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RESEARCH ARTICLE

Assessment of sticky trap parameters *viz*., colour, height, direction and combination with azadirachtin against cotton leafhopper

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ABSTRACT : In the present investigation relative trapping efficiency of various colour sticky traps at four heights; alone and in combination with azadirachtin 10000 ppm @ 2ml/lit. was assessed against cotton leafhopper. Data on trap height revealed superiority of sticky trap erected 15 cm below crop canopy in terms of significantly higher adult leafhopper trapping (716.67/trap) and was comparable with trap along the crop canopy (634.78/trap). These superior treatments were followed by trap installed at 30 cm and 60 cm above the crop canopy with 517.50 and 192.47 leafhoppers /trap, respectively. Use of yellow colour trap was most efficacious with respect to trapping of adult leafhoppers (736.56 leafhoppers/trap) and was followed by combination of yellow and blue colour (498.48 leafhoppers/trap), whereas, least population was trapped on blue colour traps with 315.10 leafhoppers/trap. Significantly higher catches of leafhopper on trap were evident when used in combination with azadirachtin sprays on crop (353.14/trap) over traps without azadirachtin sprays (274.38/trap). Interaction effect of trap height, colour and azadirachtin on total catches of leafhoppers indicated superiority of yellow sticky trap erected at 15 cm height below crop canopy in combination with azadirachtin spray and was in turn statistically at par with the yellow sticky trap along crop canopy in combination with azadirachtin spray and yellow sticky trap at 15 cm height below crop canopy without azadirachtin spray. Higher efficacy of trap colour and height combination was evident in combination with azadirachtin 10000ppm @ 2ml/lit. spray on crop with yellow sticky trap at 15cm below crop canopy as the most effective in recording minimum population of leafhoppers (2.40 and 3.32 leafhoppers/leaf) over 5.42 and 6.45 leafhoppers/leaf in untreated control at 7 and 14 days after application of azadirachtin. Irrespective of trap colour, height and combination with azadirachtin significantly maximum catches of leafhopper population was recorded on trap in North East direction as compared to South West direction.

Key Words :
Azadirachtin, Cotton leafhoppers, Sticky trap, Trap colour, Trap direction, Trap height

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Cotton is cultivated in three distinct agro-ecological regions (north, central and south) of the country. The central zone has nearly 60 per cent of cotton area of our country comprising of primarily rainfed tract of Madhya Pradesh, Maharashtra and Gujarat. 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 harbours 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 (Dhawan *et al.*, 2008). The extent of losses caused by sucking pests, bollworms and both sucking pests and

bollworms have been worked out 12, 44, and 52 per cent (Dhawan *et al*., 1988).

In the absence of effective genetic resistance against these sucking pests and bollworms, farmers solely relied on insecticides for their effective production management (Dhawan *et al.*, 2008). Post introduction of Bt cotton, the losses inflicted by sucking pest, *viz*., leafhoppers, *Amrasca biguttula biguttula* (Ishida), thrips, *Thrips tabaci* (Lindeman), aphids, *Aphis gossypii* (Glover) and whitefly, *Bemisia tabaci* (Gennadius) have occupied major pest status, especially leafhoppers posing a serious threat. In the recent years, incidence of the leafhopper, *Amrasca devastans* (Distant) in cotton has been prevalent from vegetative to reproductive phase of crop growth. The loss in seed cotton yield due to leaf hopper is accounted to 390 kg ha^{-1} and 330 kg ha^{-1} (Murugesan and Kavitha, 2010).

Bt cotton currently occupies over 93 per cent of the area under cotton cultivation. Genetic makeup of the plant is very much important to confer tolerance to biotic and abiotic stress under natural conditions. In India, introduction of Bt cotton involving several hybrids, most of which are highly susceptible to sucking pests has resulted in increased crop damage (Nagrare *et al*., 2014). Since, the donor parent Coker 312 is known to be highly susceptible to sucking pests such as jassids and thrips, the hybrids may be showing slightly enhanced susceptibility to these pests due to linkage drag, especially if the recurrent parent did not possess inherent resistance to the sucking pests.

The reduced use of insecticides for bollworm management has resulted in ecological and environmental benefits. However, the use of susceptible hybrids as carriers of Bt technology in India has resulted in increased insecticide usage for sap-sucking pest control. 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 (Kranthi, 2012).

Since 2002, every Bt cotton seed has been treated with the highly effective insecticide imidacloprid. Farmers have also been spraying this insecticide on the crop to control jassids. Jassids have developed resistance to imidacloprid and, therefore, crop can be damaged and yields are likely to decline due to sucking pests. Reports of resistance to other neonicotinoides and other conventional systemic insecticides are also on the rise. (Kranthi, 2012).

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 (Gerling and Horowitz, 1984). Sticky traps efficacy depends on colour and placement of traps in relation to crop phenology (Byrne *et al.*, 1986). Thus, Use of sticky trap can be an ecofriendly, cost effective alternative for the management of leafhoppers abundance on Bt cotton.

The present investigation was carried out to evaluate relative efficiency of various colour sticky traps with castor oil as sticky material at four heights, alone and in combination with spray of azadirachtin 10000 ppm @ 2ml/lit. of traps erected in north east (NE) and south west (SW) directions against cotton leafhoppers. This information will be useful in improving monitoring technique and trapping of these pests in cotton and more helpful in enhancing integrated pest management programmes by developing strong decision making component as sticky trap.

EXPERIMENTAL METHODOLOGY

The present investigation was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during *Kharif* 2013-14 and 2014-15 on RCH-2 Bt cotton. Factor A (4 trap heights), factor B (3 trap colours) and factor C (2 levels of azadirachtin) were laid in Factorial Randomized Block Design replicated thrice. The leafhopper abundance on plant was also recorded in these 24 treatments along with plots treated with azadirachtin without trap and an untreated control plot, analysed as per the Randomized Block Design.

Foam sheets of 30 x 45 cm size were used for preparing traps. 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 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 leafhoppers. 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 (5cm 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. Occasionally verification of error in population estimation did not exceed 10 per cent in sampling (Gerling and Horowitz, 1984).

After observations on sticky trap, they were wiped out for removal of sticky material with trapped insect with wet cotton. The sticky material was then 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/ lit. was made 15 days after emergence of crop and subsequent applications were made at 15 days interval. In all 7 sprays were undertaken for the management of cotton leafhopper. Pre- treatment observations on sucking pest on plants were recorded 24 hours before first spray. Post-treatment observations on leafhopper were recorded at 7^{th} and 14^{th} days after each spray.

The observations were recorded on randomly selected five plants on three leaves of each plant (*i.e.* from top, middle and bottom canopy) and number of leafhoppers per leaf was worked out. First count was recorded on 3 days after installation of traps and subsequent observations were recorded at 7 days interval.

EXPERIMENTAL FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Effect of trap height on total catches of leafhoppers:

NE direction:

The pooled data on effect of trap height on leafhopper catches (Table 1) revealed maximum trapping of leafhopper (445.67/trap) at 15 cm below the crop canopy. It was in turn at par with trap along the crop canopy H_2 (387.92/trap) and statistically superior over rest which recorded trapping of 307.61 leafhoppers/trap and 113.83 leafhoppers /trap at 30cm (H_3) and 60 cm above crop canopy (H_4), respectively.

SW direction:

The pooled data on effect of trap height on leafhopper catches revealed maximum trapping of leafhopper (274.14/trap) at 15 cm below the crop canopy. It was in turn at par with trap along the crop canopy H_2 (250.92/ trap) and 30 cm above crop canopy H_3 (172.89/trap). Lowest leafhopper trapping of 78.61 was evident in traps 60 cm above crop canopy (H_4), statistically inferior to former set of treatments.

Both sides :

The pooled data on effect of trap height on leafhopper catches revealed maximum trapping of leafhopper (716.67/trap) at 15 cm below the crop canopy. It was in turn at par with trap along the crop canopy H_2 (634.78/ trap) and statistically superior over rest which recorded trapping of 517.50 leafhoppers/trap and 192.47 leafhoppers /trap at 30cm (H_3) and 60 cm above crop canopy (H_4), respectively.

The results quoted above are supported by Atakan and Canhilal (2004) observed that leafhopper catches were significantly higher at 60cm than at 80 cm, 100 cm and 120 cm when plant heights were less than 80 cm and the number of leafhopper on traps at 80 cm was similar to 60 cm and 100 cm but significantly higher than 120 cm when the plant height were more than 80 cm means indicating higher trapping of leafhopper on trap installed at 10-20 cm below crop canopy followed by trap along the crop canopy. Ibrahim (2007) also observed higher *Empoasca* sp. population trapped on trap installed below crop canopy. Findings of DeGooyer *et al.* (1998) also supports present findings with significantly greater numbers of adult potato leafhopper trapped on yellow sticky traps installed along crop canopy than 25 cm above crop canopy, though the crop is different.

Effect of trap colour on total catches of leafhoppers:

NE direction :

The effect of trap colour on catches of leafhopper population (Pooled mean) revealed superiority of yellow colour (452.81 leafhoppers/trap) and was significantly superior over combination of yellow and blue and blue colour with 298.96 and 189.50 leafhoppers/trap, respectively (Table 1).

SW direction:

Similar trend was evident on traps in SW direction with highest trapping in yellow colour (239.17 leafhoppers/trap) and was significantly superior over

combination of yellow and blue and blue colour with 160.67 and 104.04 leafhoppers/trap, respectively.

Both sides :

Pooled data on effect of trap colour indicated efficacy of yellow colour (736.56 leafhoppers/trap) followed by combination of yellow and blue and blue colour with 498.48 and 315.10 leafhoppers/trap, respectively.

Present findings are in confirmation with Demirel and Yildirim (2008) who reported yellow colour traps were significantly attractive for leafhoppers species. Findings of Atakan and Canhilal (2004) about yellow sticky traps in various developmental stages of cotton for their relative efficiency in capturing the leafhopper, whitefly and thrips population support present findings. Mensah (1996) reported that yellow trap caught significantly more *A. viridigrisea* adult (8.12/trap /day) than any of the other colour tested, whereas, Suh and Spurgeon (2004) and DeGooyer *et al.* (1998) observed that yellow sticky traps tended to capture more leafhoppers than white traps. Cesar *et al.* (2012) reported that the yellow colour was most attractive to sharp-nosed leafhopper on cranberry bogs followed by green and red colour. Ibrahim (2007) observed largest population of *Empoasca* spp. trapped on yellow colour sticky trap.

Effect of trap with and without azadirachtin on total catches of leafhoppers :

NE direction :

The catches of leafhopper on traps (Pooled mean - Table 1) when used in combination with azadirachtin sprays revealed significantly maximum numbers of leafhoppers (353.14 l/trap) over traps without azadirachtin sprays (274.38/trap).

Table 1 : Effect of trap height, colour and azadirachtin on total catches of adult leafhopper/trap on Bt cotton

Direction	NE Direction			SW Direction			BS Direction		
	2013-14	2014-15	Pooled mean	2013-14	2014-15	Pooled mean	2013-14	2014-15	Pooled mean
Levels of height (4)									
H_1	498.7	392.61	445.67	322.89	225.17	274.14	819.39	613.72	716.67
	(2.65)	(2.54)	(2.60)	(2.48)	(2.33)	(2.40)	(2.86)	(2.74)	(2.80)
H_2	425.89	349.89	387.92	298.44	203.17	250.92	724.50	556.00	634.78
	(2.58)	(2.51)	(2.55)	(2.43)	(2.27)	(2.35)	(2.81)	(2.70)	(2.75)
H_3	347.28	267.89	307.61	243.50	172.89	208.19	592.83	441.89	517.50
	(2.51)	(2.40)	(2.46)	(2.35)	(2.20)	(2.29)	(2.74)	(2.61)	(2.67)
H_4	121.67	106.00	113.83	86.61	70.61	78.61	208.28	176.61	192.47
	(2.06)	(2.01)	(2.04)	(1.92)	(1.83)	(1.88)	(2.29)	(2.23)	(2.26)
C.D. (P=0.05)	0.05	0.04	0.05	0.06	0.05	0.06	0.06	0.07	0.06
Levels of colours (3)									
C_1	502.46	403.13	452.81	330.46	239.17	284.96	832.79	640.08	736.56
	(2.60)	(2.52)	(2.56)	(2.43)	(2.31)	(2.37)	(2.83)	(2.72)	(2.77)
C_2	207.21	171.79	189.50	147.17	104.04	125.60	354.38	275.83	315.10
	(2.27)	(2.20)	(2.24)	(2.13)	(1.98)	(2.06)	(2.50)	(2.41)	(2.45)
C_3	335.50	262.38	298.96	235.96	160.67	198.33	571.58	425.25	498.48
	(2.48)	(2.38)	(2.43)	(2.33)	(2.17)	(2.26)	(2.70)	(2.58)	(2.65)
C.D. (P=0.05)	0.05	0.03	0.04	0.05	0.04	0.05	0.05	0.06	0.05
Azadirachtin (2)									
A_1	397.31	308.92	353.14	256.47	185.42	221.01	654.97	497.83	573.76
	(2.51)	(2.42)	(2.47)	(2.34)	(2.21)	(2.27)	(2.73)	(2.63)	(2.68)
A_2	299.47	249.28	274.38	219.25	150.50	184.92	517.53	396.28	456.94
	(2.38)	(2.31)	(2.35)	(2.26)	(2.10)	(2.18)	(2.62)	(2.51)	(2.57)
C.D. (P=0.05)	0.04	0.03	0.03	0.04	0.03	0.04	0.04	0.05	0.04

N.B: Figures in parentheses are logarithm transformed values.
H_1 = Trap at 15 cm below crop canopy, C_1 = Yellow colour.
H_2 = Trap along the crop canopy, C_2 = Blue colour
H_3 = Trap at 30 cm above crop canopy C_3 = Combination of yellow and blue colour
H_4 = Trap at 60 cm above crop canopy
A_1 = With spray of azadirachtin 10000ppm @ 2ml/lit
A_2 = Without spray of azadirachtin

SW direction:

Pooled data revealed superiority of traps used in combination with azadirachtin sprays with maximum numbers of leafhoppers (221.01/trap) over traps without azadirachtin sprays (184.92/trap).

Both sides:

Statistically significant differences were evident in catches of leafhopper on traps when used in combination with azadirachtin sprays on plants (573.76 /trap) over traps without azadirachtin sprays (456.94/trap). It is evident from above findings, that traps in combination with spraying of azadirachtin 10000 ppm @2ml/lit. on crop was found effective in trapping higher leafhopper population.

Effect of trap direction on total catches of leafhoppers:

Irrespective of trap colour, height and combination with azadirachtin significantly maximum catches of leafhopper population was recorded on trap in NE direction as compared to SW direction. It was concluded that direction affect the population captured on sticky traps in NE direction has more exposure to sunlight thus, higher orientation of leafhoppers population is evident then on traps in SW direction.

Table 2 : Effect of various treatments on pooled mean population of leafhopper/leaf

Treatments no.	Treatments details	No. of leafhopper/leaf	
		7 DAS	14 DAS
T_1	YST at 15 cm BCC with azadirachtin	2.40 (1.54)	3.32 (1.81)
T_2	YST at AlCC with azadirachtin	2.58 (1.61)	3.53 (1.87)
T_3	YST at 30 cm AbCC with azadirachtin	2.80 (1.67)	3.90 (1.97)
T_4	YST at 60 cm AbCC with azadirachtin	2.97 (1.72)	4.12 (2.02)
T_5	YST at 15 cm BCC	4.36 (2.08)	5.48 (2.34)
T_6	YST at AlCC.	4.68 (2.15)	5.60 (2.35)
T_7	YST at 30 cm AbCC.	4.90 (2.21)	5.80 (2.41)
T_8	YST at 60 cm AbCC	5.16 (2.26)	6.12 (2.47)
T_9	BST at 15 cm BCC with azadirachtin	2.78 (1.66)	3.53 (1.87)
T_{10}	BST at AlCC with azadirachtin	2.94 (1.71)	3.64(1.88)
T_{11}	BST at 30 cm AbCC with azadirachtin	3.06 (1.75)	4.10(2.02)
T_{12}	BST at 60 cm AbCC with azadirachtin	3.27 (1.81)	4.35 (2.08)
T_{13}	BST at 15 cm BCC	4.55 (2.13)	5.75 (2.39)
T_{14}	BST at AlCC	4.79 (2.17)	5.84 (2.42)
T_{15}	BST at 30 cm AbCC	5.06 (2.24)	5.99 (2.45)
T_{16}	BST at 60 cm AbCC	5.29 (2.29)	6.33 (2.49)
T_{17}	Y/BST at 15 cm BCC with azadirachtin	2.75 (1.65)	3.44 (1.85)
T_{18}	Y/BST at AlCC with azadirachtin	2.91 (1.70)	3.54 (1.86)
T_{19}	Y/BST at 30 cm AbCC with azadirachtin	3.10 (1.76)	4.01 (2.00)
T_{20}	Y/BST at 60 cm AbCC with azadirachtin	3.30 (1.81)	4.10 (2.02)
T_{21}	Y/BST at 15 cm BCC	4.51 (2.12)	5.54 (2.34)
T_{22}	Y/BST at AlCC	4.67 (2.15)	5.62 (2.37)
T_{23}	Y/BST at 30 cm AbCC	4.87 (2.20)	5.88 (2.41)
T_{24}	Y/BST at 60 cm AbCC	5.06 (2.24)	6.18 (2.48)
T_{25}	Foliar spray of azadirachtin	3.39 (1.84)	4.46 (2.11)
T_{26}	Untreated control	5.42 (2.32)	6.45 (2.53)
C.D. (P=0.05)		0.30	0.33
CV %		9.71	9.44

Figures in parentheses are square root transformed values, azadirachtin 10000 ppm spray @ 2 ml/lit.
BCC = Trap below crop canopy, YST = Yellow colour sticky trap
AlCC = Trap along crop canopy, BST = Blue colour sticky trap
AbCC = Trap above crop canopy Y/BST = Combination of yellow and blue colour sticky trap

Effect of treatment combinations of trap colour, height and azadirachtin on leafhopper abundance on cotton:

7 days after application of azadirachtin :

The data presented in Table 2 about the abundance of cumulative mean population of leafhopper at 7 days after application of azadirachtin revealed the higher efficacy of trap colour and height combination in combination with azadirachtin 10000ppm @ 2ml/lit. spray. Use of yellow sticky trap at 15cm below crop canopy as the most effective in recording minimum population of leafhoppers (2.40/leaf) and was statistically at par with treatment, yellow sticky trap along the crop canopy (2.58/ leaf), combination of yellow and blue sticky trap at 15 cm below crop canopy (2.75 /leaf), blue sticky trap at 15 cm below crop canopy (2.78 /leaf), yellow sticky trap at 30 cm above crop canopy (2.80 /leaf), combination of yellow and blue sticky trap along the crop canopy (2.91 /leaf), blue sticky trap along the crop canopy (2.94 /leaf), yellow sticky trap at 60 cm above the crop canopy (2.97 /leaf), blue sticky trap at 30 cm above the crop canopy (3.06 /leaf), combination of yellow and blue sticky trap at 30 cm above the crop canopy (3.10 /leaf), blue sticky trap at 60 cm above the crop canopy (3.27 /leaf), combination of yellow and blue sticky trap at 60 cm above the crop canopy (3.30/leaf) in combination with azadirachtin 10000ppm @ 2ml/lit. spray and treatment due to only foliar spray of azadirachtin 10000ppm @ 2ml/ lit. (3.39 /leaf). In all seven spray of azadirachtin 10000 ppm @ 2 ml/L were undertaken, commencing first application after 15 days of crop emergence at an interval of 15 days and were superior over rest of the treatments. Maximum population of leafhopper was recorded in untreated control plot with 5.42 leafhoppers/leaf which was at par with treatments with no sprays of azadirachtin.

14 days after application of azadirachtin:

The data shown in Table 2 revealed that the treatment of yellow sticky trap at 15 cm height below crop canopy was found to be statistically most effective in recording minimum population of leafhopper (3.32/leaf) and was in turn statistically at par with treatment combination of yellow and blue sticky trap at 15 cm below the crop canopy (3.44 /leaf), combination of yellow and blue sticky trap along the crop canopy (3.54 /leaf), yellow sticky trap along the crop canopy (3.53 /leaf), blue sticky trap at 15 cm below crop canopy (3.53 /leaf), blue sticky trap along the crop canopy (3.64 /leaf), yellow sticky trap at 30 cm above crop canopy (3.90 /leaf), combination of yellow and blue sticky trap at 30 cm above crop canopy (4.01 /leaf), yellow sticky trap at 60 cm above crop canopy (4.12 /leaf), blue sticky trap at 30 cm above crop canopy (4.10 /leaf), combination of yellow and blue sticky trap at 60 cm above crop canopy (4.10 /leaf), blue sticky trap at 60 cm above crop canopy (4.35 /leaf) with seven spray of azadirachtin and only spray of azadirachtin (4.46 /leaf), wherein, a seven spray of azadirachtin 10000 ppm @ 2 ml/lit. were undertaken at 15 days interval and were found superior over rest of the treatments. Maximum population of leafhopper was recorded in untreated control (6.45 leafhoppers/leaf) and it was at par with all other treatments, in which no spray of azadirachtin was undertaken during season.

The above results are in agreement with Khaire (2014) who reported significantly minimum cumulative mean population of leafhopper of 7.32/3 leaves at 14 days after spraying in yellow sticky trap with castor oil along the crop canopy in combination with azadirachtin 10,000 ppm @ 2 ml/lit. and was at par with yellow sticky trap with castor oil at 15 cm height above crop canopy in combination with azadirachtin10,000 ppm @ 2 ml/lit. with abundance of 7.48 leafhoppers/3 leaves. Similarly, the results quoted above are in confirmation with Bhonde (2013) who showed combination of trap with spraying of azadirachtin as an effective tactic for management of sucking pests like aphid, leafhopper and whitefly. Nboyine *et al*. (2013) showed that application of 10 per cent NSKE significantly reduced the leafhopper population on cotton. Rashid *et al*. (2012) reported that neem oil 2 per cent and neem seed water extract 3 per cent reduced 59.85 per cent and 52.52 per cent population of jassids in cotton, respectively. Neelima *et al*. (2011) reported higher efficacy of neem oil 5 per cent, whereas, Jat and Jeyakumar (2006) reported neem oil 3 per cent as more effective against jassids. Reports of Vinodhini and Malaikozundan (2011) revealed superiority of neem seed kernel extract (5%) over neem oil (3%) against jassids, whereas, Khattak *et al*. (2006) reported that neem oil 2 per cent and neem seed water extract 3 per cent reduced jassids population which strongly supports present findings.

This information will be useful in the development of sampling techniques to aid the farmers in making decisions for managements of sucking pests in cotton

and further research on need based use of chemical pesticides in combination with yellow colour sticky trap and per hectare quantification requirement of trap is need of the day.

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