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Evaluation of colour sticky traps at various heights for monitoring of whitefly *Bemesia tabaci* (Gennadius) in cotton

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ABSTRACT : In the present investigation relative trapping efficiency of various colour sticky traps at 4 heights; alone and in combination with azadirachtin 10000 ppm @ 2ml/l was assessed against cotton whitefly. Data on trap height revealed superiority of sticky trap erected 15 cm below crop canopy level in terms of significantly higher adult whitefly trapping (2995.17/trap/week) and was comparable with trap along the crop canopy (2641.81/trap/week). These superior treatments were followed by trap installed at 30 cm and 60 cm above the crop canopy with 2093.33and 720.78 /trap/weeks, respectively. Use of yellow colour trap was most efficacious with respect to trapping of adult whitefly (3033.44 /trap/week) followed by combination of yellow and blue colour (2010.96 whitefly/trap/week), whereas, least population was trapped on blue colour traps with 1293.92 whitefly/trap/week. Significantly higher catches of whitefly on trap were evident when used in combination with azadirachtin sprays on crop (2368.40 whitefly/trap/ week) over traps without azadirachtin sprays (1857.14 /trap/ week).

Yellow colour sticky trap at 15 cm height below crop canopy and along the crop canopy level with 7 application of azadirachtin were found equally effective in order of merit in maximum trapping and minimizing the infestation of whitefly on plants at 7 and 14 days after spray, respectively. Irrespective of trap colour, height and combination with azadirachtin significantly maximum catches of whitefly population was recorded on trap in north east direction as compared to south west direction.

Key words : Azadirachtin, cotton, sticky trap, trap colour, trap height, whitefly

Cotton is cultivated in 3 distinct agro ecological regions (north, central and south) of the country. Predominant area is under black soil with low productivity (444 kg lint/ha) due to uncertainty of monsoon and severe pest and disease problems. In India cotton ecosystem harbors about 162 insect pest species and the monetary value of yield losses due to insect pests has been estimated to be Rs 2,87,000 million annually.

Besides, a complex of sucking pests *viz.* aphid, *Aphis gossypii* (Glover), leafhopper, *Amrasca biguttula biguttula* (Ishida), thrips, *Thrips tabaci* (Linnman) and whitefly, *Bemisia tabaci* (Gennadius), are known to have occupied major pest status. Estimated losses due to sucking pests are upto 21.28 per cent and yield loss due to sucking pests 22.85 per cent Satpute *et al.,* (1990). It is estimated that about 20-40 per cent losses occur annually due to different pest of cotton Aslam *et al.*, (2004) while, Chavan *et al.,* (2010) reported 28.13 per cent avoidable yield loss due to major sucking pests in cotton.

About 90 per cent of the current *Bt* hybrids are susceptible to jassids and whiteflies. Clearly, insecticide usage for bollworm control decreased after 2004 and usage for sucking pest control increased after 2006.

Sticky traps have been widely used to sample harmful and beneficial insects in wild

and cultivated plants worldwide. Traps based on the response of insects to colour have been widely used in integrated pest management programme in diverse cultivated crops. Sticky traps efficacy depends on colour and placement of traps in relation to crop phonology. Thus, use of sticky trap can be an ecofriendly, economical and cost effective alternative for the management of whitefly abundance on *Bt* cotton.

The yellow colour was proven to be the most effective colour for attracting flying insects than other colors including yellow green, orange, green and blue card Atakan and Canhilal (2004) assessed that yellow sticky traps at 60, 80, 100, and 120 cm heights above ground level were assessed in various developmental stages of cotton. Numbers of whiteflies were highest at 60 cm and lowest at 120 cm trap heights at all plant heights level.

This information will help in improving the monitoring technique and mass trapping of whitefly in cotton and more helpful in enhancing integrated pest management programs by developing strong decision making component as sticky trap.

MATERIALS AND METHODS

The experiments were conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* 2013-2014 and 2014-2015 by using variety RCH 2 (Rasi) hybrid *Bt* cotton. Factor A (4 trap heights), Factor B (3 trap colors) and Factor C (2 levels of azadirachtin with and without) were laid in factorial randomized block design replicated thrice. The whitefly abundance on plant was also recorded in these 24 treatments along with plots treated with azadirachtin without trap and an untreated control plot, analyzed as per the randomized block design.

Foam sheets of 30 x 45 cm size were used for preparing traps (on the basis of 50 traps / ha). The golden yellow, brilliant blue and combination of yellow and blue colour (upper half blue and lower half yellow) were evaluated. The traps were erected on bamboo sticks at different heights *viz.,* 15 cm below crop canopy, along the crop canopy, 30 and 60 cm level above crop canopy facing north east (NE) or south west (SW) direction. The trap heights were adjusted as per the crop growth. Castor oil was used as the sticky material for trapping of the whitefly. A border of 2 cm width (white) was kept as such without castor oil for handling the traps without disturbing sticky material. The traps were installed at 10 days after emergence of the crop. The trap was covered with a grid of 54 squares (5 x 5 cm) of which every second square in every second row and centre square in this way 5 squares counted and then multiplied. The count was then extrapolated to per trap.

After observations on sticky trap, they were wiped out for removal of sticky material with trapped insect with wet cotton. The sticky material was again smeared on the trap for trapping of new pests. Cumulative total of sucking pests trapped on both sides of trap were worked out on the basis of observation of all counts.

First application of azadirachtin 10,000 ppm @ 2ml/l was made 15 days after emergence of crop and subsequent applications were made

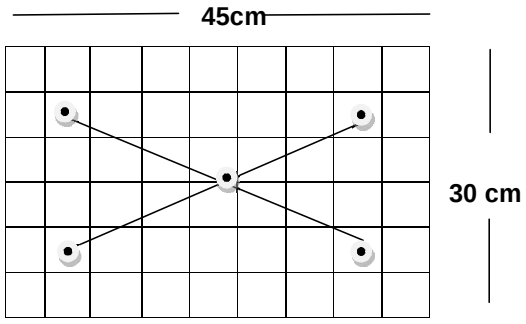

Fig.1. Trap grid design for whitefly count

at 15 days interval. In all 7 sprays were undertaken for the management of cotton whitefly. Pre treatment observations on sucking pest on plants were recorded 24 h before first spray. Post treatment observations on whitefly were recorded at 7th and 14th days after each spray.

The observations were recorded on 3 leaves (top, middle and bottom) randomly selected 5 plants and calculated number of insects/leaf. First count of sucking pests of whitefly were recorded 3 days after installation of colour traps in the field initially and subsequent count were recorded at weekly interval upto 123 old crop.

RESULTS AND DISCUSSION

Effect of trap height on total catches of whitefly

Trap on north east (NE) direction: The effect of trap heights on catches of whitefly in NE direction (Table 1) was found statistically significant during 2013-2014. The highest numbers of whitefly (2302.6/trap/week) were trapped at trap 15 cm height below the crop canopy which is statistically *at par* with the height of trap at along crop canopy level (1945.17/trap). Similar, trend was evident during 2014-2015 with highest catches (1717.50/trap/week) was catches at trap 15 cm below height crop canopy which was at equal with along crop canopy (1536.44/trap/week). On the basis of pooled data catches of whitefly also registered same trend (2010.17/trap/week) were trapped at 15 cm below crop canopy which was similar with along crop canopy (1740.94/trap/week).

South west (SW) direction: The effect of traps heights on catches of whitefly in SW south west direction was found significant during 2013-2014, 2014-2015 and pooled data. The highest numbers of whitefly catches (1194.78, 789.78 and 992.39/trap/week, respectively) were trapped 15 cm below the crop canopy which in turn was equal with the height of trap at along crop canopy level with 1058.61, 743.11 and 900.94/trap/week, respectively.

Both side (BS) direction: The effect of traps heights in BS both side directions on catches of whitefly was found statistically significant during 2013-2014. The highest numbers of whitefly with 3488.94 whitefly /trap/week were trapped at 15cm below height the crop canopy level which was equal with the trap along crop canopy level (3003.78/trap/week). Similar, trend was evident during 2014-2015 (2501.28/trap/week) were trapped at 15 cm height below crop canopy which was *at par* with the height of trap along crop canopy (2279.56/trap/week). On the basis of pooled data catches of whitefly also registered same trend (2995.17/trap/week) were trapped at 15 cm below crop canopy which was *at par* with along crop canopy (2641.81/trap/week).

It is clear from above data that trap height at 15 cm below crop canopy level followed by trap height at along crop canopy was found significantly most effective in trapping maximum whitefly population in decreasing order on NE and SW direction. However, overall population of whitefly trapping on NE direction was 2 times more than SW direction.

Similar findings were also reported that the populations of whitefly were captured effectively on yellow traps placed at ground level in cotton fields and also reported that more whiteflies on traps at the lowest levels might be related to better feeding and oviposition sites in the lower part of the cotton canopy and Atakan and Canhilal (2004) reported the whitefly catches were highest at 60 cm above ground level and

Table 1. Effect of trap height, colour and azadirachtin on total catches of adult whitefly/trap/week

Direction	NE (North East) direction			SW (South west) direction			BS(Both side) direction		
	2013-2014	2014-2015	**Mean**	2013-2014	2014-2015	**Mean**	2013-2014	2014-2015	**Mean**
A) Heights									
H_1	2302.67(3.32)	1717.50(3.17)	**2010.17(3.24)**	1194.78(3.03)	789.78(2.86)	**992.39(2.95)**	3488.94(3.49)	2501.28(3.33)	**2995.17(3.42)**
H_2	1945.17(3.25)	1536.44(3.12)	**1740.94(3.19)**	1058.61(2.98)	743.11(2.83)	**900.94(2.92)**	3003.78(3.43)	2279.56(3.30)	**2641.81(3.360**
H_3	1643.56(3.18)	1101.39(3.00)	**1372.58(3.10)**	840.22(2.90)	586.89(2.72)	**713.61(2.82)**	2492.28(3.37)	1694.28(3.17)	**2093.33(3.28)**
H4	640.06(2.78)	326.44(2.49)	**483.31(2.66)**	340.22(2.51)	202.39(2.26)	**271.31(2.41)**	980.28(2.97)	528.83(2.68)	**720.78(2.85)**
"F" Test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sjg.	Sig.	Sig.
SE (m)±	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.04	0.03
CD (p= 0.05)	0.09	0.06	0.09	0.07	0.09	0.06	0.09	0.11	0.09
B) Colors									
C_1	2268.33(3.27)	1799.79(3.12)	**2034.17(3.20)**	1190.92(2.99)	804.29(2.81)	**997.71(2.91)**	3462.71(3.45)	2604.08(3.28)	**3033.44(3.37)**
C_2	1055.13(2.99)	624.96(2.75)	**840.10(2.88)**	553.29(2.71)	354.25(2.50)	**453.77(2.62)**	1608.42(3.16)	979.21(2.94)	**1293.92(3.06)**
C_3	1575.13(3.14)	1086.58(2.97)	**1330.98(3.06)**	831.17(2.88)	583.08(2.70)	**707.21(2.80)**	2402.83(3.33)	1669.67(3.14)	**2010.96(3.25)**
"F" Test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sjg.	Sig.	Sig.
SE (m)±	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.03	0.03
CD (p= 0.05)	0.08	0.05	0.08	0.06	0.08	0.06	0.08	0.09	0.08
C) Azadirachtin									
A_1	1822.75(3.19)	1335.28(3.02)	**1579.10(3.11)**	939.31(2.90)	633.53(2.73)	**786.46(2.83)**	2764.86(3.37)	1971.81(3.19)	**2368.40(3.29)**
A_2	1442.97(3.07)	1005.61(2.87)	**1224.40(2.98)**	777.61(2.81)	527.56(2.61)	**652.67(2.73)**	2217.78(3.26)	1530.17(3.05)	**1857.14(3.17)**
"F" Test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sjg.	Sig.	Sig.
SE (m)±	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.02
CD (p= 0.05)	0.06	0.04	0.07	0.05	0.06	0.05	0.06	0.08	0.06

N.B: Figures in parentheses are logarithm transformed values.

H1= Trap at 15 cm below crop canopy, **C1**= Yellow colour **A1** = Spray azadirachtin 10000ppm@2ml/l

H2= Trap at along the crop canopy, **C2**= Blue colour **A2** = Without azadirachtin

H3= Trap at 30 cm above crop canopy **C3** = Combination of yellow and blue colour

H4= Trap at 60 cm above crop canopy

lowest at 100 cm and 120 cm trap height at all plant heights. Present findings are confirmed with Ibrahim (2007) reported the highest whitefly population captured at trap 30 cm above the ground level compared to 25 cm above the cotton plant level.

Effect of trap colour on total catches of whitefly : The maximum number of whitefly trapped (Table 1) during 2013-2014, 2014-2015 and pooled data in NE direction (*i.e.* 2268.33, 1799.79 and 2034.17/trap/week, respectively), in SW direction (*i.e.* 1190.92, 804.29 and 997.71/ trap/week, respectively) and BS direction (*i.e.* 3462.71, 2604.08 and 3033.44/trap/week, respectively) on yellow colour trap and were statistically superior over rest of the other colour traps.

It is clear from above findings that yellow colour trap was found most effective in trapping highest whitefly population/trap/week. Similarly the results are supported by Atakan and Canhilal (2004) reported the number of whiteflies trapped were highest on yellow colour sticky trap and Ibrahim (2007) reported largest population captured on yellow sticky trap at 30 cm above the ground level. Premalatha and Rajangam (2011) tested the efficacy of yellow sticky traps and yellow charts coated with castor oil and managed the pests effectively.

Effect of with and without azadirachtin on catches of whitefly : The catches of whitefly in NE, SW and BS direction (Table 1) during 2013-2014, 2014-2015 and pooled data revealed that the maximum numbers of whitefly with azadirachtin 10000 ppm @ 2 ml/l in NE direction (*i.e.* 1822.75, 1335.28 and 1579.10/trap/week, respectively), in SW direction (*i.e.* 939.31, 633.53 and 786.46/trap/week, respectively) and BS direction (*i.e.* 2764.86, 1971.81 and 2368.40/ trap/week, respectively) with spray of azadirachtin and was significantly superior over the trap without application of azadirachtin.

It is clear from above findings that colour trap with spraying of azadirachtin 10000ppm @2ml/l was most effective in trapping highest whitefly population/trap.

Present findings are conformed with Khaire (2014) who reported that maximum catches of whitefly on yellow colour sticky trap with castor oil followed by application of azadirachtin 10,000 ppm @ 2 ml/lit as compared to the without spray of azadirachtin on cotton crop, similarly Bhonde (2013) who proved that combination of trap and azadirachtin are effective for management of sucking pests as whiteflies on okra crop.

Effect of treatment combinations of trap colour, height and azadirachtin on whitefly abundance on cotton : The mean population of whitefly/leaf (Table 2) was recorded at 7 and 14 days after spray in various treatments was found significant. The treatment yellow sticky trap with at 15 cm below crop canopy level was found statistically most effective in recording minimum population of whitefly (1.93 /leaf) and (2.87/leaf) at 7 and 14 days after spray and which was statistically *at par* with treatment, wherein a 7 spray of azadirachtin 10000 ppm @ 2 ml/l were undertaken with 7 spray of azadirachtin only were found ecofriendly and economically effective and superior over all other remaining treatments.

The present study gets support from the findings by Khaire (2014) who reported yellow sticky trap at along the crop canopy level in combination with azadirachtin 10,000 ppm @ 2 ml/l were found significantly minimized population of whitefly (1.70/3 leaves/plant) at 14 DAS and was found effective and statistically

Table 2. Effect of treatments on pooled mean populations of whitefly/leaf at 7 and 14 DAS (Pooled of years)

Treat. No.	Treatment details	Number of whitefly/leaf	
		7 DAS	14 DAS
T_1	YST at 15 cm BCC fb azadirachtin 10000ppm @ 2 ml/L	1.93 (1.38)	2.87 (1.69)
T_2	YST at AlCC fb azadirachtin 10000ppm @ 2 ml/L	2.11(1.45)	3.10 (1.76)
T_3	YST at 30 cm AbCC fb azadirachtin 10000ppm @ 2 ml/L	2.46(1.56)	3.27 (1.81)
T_4	YST at 60 cm AbCC fb azadirachtin 10000ppm @ 2 ml/L	2.60(1.59)	3.38(1.84)
T_5	YST at 15 cm BCC without azadirachtin	2.84(1.68)	3.92(1.98)
T_6	YST at AlCC without azadirachtin	2.94(1.71)	4.17(2.03)
T_7	YST at 30 cm AbCC without azadirachtin	3.19(1.78)	4.41(2.10)
T_8	YST at 60 cm AbCC without azadirachtin	3.30(1.79)	4.65(2.15)
T_9	BST at 15 cm BCC fb azadirachtin 10000ppm @ 2 ml/L.	2.13(1.46)	3.16(1.77)
T_{10}	BST at AlCC fb azadirachtin 10000ppm @ 2 ml/L	2.29(1.51)	3.31(1.81)
T_{11}	BST at 30 cm AbCC fb azadirachtin 10000ppm @ 2 ml/L	2.39(1.54)	3.49(1.86)
T_{12}	BST at 60 cm AbCC fb azadirachtin 10000ppm @ 2 ml/L	2.66(1.63)	3.57(1.88)
T_{13}	BST at 15 cm BCC without azadirachtin	3.01(1.73)	4.16(2.00)
T_{14}	BST at AlCC without azadirachtin	3.13(1.77)	4.42(2.10)
T_{15}	BST at 30 cm AbCC without azadirachtin	3.43(1.83)	4.71(2.15)
T_{16}	BST at 60 cm AbCC without azadirachtin	3.51(1.87)	4.95(2.21)
T_{17}	Y/BST at 15 cm BCC fb azadirachtin 10000ppm @ 2 ml/L.	2.08(1.44)	2.99(1.73)
T_{18}	Y/BST at AlCC fb azadirachtin 10000ppm @ 2 ml/L	2.20(1.48)	3.18(1.78)
T_{19}	Y/BST at 30 cm AbCC fb azadirachtin 10000ppm @ 2 ml/L	2.43(1.56)	3.41(1.84)
T_{20}	Y/BST at 60 cm AbCC fb azadirachtin 10000ppm @ 2 ml/L	2.63(1.61)	3.53(1.87)
T_{21}	Y/BST at 15 cm BCC without azadirachtin	2.90(1.70)	4.00(1.99)
T_{22}	Y/BST at AlCC without azadirachtin	3.04(1.74)	4.30(2.07)
T_{23}	Y/BST at 30 cm AbCC without azadirachtin	3.28(1.80)	4.42(2.10)
T_{24}	Y/BST at 60 cm AbCC without azadirachtin	3.09(1.75)	4.72(2.16)
T_{25}	No traps only foliar spray azadirachtin 10000ppm @ 2ml/L	2.72(1.65)	3.68(1.91)
T_{26}	Untreated control	3.62(1.90)	4.99(2.22)
F' Test		Sig.	Sig.
SE(m)±		0.08	0.10
CD (p=0.05)		0.24	0.30
CV (%)		9.01	9.46

N.B: Figures in parentheses are square root transformed values. YST = Yellow sticky trap; BST = Blue sticky trap DAS= days after spray, BCC= Below crop canopy, AlCC= along the crop canopy, AbCC= above crop canopy

at par with yellow sticky trap at 15 cm height above the crop canopy in combination with azadirachtin 10,000 ppm @ 2 ml/L (1.74/3 leaves/plant).

The results regarding the whitefly population are in agreement with Rashid *et al.,* (2012) reported that neem oil 2 per cent and neem seed water extract 3 per cent reduced 57.46 per cent and 48.29 per cent population of whitefly in cotton, respectively. Similar results were reported by Jat and Jeyakumar (2006) that neem products neem oil 3 per cent and NSKE 5 per cent were found to reduce white fly population and Khattak *et al.,* (2006) showed that the neem oil 2 per cent and neem seed water extract 3 per cent were effective against whitefly population. while, Bhonde (2013) who proved that combination of trap and azadirachtin are effective for management of sucking pests on okra crop.

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