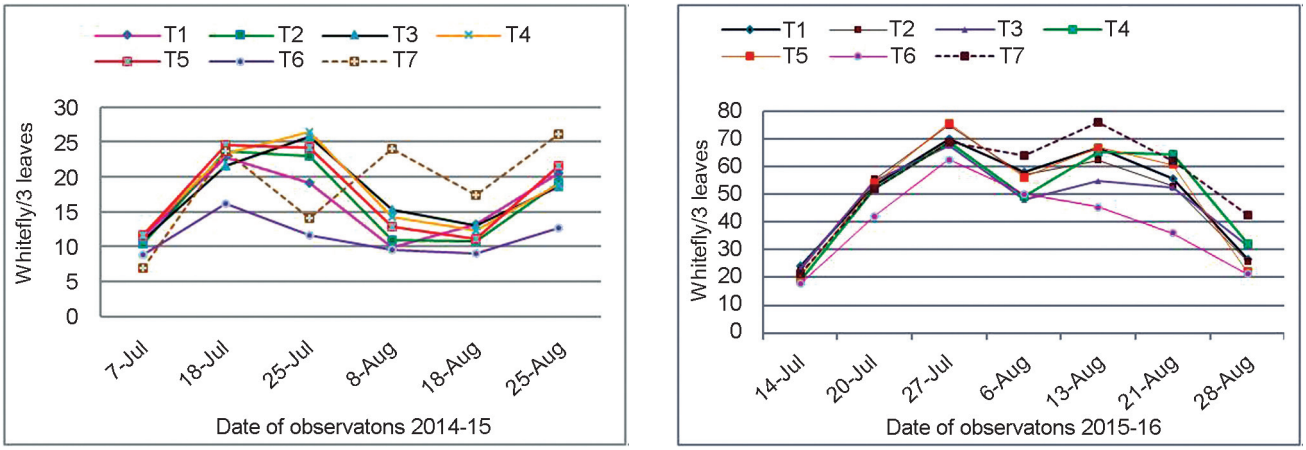

Fig 1 Whitefly population dynamics after treatment during 2014-15 and 2015-16.

whitefly on cotton crop as the whitefly adults trapped were more during 2015-16 in comparison to 2014-15; the general population level was low during the latter year, i.e. 2014-15. The treatment where yellow sticky trap installed as stationary unit trapped the maximum number of adult whitefly 193.8±28.16 and 490. 5±155.6 per trap, 24 hours after installation during both the years 2014-15 and 2015-16, respectively. This was followed by YSTrw, which attracted 158.4±136.7 and 315.5±134.63 whitefly/trap during 2014-15 and 2015-16, respectively. However, more deviation in the trapping in this treatment was due to the non -matching of height of YSTs attached on the power weeder with the crop canopy during initial and later part of the season. Similarly the whitefly adults trapped during 2014-15 & 2015-16 in YSTpr (56.1±25.2 & 266.7±115.5) and YSTot (86.7±31.3 & 296.4±129.7) were significantly lower than the YSTst and YSTrw (Table 3) followed by YST br (16.35±8.5 & 142.3±117.2).

The average time taken for moving of trap/plot (100 sq m) was 7 min. in treatment YSTrw and 5-6 min. in treatments YSTpr, YSTot and YSTbr. However, in YSTst, the trap was stationary among the six rows. In case of the YSTst only attraction was the single mechanism, whereas in rest of the treatments the time taken for the movement was very less but the traps were moved along each and every row to facilitate the disturbance and trapping of the available whitefly adults. Among all the methods of traps used, stationary installation of the traps was found to be the best, but movement of YST with agricultural intercultural operations were also useful in reduction of whitefly adults pressure. The comparison of data on whitefly population on five different YST treatment methods and the whitefly adults population available on leaves (through manual scouting) indicated positive correlation between the yellow sticky trap in treatment YSTst and YSTrw (r^2= 0. 128 and r^2=0. 106), this can be further improved based on the location and movement with respect to crop canopy, horizontal/vertical installation etc. However, the correlation between rest of the YST installation methods and control was negatively correlated. Thus, the correlation coefficient calculated also signifies the importance of installation of the YST or its attachment on either side of power weeder (YSTrw) as their efficiency increased with the increase in population of adult whitefly. However, other methods associated with intercultural operations are also important and do not require extra efforts/labour except for the inclusion of the trap cost. The trap cost can be reduced by using low cost YST.

Attraction of adult insects to yellow colour is well known now and yellow traps have been used for the trapping of fruit flies (Cyrtrynowicz *et al.* 1982), aphids (Heathcote 1957), and whitefly (Webb and Smith 1980). Like most foliage feeding insects, whiteflies are attracted to the yellow trap, and positive response to yellow colour is common (Prokopy and Owens 1983). Yellow sticky traps have been used as a control method for whitefly in the field for many years. But according to our knowledge, all prior studies were done in with the stationary installation of the YST for a limited period of crop growth and were also not moved in synchrony with intercultural operations as tested in the present studies. Previous studies on use of YSTs for whitefly control in the field were conducted with variation in the original number of pests, which is not reliable method for showing a significant difference between treatment and control resulting from the effect of traps (Gu *et al.* 2008). In the study, YST treatments were continued throughout crop season and whitefly population

Table. 3 Average population of whitefly in different yellow sticky traps used for scouting of whitefly during 2014-15 and 2015-16

Treament	Whitefly adults pollination/trap*		Pooled mean	WF/3 Leaves**		Pooled mean	Coefficient (r^2)
	2014	2015		2014	2015		
YSTst	193.8±28.16 (14.0)	490.5±105.6 (22.1)	342.2 ±209	16.16	50.65	33.405	0.128
YSTrw	158.4±136.7 (12.58)	315.5±134.6 (17.76)	236.95 ±111	16.34	50.11	33.225	0.106
YSTpr	56.1±25.2 (7.49)	266.7±115.5 (16.33)	161.2 ±148	17.54	47.40	32.47	-0.153
YSTot	86.7±31.3 (9.31)	296.4±129.7 (17.22)	127.7 ±148	17.86	50.11	33.985	-0.132
YSTbr	16.35±8.5 (4.04)	142.3±117.2 (11.93)	79.33 ±89	17.64	50.79	34.215	-0.210
YSTcc	--			11.29	39.31		
YSTuc	--			18.71	55.21		
CD	2.2	2.4					
CV	24.1	21.2					

* Mean of six observations recorded at fortnight interval during 2014and seven during 2015, **whitefly population recorded /3 leaves. Parenthesis values are square root transformation. YSTst- Yellow sticky trap (YST) as stationary units at recommended rates being replaced at recommended intervals, standard methods of YST usage, YSTrw- YST attached by a rod on either side of the power weeder so as to move just above the crop canopy while ploughing the fields at normal speed, YSTpr- Moving YST behind two persons who will move a rope between two plant rows so as to dislodge sucking pest facilitating adults stick to the YST, YSTot- YST stuck on the pants of the plough operator in the portion just outer to the thigh, YSTbr-Movement of badminton racket covered with YST on both sides between two rows, YSTcc- Recommended chemical control where insecticides applied based on the pest situation, YSTuc-Untreated control with manual scouting.

before initiation of the treatments were almost equal and care was taken to avoid any field variation. Cotton being grown at wider spacing's of 67.5–100 cm between row to row, mechanical or manual operations are required. Movement of the YSTs in the present studies like synchronizing with the various intercultural operations, helped in trapping the whitefly adults though less than the stationary installation as recorded by the earlier workers (Rao *et al*. 1991, Gu *et al.* 2008, Yaobin Lua 2012) where the YSTs were fixed in the fields but in these treatments the YSTs were operated for a shorter duration of 5-7 minutes/100 sq m area along with the various field operations. Over two years of the study confirmed the use of YSTs for monitoring the whitefly population from the very beginning of the season through stationary installation of YSTs at recommended rates but cannot significantly suppress the increase in population of adult and immature whiteflies in the fields. Other methods involving movement of YST demonstrated low trapping intensity that can be appreciated in context of slight reduction in whitefly population and detection of early infestations without any extra efforts.

Yaobin (2012) reported that YSTs are mostly used for monitoring and detection of whiteflies can also be used in suppression of whitefly population but it has certain limitations in suppressing whitefly population under greenhouse condition due to high pressure of population. Our study also supported these views and YSTs should be used in conjunction with other suitable methods, such as biological control, cultural control, and selective insecticides (Shen and Ren 2003, Gu *et al.* 2008) to significantly reduce whitefly population.

The installation of YSTs in YSTst was in horizontal conditions and operation of the trap in the other treatments were neither horizontal conditions nor vertical, but were modified according to the intercultural operations. Whitefly population data was recorded either 24 hr of operation in stationary treatments or immediately after operation in rest of the treatments (Idris *et al.* 2012), which indicates that traps exposed for more than one day are often unreliable because of the dust and dirt coverage on the sticky material. The traps were installed slightly above the canopy and were operated within plant canopy in other treatments as reported by Byrne *et al.* (1996). In our study, the positive correlation on whitefly population dynamics between the yellow sticky traps installed as stationary units treatment (r^2= 0.128) or attached by the either side of power weeder (r^2= 0.106) and the whitefly population on leaves (manual scouting) showed its use for monitoring, management as well as for deciding the use of other management options. However, the negative correlation between other methods of using YSTs and the whitefly population dynamics ignores the use of these methods for whitefly monitoring rather these can be used to minimize the adult population up to certain extent. The catch levels of whitefly on YSTs certainly help to study of whitefly populations and their behavior, determine timing of spray applications and possibly to control whiteflies (Melamed-Madjar *et al.* 1979). Here, we conclude that YSTs as stationary unit should be continued for monitoring and management of whitefly in cotton and low cost YSTs can be moved in the field along with intercultural operations for numerical suppression of whitefly adults' populations.

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