The Bioscan 9(2): 629-632, 2014
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

POPULATION DYNAMICS AND MONITORING OF SUCKING PESTS AND BOLLWORMS ON BT COTTON IN HUMID ZONE OF SOUTHERN RAJASTHAN

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KEYWORDS
Sucking pests
Jassids
Whitefly
Thrips
Mealy bugs
American boll worm
Spodoptera litura.

Received on :
15.05.2013

Accepted on :
22.02.2014

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ABSTRACT
The population dynamics of sucking pests and boll worms of Bt cotton along with their correlation with weather factors were studied during 2011 at the experimental farm, Agricultural Research Station, Banswara. The incidence of Jassids was observed throughout the crop season. Whitefly population was ranged from 3.9 to 42.0/3 leaves. Similarly, thrips population was in higher side and population was ranged from 0.0 to 87.0 /3 leaves. Mealy bug grade was ranged from 1.0 to 4. Moth population of *Spodoptera litura* noticed throughout the season while no moth catches of American bollworm with nil larvae population on Bt cotton was recorded. The peaks of moth populations of pink bollworm were recorded during 41-52nd standard week corresponding with larval population in field. Correlation studies revealed that the maximum temperature, morning relative humidity and rainy days were significant and positively correlated with the leafhopper population. Rainy days and relative humidity was the main significant contributing factor for the maximum occurrence of whitefly in Bt cotton. The main contributing weather factor for the incidence of thrips in Bt cotton was maximum temperature (r=-0.613**) and sunshine hours (r=-0.344**). The present studies revealed that the mealy bug population was increased with the increase in maximum temperature and sunshine hours. Regression models and the coefficients of determination (R^2) indicated that the sucking pests *viz*., jassids, thrips, whitefly were predicated to an extent of 74, 62 and 43 per cent, respectively. While, the prediction rate of populations of male moth catches of spotted bollworm, pink bollworm and tobacco caterpillar were 44%, 84% and 37%, respectively during 2011. Analysis clearly showed the importance of weather factors in predicting the pest incidence in Bt cotton.

INTRODUCTION

A complex of sucking pests and bollworms infesting throughout have made the cotton as intensive insecticide usage crop. Bt cotton plants are genetically engineered to produce insecticidal toxins from the *Bacillus thuringiensis* Berliner (Bacillales: Bacillaceae) a gram-positive bacteria. The transgenic Bt cottons expressing *Cry1Ac* delta endotoxin became inevitable to solve the problem of insecticide resistance in bollworms and to reduce insecticide usage upto 69%. Significant reduction in usage of insecticide especially broad spectrum organophosphates and pyrethroids has given scope for emergence of new pests especially the sap feeders (www.icac.org/tis/regional_networks). The use of insecticide to control bollworm has dropped by 6,599 tonnes in 2003 to 222 tonnes in 2011. Similarly, the use of insecticide to control sucking pests has more than doubled from 2,909 tonnes in 2003 to 6,372 tonnes in 2011 (CICR, Nagpur).

The incidence, spread and chemical control exercised over mealy bugs, *Phenacoccus solenopsis* recently in India stands as land mark example for altered insect pest scenario. In 2000, it was noticed that one of the problems due to the cultivation of Bt cotton is the resurgence of sucking insects as reported by (Uthamasamy and Raguraman, 2000). In 2006, it was shown that mirids become pests damaging Bt cotton in India (Khadi, 2006). Krishna Reddy *et al*. (2011) studied the population dynamics of jassids in Bt cotton with the changing pest scenario of sucking pests. They observed the incidence of jassids from moderate to high throughout the *kharif* season. Recently, white fly menace has been reported from different parts of cotton fields in Punjab that cripples the growth of cotton plant and this has resulted in reduction of Bt cotton yield (Business line). Saif-ur-Rehman *et al*. (2013) observed that revealed that transgenic cultivars were more susceptible to thrips infestation as compared to conventional genotypes.

In 2009, scientists have reported unusual survival of the pink bollworm to the first-generation single-protein bollgard cotton. The knowledge about incidence of pest during the cropping season and its possible dynamics help in designing pest management strategies (Santhosh *et al.,* 2009). The present study was planned to study the population dynamics and seasonal abundance of sucking pests and bollworms on Bt cotton to identify the peak abundance period and timely management measures against pests of Bt cotton.

MATERIALS AND METHODS

Taking this into consideration, the field experiment was conducted at ARS, Borwat Farm, Banswara during *kharif* 2011, with the objective to study the population dynamics of sucking

pests as well as boll worms in Bt cotton hybrid, NCS-138. The experiment was laid out in such a manner that each plot measured 7.2 X 3.5 m in size and considered as one block. They were sown in *kharif*, 2011 and the regular agronomic practices were followed. The crop was raised under unprotected condition. The incidence of sucking pests and bollworms were recorded at weekly interval from 10 randomly selected plants from each block. Sucking pests such as aphids, jassids (nymphs), thrips and whiteflies (both nymphs and adults) were recorded from three leaves, each one from top, middle and bottom canopies of the plant. The assessment of infestation of mealy bug was carried out based on presence or absence of mealy bugs and the severity using zero to four scale of infestation viz., 0 - No mealy bug; 1 - Scattered appearance of few mealy bugs on the plant; 2 – Severe incidence of mealy bug on any one branch of the plant; 3 - Severe incidence of mealy bug on more than one branch or half portion of the plant and 4 - Severe incidence of mealy bug on the whole plant was recorded (Source: NCIPM, New Delhi). Aphid incidence was also observed on presence or absence per plant. While the American bollworm per cent square damage was recorded from whole plant. The incidence of pink bollworm larvae was observed through destructive sampling of 20 randomly collected green bolls from each block and per cent damage in green bolls were recorded. The data was also compared with other Bt hybrids, non-bt hybrids as well as with popular cotton hybrid, DCH-32. The pheromone traps were employed to monitor and record the moth population of boll worms including tobacco caterpillar. Data on weather parameters were obtained from the Meteorological unit at ARS, Banswara. The relationship between weather parameters and sucking pests and pheromone trap catches of male adults of bollworms was established by using simple correlation co-efficient and regression analysis.

RESULTS AND DISCUSSION

Population dynamics of sucking pests and bollworms in Bt cotton

Weekly population of each insect was recorded and presented graphically in Fig. 1.

Jassids

The incidence of Jassids was observed throughout the crop season. The population was ranged from 6.6 to 22.2 /3 leaves. The maximum population was observed during the standard weeks of 34-37. Jassid's highest population (13.80/3 leaves) was observed during 39th and 40th standard week in Bt cotton as reported by Bhute *et al* (2012). Similarly Krishna Reddy *et al* (2011) observed the peak incidence was observed from the second fortnight of October to first fortnight of November in 2009-10 (10.11 to 10.82/leaf) and in the season of 2010-11, the peak incidence was noticed in mid September to first fortnight of October (6.02 to 5.48/leaf). This may be due to climatic differences in different regions of the country. The results revealed that the maximum temperature, morning relative humidity and rainy days were significant and positively correlated with the leafhopper population. Other weather factors were positively correlated except sunshine hours which showed negatively correlated with the population of jassids but with non significant effect. Murugan and Utamasamy (2011) reported that meteorological parameters play an important role in the population fluctuations in sucking pests. The present findings are inline with the findings of Bhute *et al* (2012) & Shivanna *et al* (2011) who reported maximum temperature showed significant positive correlation with jassids and the other factors like rainfall is negatively correlated whereas minimum temperature and relative humidity were showed non significant effect.

Whitefly

Whitefly population was ranged from 3.9 to 42.0/3 leaves. The unusual appearance of whitefly population was observed on Bt cotton during the crop season. The maximum population was observed during the standard weeks of 37-39 where cloudy conditions prevailed during this period contributes the increased in population of whitefly. Whereas, Bhute *et al*. (2012) reported incidence of whitefly (52.75-63.00/3 leaves) during 45th standard week. Jeyakumar *et al* (2008) reported higher incidence of whitefly in Bt cotton hybrids. Rainy days and morning relative humidity was the main significant contributing factor for the maximum occurrence of whitefly in Bt cotton with the correlated r value of 0.538 and 0.416, respectively (P = 0.05). This contradictory the results of Bhute *et al*. (2012) who reported whitefly population did not show significant effect with relative humidity. Rainy days showed significant and negative correlation with whitefly population

Thrips

Among the sucking pests, thrips population was in higher side and population was ranged from 0.0 to 87.0 /3 leaves and this was observed during the standard weeks of 39-41. This high incidence was conformity with the results of Bhute *et al*. (2012) who observed highest incidence of 110.10 thrips/ 3 leaves in 40th standard week in Bt cotton. Saif-ur-Rehman *et al*. (2013) observed that Bt cotton cultivars had higher level of thrips population compared to non Bt cultivars. The main contributing weather factor for the incidence of thrips in Bt

Table 1: Correlation co-efficient between sucking pests, moth populations of bollworms and weather parameters during 2011 on Bt cotton

Parameters	Jassids	Thrips	Whitefly	Spotted bollworm	Pink bollworm	*Spodoptera litura*
Maxi.Temp.(°C)	-0.523**	-0.613**	-0.165	0.471*	-0.206	-0.086
Mini.Temp.(°C)	0.254	0.246	-0.002	-0.172	-0.662**	0.161
Mor. RH (%)	0.480**	0.355	0.416**	-0.277	-0.499	0.218
Eve. RH (%)	0.292	0.293	0.128	-0.304	-0.496	0.197
Rainfall(mm)	0.200	0.144	0.118	-0.211	-0.296	0.218
Rainy days	0.517**	0.425	0.538**	-0.339	-0.399	0.129
Windspeed(Km/hr)	0.283	0.475**	-0.017	-0.265	-0.279	-0.138
Sunshine(hrs)	-0.328	-0.344**	-0.12	0.431*	0.272	-0.160

*Significant at 1% **Significant at 5%

Table 2: Regression analysis between sucking pests and pheromone moth trap catches of boll worms and weather parameters during 2011 on Bt cotton

Parameters	Regression equation	R^2
Jassids (n = 24)	$Y = 5.657 + (-1.455^{**}) X_1 + (1.780^{**}) X_2 + (0.253^{**}) X_3 + (-0.052) X_4 + (0.004) X_5 + (-1.110) X_6 + (-0.861^{**}) X_7 + (0.416) X_8 + 2.703$	0.74**
Thrips(n = 24)	$Y = 110.525 + (-7.039^{**}) X_1 + (0.361) X_2 + (0.027) X_3 + (1.214) X_4 + (-0.025) X_5 + (1.328) X_6 + (3.027) X_7 + (8.349) X_8 + 17.035$	0.62*
Whitefly(n = 24)	$Y = -6.872 + (0.376) X_1 + (0.771) X_2 + (0.162) X_3 + (-0.246) X_4 + (-0.023) X_5 + (2.536) X_6 + (-1.053) X_7 + (-0.952) X_8 + 9.038$	0.43**
Spotted bollworm(n = 24)	$Y = -17.931 + (2.429) X_1 + (0.894) X_2 + (-1.739) X_3 + (1.008) X_4 + (0.023) X_5 + (-0.612) X_6 + (-1.345) X_7 + (3.689) X_8 + 11.221$	0.44**
Pink bollworm(n = 24)	$Y = 797.761 + (-14.830) X_1 + (0.256) X_2 + (-2.712) X_3 + (-1.618) X_4 + (0.102) X_5 + (3.671) X_6 + (-0.075) X_7 + (-0.736) X_8 + 16.410$	0.84**
Tobacco caterpillar(n = 24)	$Y = 123.913 + (20.683) X_1 + (3.693) X_2 + (-4.226) X_3 + (2.775) X_4 + (0.193) X_5 + (-48.059) X_6 + (-36.748) X_7 + (-50.862^{**}) X_8 + 104.433$	0.37**

*Significant at 1% **Significant at 5% X_1 = Maximum temperature (°C) X_2 = Minimum temperature (°C) X_3 = Morning relative humidity (%) X_4 = Evening relative humidity (%) X_5 = Rainfall (mm) X_6 = Rainy days X_7 = Wind speed (Km/hr) X_8 = Sunshine hours + SE

Table 3: Per cent green boll damage by bollworm complex on different cotton hybrids

Parameters	DCH-32	H-8	RCH-NBt	RCH-Bt	NCS-138	Jassi Bt
% larval population(pink bollworm)	16.24	2.50	10.00	7.50	12.78	0.50
% Seed/green boll damage(bollworm complex)	29.62	2.50	10.00	5.50	25.87	3.50

cotton was maximum temperature, wind speed and sunshine hours. Correlation studies revealed that the thrips population was positively correlated with all the weather factors but non-significant and significant negative correlation was observed with the maximum temperature and sunshine hours. It contradicted the observation of Bhute *et al*. (2012) who showed positive correlation with the maximum temperature. Venilla *et al*. (2007 a and b) reported the severity of sucking pests and also reported Thrips has population peaks during dry spell with high temperature and low humidity.

Mealy bug and aphids

The peak incidence of mealy bug was observed during 42nd standard week and continued upto 50th standard week during 2011. The dry condition prevailed during this standard weeks contributed to the higher incidence of mealy bug population during the season. Mealy bug grade was ranged from 1.0 to 4. The present studies revealed that the mealy bug population was increased with the increase in maximum temperature and sunshine hours. Similarly, dry condition prevailed during the standard weeks of 45-48th onwards, contributes to the higher incidence of aphid population in Bt cotton. On an average 180-200 nymphs and adults per leaf were observed (data not shown). Similarly, Bhute *et al*. (2012), observed the higher incidence of aphid population in the range of 75.40-86.45 aphids/3 leaves during 35 and 37th standard week, respectively. While mealy bug's highest incidence (42.40 mealy bugs/2.5cm shoot length) was observed in 49 to 51st standard week 49th MW. They also correlated the rainfall, rainy days, morning RH and evening RH showed significant and negative correlation with aphids. Weather parameters showed significantly negative correlation with the infestation of mealy bugs except maximum and minimum temperatures.

Bollworms

The pheromone catches of spotted bollworm indicated that the maximum peak population was observed during the 41st standard week. The larval population was observed in the green bolls. Moth population of *Spodoptera litura* noticed throughout the season while no moth catches of American bollworm with nil larvae population on Bt cotton was recorded (Fig. 2). The peaks of moth catches of *Spodoptera* were recorded during 38-43rd standard week which however, did not correlated with larval population in the field. This may be due to polyphagous nature of the *S. litura*. Contrarily, on the other hand the peaks of moth populations of pink bollworm were recorded during 41-52nd standard week with corresponding with larval population in field. Surprisingly, there was a total disappearance of American bollworm in the zone whereas there were traces of spotted bollworm larvae were recorded. Correlation studies revealed that the maximum temperature and sunshine hours were significant and positively correlated with the male moth catches of spotted bollworm. Whereas, minimum temperature was the main contributing factor for the pheromone trap catches of pink bollworm male moths. There is an indication of increasing in population of male moth catches and larvae of pink bollworm. In Bt cotton there was a comparable larval population of pink bollworm was noticed. The larval and seed damage percentage by bollworms on different hybrids was shown in Table 3. Shitole *et al*. (2011) observed square and green boll damage in different Bt hybrids. In regional meeting, scientists have reported the incidence of pink bollworm in different Bt hybrids (https://www.icac.org/tis/regional_networks).

Regression studies

Based on regression analysis (Table 2) by taking sucking pest population and male moth catches of bollworms and tobacco caterpillar (y) as a dependent variable and weather parameters (x) as independent variables following equations were fitted for the year 2011. The regression equation indicated that an increase in 1ºC of maximum temperature decreased the jassids population by 1.455 per three leaves per week similarly, increase in 1 km/hr of wind speed reduced the jassid population by 0.861 per three leaves per week whereas increase in 1ºC of minimum temperature and increase of 1% morning relative humidity contributes to the increase in jassids population by 1.780 and 0.253 per three leaves per week,

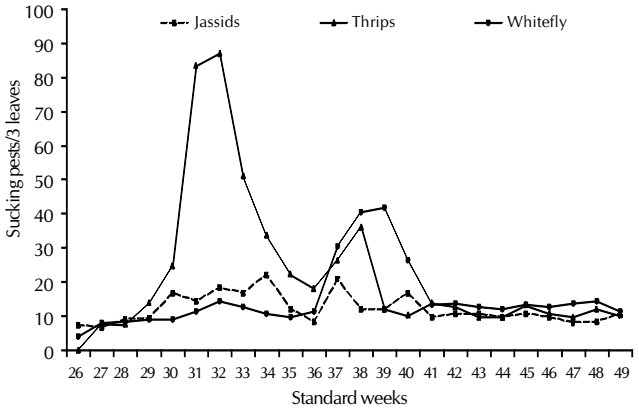

Figure 1: Population dynamics of sucking pests on Bt cotton

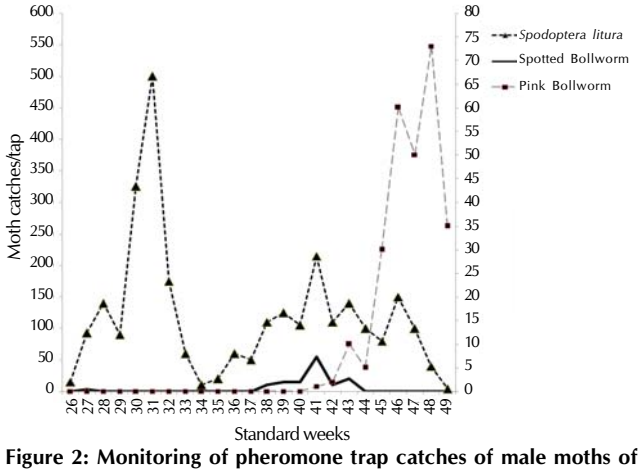

Figure 2: Monitoring of pheromone trap catches of male moths of Spotted Bollworm, Pink Bollworm and *Spodoptera litura* on Bt cotton

respectively. Increase in 1ºC maximum temperature resulted in decrease in thrips population by 7.039 per three leaves per week. During 2011, due to increase in wind speed of 1 km/h highly reduced the male moth catches of *S .litura* by almost 50.862 per trap per week. The multiple regression equations were developed for predicting the sucking pests and boll worms of Bt cotton by using regression models. By using regression models and the coefficients of determination (R^2) indicated that the sucking pests *viz*., jassids, thrips, white fly were predicated to an extent of 74, 62 and 43 per cent, respectively. While, the prediction rate of populations of male moth catches of spotted bollworm, pink bollworm and tobacco caterpillar were 44%, 84% and 37%, respectively during 2011. The correlation and regression analysis clearly showed the importance of weather factors in predicting the pest incidence in Bt cotton.

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