

## Effect of abiotic factors on population dynamics of pink bollworm in relation to genetically modified cotton

DEEPIKA KALKAL, ROSHAN LAL\*, K.K. DAHIYA, B. L. JAT AND ANKIT KUMAR

Department of Entomology, CCS, Haryana Agricultural University, Hisar-125 004

\*E-mail : roshanhau@yahoo.co.in

**ABSTRACT :** Studies were conducted at CCS Haryana Agricultural University, Hisar during *khari*, 2008 and 2009 for population dynamics of pink bollworm in relation to genetically modified cotton. Nineteen genotypes comprising 17 *Bt* hybrids, 1 conventional hybrid and 1 variety were evaluated for their reaction to pink bollworm. Maximum infestation of green bolls was recorded in genotype VBCH 1006 *Bt*, 3.25, 3.75 and 5.00 per cent at 80, 110 and 140 DAS, respectively. Non *Bt* variety of cotton H 1226 had 9.37, 27.82 and 30.72 per cent infestation of green bolls at this stage during 2008. Maximum open boll infestation was recorded in H 1226, 22.93 and 24.59 per cent in 2008 and 2009, respectively on boll basis and 9.66 per cent in 2008 and 10.1 per cent in 2009 on locule basis. Pink bollworm population was significantly negative correlation with temp, relative humidity and rainfall while positive correlation with sunshine h. The *Bt* genotypes had not consistent results against *P. gossypiella* and after comparing the infestation only two genotypes ANKUR JASSI BG II and NCS-145 *Bt* 2 performed better.

**Key words :** Abiotic factors, *Bt* cotton, correlation coefficient, pink bollworms, population dynamics

Cotton is grown principally for the fibre for clothes and seed as feed as well as oils for the animals. Among the vast array of insect pests, bollworms [American bollworm, *Helicoverpa armigera* (Hubner); pink bollworm, *Pectinophora gossypiella* (Saunders) and spotted bollworms, *Earias insulana* Boisduval and *E. vittella* (Fabricius)] not only cause tremendous reduction in yield but adversely affect the quality of lint and seed. Recently a novel method for the management of lepidopterans is the use of *Bt* Cry toxin obtained from soil bacterium, *Bacillus thuringiensis* (*Bt*). Since the release of *Bt* cotton hybrids has been able to reduce the use of chemical insecticides, thereby lowering the risks pertaining to environment hazards, human health and production costs.

The introduction of *Bt* cotton in India proved useful in the management of the bollworm, *H. armigera* with reduced dependence on pesticides. Cui and Xia (2000) studied the effect of *Bt* transgenic cotton on population dynamics of the major pests and their natural enemies in the field. Mohapatra (2004) studied the incidence of 3 species of lepidopteran bollworm *i.e.* *E. vittella* (Fab.), *H. armigera* (Hubner) and *P. gossypiella* (Saunders). The pink bollworm appeared at the end of crop season in November and continued upto January with peak in second week of January.

### MATERIALS AND METHODS

The studies were carried out under field conditions at CCSHAU, Hisar on 19 genotypes comprising 17 *Bt* hybrids, one conventional hybrid HHH223 and 1 variety H1266 namely; Conventional hybrid HHH 223 (LC), Variety H 1226 (LC). *Bt* Genotypes, KDCHH 9810 BG I, KDCHH 441 BG II, TULSI 45 BG II, MRC 7031 BG II, MRC 6301 *Bt*, RCH 134 BG II, RCH 134 *Bt*, VBCH 1504 BG II, VBCH 1501 BG II, VBCH 1006 *Bt*, SIGMA *Bt*, ANKUR 2534 *Bt*, ANKUR JASSI BG II, NCS 145 *Bt* 2, NCS 913 *Bt*, NCEH 6 *Bt*, and IT 905 *Bt*. The seeds were dibbled with line to line spacing of 67.5 cm and plant to plant at 60 cm in case of hybrids and 30 cm in case of the variety. Two to three seeds of respective genotypes were sown at a depth of 3-4 cm in each hill in the well prepared soil. Sowing was done on 25<sup>th</sup> May, 2008 and 15<sup>th</sup> May, 2009 in a randomized block design in 3 replications in a plot size of 24.3 m<sup>2</sup> each. Thinning of the crop was done one month after sowing. The observations were recorded at weekly intervals. The observations on Pink bollworm infestation in green fruiting bodies (buds, flowers, squares and bolls) was started from August for both the years of study. Population and damage in open bolls and loculi was taken at the time of maturity. For pink bollworm infestation, 50 unopened green bolls were plucked from each

plot randomly at 80, 110 and 140 DAS. Boll infestation was recorded in open bolls on boll and locule basis from randomly selected 5 plants / treatment and all bolls and their loculi were examined critically for pink bollworm infestation. The per cent infestation was calculated with the following formula: -

$$\text{Per cent boll infestation} = \frac{\text{Bolls infested}}{\text{Total bolls}} \times 100$$

$$\text{Per cent locule infestation} = \frac{\text{Infested loculi}}{\text{Total loculi}} \times 100$$

## RESULTS AND DISCUSSION

**Pink bollworm infestation:** Data presented on green boll basis in Table 1 indicated that there was no infestation of pink bollworm in KDCHH 9810 *Bt*, KDCHH 441 BG II, MRC 7031 BG II, RCH 134 BG II, VBCH 1501 BG II, ANKUR JASSI BG II, NCS 145 *Bt* 2, and IT 905 and non *Bt* hybrid HHH 223 at 80 DAS. All the *Bt* genotypes and non *Bt* hybrid HHH 223 were significantly superior over the variety H1226 (27.82%) at 110 DAS. Maximum infestation of pink bollworm was recorded in *Bt* hybrid VBCH 1006 *Bt* (5.00%) at 140 DAS and it was statistically *on par* with HHH 223. These were followed by RCH 134 *Bt* and NCEH 6 *Bt*. The genotypes KDCHH 441 BG II, MRC 7031 BG II, RCH 134 BG II, VBCH 1501 BG II, ANKUR JASSI BG II and NCS 145 *Bt* 2 could protect the cotton bolls from pink bollworm infestation upto 140 DAS. High infestation of *P. gossypiella* was recorded in local variety H 1226 (30.72%) at this stage. Similar results were observed on locule basis and minimum incidence of pink bollworm was recorded in *Bt* genotypes *viz.*, KDCHH 9810 BG I, KDCHH 441 BG II, MRC 7031 BG II, RCH 134 BG II, VBCH 1501 BG II, ANKUR JASSI BG II, NCS 145 *Bt* 2 at 140 DAS.

Data presented on green boll basis in Table 2 (2<sup>nd</sup> crop season) revealed that there was no pink bollworm infestation in TULSI 45 BG II, MRC 6301 *Bt*, VBCH 1501 BG II, VBCH 1504 BG II, SIGMA *Bt*, ANKUR JASSI BG II, NCS 913 *Bt* and NCS 145 *Bt* 2, IT 905 *Bt* and hybrid HHH 223 at 80 DAS. Infestation varied from 0.33 to 1.46 per cent in genotypes KDCHH 9810 BG I, KDCHH 441 BG II, MRC 7031 BG II, RCH 134 BG II, VBCH 1504 BG II, VBCH 1006 *Bt* and NCEH 6 *Bt*. All the

*Bt* genotypes and the hybrid HHH 223 were significantly superior over non *Bt* variety H 1226 (25.65%) at 110 DAS. The infestation of pink bollworm varied from 0.20 to 2.32 per cent. The genotypes KDCHH 9810 BG I could not be protected from *P. gossypiella* infestation. Observations recorded at 140 DAS, the genotypes TULSI 45 BG II, MRC 6301 *Bt*, VBCH 1501 BG II, VBCH 1504 BG II, SIGMA *Bt*, ANKUR JASSI BG II, NCS 913 *Bt* and NCS 145 *Bt* 2, NCS 913 *Bt* and IT 905 *Bt* were free from pink bollworm infestation. Similar results were recorded on locule basis and no incidence of pink bollworm was recorded in *Bt* genotypes *viz.*, TULSI 45 BG II, MRC 6301 *Bt*, VBCH 1501 BG II, VBCH 1504 BG II, SIGMA *Bt*, ANKUR JASSI BG II, NCS 913 *Bt* and NCS 145 *Bt* 2, NCS 913 *Bt*.

The results of the present study indicated that infestation of pink bollworm was less among *Bt* genotypes during both the crop season. The infestation of pink bollworm was in increasing order in genotypes TULSI 45 BG II, RCH 134 *Bt*, VBCH 1006 *Bt*, NCEH 6 *Bt*, KDCHH 9810 BG I, KDCHH 441 BG II, MRC 7031 BG II, from 80 DAS to 140 DAS. The infestation of pink bollworm persisted upto harvesting stage.

**Larval population of pink bollworm:** The larval population of pink bollworm recorded at 80, 110 and 140 DAS from *Bt* and non *Bt* genotypes. During 2008, larval population varied from 0.0 to 0.11 larvae/green boll at 80 DAS in *Bt* genotypes (Table 3). At 110 DAS, the genotypes KDCHH 9810 BG I, KDCHH 441 BG II, MRC 7031 BG II, RCH 134 *Bt*, VBCH 1504 BG II, VBCH 1501 BG II, SIGMA *Bt*, ANKUR 2534 *Bt*, ANKUR JASSI BG II, NCS 145 *Bt* 2 were free from larval population of pink bollworm. Among *Bt* genotypes, maximum larval population was recorded on genotypes TULSI 45 BG II (0.22 1/green boll) and it was statistically *on par* with H 1226 and VBCH 1006 *Bt*. At 140 DAS, *Bt* genotypes KDCHH 441 BG II, MRC 7031 BG II, RCH 134 *Bt*, VBCH 1504 BG II, VBCH 1501 BG II, ANKUR JASSI BG II, NCS 145 *Bt* 2 were free from larval population of pink bollworm. During 2009, TULSI 45 BG II, MRC 7031 BG II, RCH 134 *Bt*, VBCH 1504 BG II, VBCH 1501 BG II, SIGMA *Bt*, ANKUR 2534 *Bt*, ANKUR JASSI BG II, NCS 145 *Bt* 2, RCH 134 *Bt*, VBCH 1006 *Bt*, NCEH 6 *Bt*, KDCHH 9810 BG I, KDCHH 441 BG II, MRC 7031 BG II, were free from larval population of

**Table 1.** Pink Bollworm (*Pectinophora gossypiella*) infestation in *Bt* and non *Bt* genotypes of cotton during 2008 crop season

Genotypes	Mean per cent bollworm infestation (n=50)													
	Boll basis						Mean	locule basis						Mean
	80 days		110 days		140 days			80 days		110 days		140 days		
KDCHH 9810 BG I	0.00	(1.81)	0.00	(1.81)	0.67	(4.69)	<b>0.22</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
KDCHH 441 BG II	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
TULSI 45 BG II	0.30	(3.63)	1.46	(6.93)	2.60	(9.24)	<b>1.45</b>	0.00	(1.81)	0.00	(1.81)	0.30	(3.14)	<b>0.10</b>
MRC 7031 BG II	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
MRC 6301 <i>Bt</i>	1.15	(6.05)	0.66	(4.64)	1.49	(7.01)	<b>1.10</b>	0.00	(1.81)	0.30	(2.53)	1.10	(6.01)	<b>0.47</b>
RCH 134 BG II	0.00	(1.81)	0.00	(1.81)	1.69	(7.44)	<b>0.56</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
RCH 134 <i>Bt</i>	1.43	(6.80)	2.62	(9.26)	4.11	(11.70)	<b>2.72</b>	0.00	(1.81)	1.10	(6.01)	1.45	(6.92)	<b>0.85</b>
VBCH 1504 BG II	1.88	(1.81)	0.00	(1.81)	2.00	(8.13)	<b>1.29</b>	0.00	(1.81)	0.00	(1.81)	1.83	(7.76)	<b>0.61</b>
VBCH 1501 BG II	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
VBCH 1006 <i>Bt</i>	3.25	(9.97)	3.75	(11.16)	5.00	(12.91)	<b>4.00</b>	1.00	(5.74)	2.10	(8.33)	3.26	(10.40)	<b>2.12</b>
SIGMA <i>Bt</i>	0.75	(5.13)	0.00	(1.81)	2.00	(8.13)	<b>0.92</b>	0.00	(1.81)	0.00	(1.81)	0.75	(4.95)	<b>0.25</b>
ANKUR 2534 <i>Bt</i>	<b>0.05</b>	<b>(2.22)</b>	0.00	(1.81)	0.67	(4.69)	<b>0.24</b>	0.00	(1.81)	0.00	(1.81)	<b>0.10</b>	<b>(1.05)</b>	<b>0.03</b>
ANKUR JASSI BG II	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
NCS 145 <i>Bt</i> 2	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
NCS 913 <i>Bt</i>	2.19	(8.53)	1.69	(7.44)	3.00	(9.97)	<b>2.29</b>	0.00	(1.81)	1.83	(7.76)	2.23	(8.58)	<b>1.35</b>
NCEH 6 <i>Bt</i>	1.43	(7.44)	2.87	(9.74)	3.88	(11.36)	<b>2.73</b>	0.33	(2.65)	1.17	(6.19)	1.45	(6.92)	<b>0.98</b>
IT 905 <i>Bt</i>	0.00	(1.81)	0.67	(4.69)	1.69	(7.44)	<b>0.79</b>	0.00	(1.81)	0.00	(1.81)	0.75	(4.95)	<b>0.25</b>
HHH 223 (LC)	0.00	(1.81)	1.25	(6.42)	4.67	(12.47)	<b>1.97</b>	0.00	(1.81)	0.00	(1.81)	2.87	(9.74)	<b>0.96</b>
H 1226 (LC)	9.37	(17.82)	27.82	(31.82)	<b>30.72</b>	<b>(33.64)</b>	<b>22.63</b>	2.99	(9.96)	13.82	(21.82)	<b>15.25</b>	<b>(22.98)</b>	<b>10.69</b>
P=0.05	(0.27)	(0.54)	(0.55)		(0.92)	(0.88)	<b>(0.76)</b>							

Figures in parentheses are angular transformed values

**Table 2.** Pink Bollworm (*Pectinophora gossypiella*) infestation in *Bt* and non *Bt* genotypes of cotton during 2009 crop season

Genotypes	Mean per cent bollworm infestation (n=50)													
	Boll basis						Mean	locule basis						
	80 days		110 days		140 days			80 days		110 days		140 days		Mean
KDCHH 9810 BG I	0.00	(1.81)	0.66	(4.56)	2.87	(9.74)	<b>1.18</b>	0.00	(1.81)	0.00	(1.81)	1.10	(6.01)	
KDCHH 441 BG II	1.46	(6.93)	2.32	(8.76)	4.11	(11.70)	<b>2.63</b>	0.00	(1.81)	0.33	(2.65)	2.23	(8.58)	<b>0.85</b>
TULSI 45 BG II	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
MRC 7031 BG II	<b>0.33</b>	<b>(2.65)</b>	1.11	(6.05)	3.00	(9.97)	<b>1.48</b>	0.00	(1.81)	0.67	(4.69)	1.17	(6.19)	<b>0.61</b>
MRC 6301 <i>Bt</i>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
RCH 134 BG II	0.00	(1.81)	0.00	(1.81)	1.22	(6.33)	<b>0.41</b>	0.00	(1.81)	0.00	(1.81)	0.30	(3.14)	<b>0.10</b>
RCH 134 <i>Bt</i>	1.00	(5.74)	1.49	(7.01)	4.00	(11.53)	<b>2.16</b>	0.33	(2.65)	1.17	(6.19)	2.10	(8.33)	<b>1.20</b>
VBCH 1504 BG II	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
VBCH 1501 BG II	0.00	(1.81)	0.00	(1.81)	1.00	(5.74)	<b>0.33</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
VBCH 1006 <i>Bt</i>	1.25	(6.42)	2.00	(8.13)	5.00	(12.91)	<b>2.75</b>	0.93	(5.53)	1.40	(5.56)	3.26	(10.40)	<b>1.86</b>
SIGMA <i>Bt</i>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
ANKUR 2534 <i>Bt</i>	0.00	(1.81)	0.00	(1.81)	1.00	(5.75)	<b>0.33</b>	0.00	(1.81)	0.00	(1.81)	0.74	(4.92)	<b>0.25</b>
ANKUR JASSI BG II	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
NCS 145 <i>Bt</i> 2	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
NCS 913 <i>Bt</i>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>	0.00	(1.81)	0.00	(1.81)	0.00	(1.81)	<b>0.00</b>
NCEH 6 <i>Bt</i>	0.67	(4.69)	1.30	(6.54)	2.88	(9.76)	<b>1.62</b>	<b>0.22</b>	<b>(1.55)</b>	1.54	(7.12)	1.48	(6.98)	<b>1.08</b>
IT 905 <i>Bt</i>	0.00	(1.81)	0.00	0.00	1.22	(6.33)	<b>0.41</b>	0.00	(1.81)	1.00	(5.75)	0.76	(5.01)	<b>0.59</b>
HHH-223 (LC)	0.00	(1.81)	0.20	(2.53)	3.88	(11.36)	<b>1.36</b>	0.00	(1.81)	1.83	(7.76)	1.83	(7.76)	<b>1.22</b>
H 1226 (LC)	9.14	(17.59)	25.65	(30.42)	<b>31.03</b>	<b>(33.84)</b>	<b>21.94</b>	2.86	(9.74)	14.04	(22.00)	<b>15.36</b>	<b>(23.07)</b>	<b>10.76</b>
<b>Mean</b>	<b>0.73</b>	<b>1.83</b>	<b>3.22</b>	<b>1.93</b>	<b>0.23</b>	<b>1.16</b>	<b>1.60</b>	<b>0.99</b>						
P=0.05	(0.93)	(0.49)	(0.38)		(1.35)	(2.00)	<b>(0.26)</b>							

Figures in parentheses are angular transformed values

**Table 3.** Pink bollworm (*Pectinophora gossypiella*) population in *Bt* and non *Bt* genotypes of cotton during 2008 and 2009 crop seasons

Genotypes	No. of larvae/green boll (n=50)													
	Crop Season 2008						Yield (q/ha)	Crop Season 2009						Yield (q/ha)
	80 days		110 days		140 days			80 days		110 days		140 days		
KDCHH 9810 BG I	0.00	(1.81)	0.66	(4.56)	2.87	(9.74)	1.18	0.00	(1.81)	0.00	(1.81)	1.10	(6.01)	0.37
KDCHH 9810 BG I	0.00	11.39	0.00	(1.00)	0.01	(1.00)	11.68	0.00	(1.00)	0.01	(1.00)	0.11	(1.05)	10.77
KDCHH 441 BG II	0.00	13.61	0.00	(1.00)	0.00	(1.00)	11.39	0.01	(1.00)	0.11	(1.05)	0.18	(1.09)	10.62
TULSI 45 BG II	0.00	<b>14.10</b>	0.22	(1.11)	0.05	(1.02)	13.61	0.00	(1.00)	0.00	(1.00)	0.00	(1.00)	<b>13.48</b>
MRC 7031 BG II	0.00	12.54	0.00	(1.00)	0.00	(1.00)	<b>14.10</b>	0.00	(1.00)	0.06	(1.03)	0.15	(1.07)	10.72
MRC 6301 <i>Bt</i>	0.00	11.69	0.01	(1.00)	0.08	(1.04)	12.54	0.00	(1.00)	0.00	(1.00)	0.00	(1.00)	11.36
RCH 134 BG II	0.00	11.17	0.00	(1.00)	0.06	(1.03)	11.69	0.00	(1.00)	0.00	(1.00)	0.10	(1.05)	11.72
RCH 134 <i>Bt</i>	0.00	<b>20.06</b>	0.05	(1.02)	0.20	(1.10)	11.17	0.05	(1.02)	0.08	(1.04)	0.17	(1.08)	10.83
VBCH 1504 BG II	0.00	<b>14.26</b>	0.00	(1.00)	0.18	(1.09)	<b>20.06</b>	0.00	(1.00)	0.00	(1.00)	0.00	(1.00)	10.99
VBCH 1501 BG II	0.00	11.47	0.00	(1.00)	0.00	(1.00)	<b>14.26</b>	0.00	(1.00)	0.00	(1.00)	0.08	(1.04)	11.02
VBCH 1006 <i>Bt</i>	0.01	11.75	0.17	(1.08)	0.20	(1.10)	11.47	0.08	(1.04)	0.10	(1.05)	0.18	(1.09)	11.38
SIGMA <i>Bt</i>	0.00	13.62	0.00	(1.00)	0.17	(1.08)	11.75	0.00	(1.00)	0.00	(1.00)	0.00	(1.00)	<b>12.87</b>
ANKUR 2534 <i>Bt</i>	0.00	13.95	0.00	(1.00)	0.06	(1.03)	13.62	0.00	(1.00)	0.00	(1.00)	0.08	(1.04)	11.53
ANKUR JASSI BG II	0.00	11.79	0.00	(1.00)	0.00	(1.00)	13.95	0.00	(1.00)	0.00	(1.00)	0.00	(1.00)	12.79
NCS 145 <i>Bt</i> 2	0.00	11.56	0.00	(1.00)	0.00	(1.00)	11.79	0.00	(1.00)	0.00	(1.00)	0.00	(1.00)	11.62
NCS 913 <i>Bt</i>	0.00	11.54	0.08	(1.04)	0.10	(1.05)	11.56	0.00	(1.00)	0.00	(1.00)	0.00	(1.00)	11.55
NCEH 6 <i>Bt</i>	0.11	13.57	0.11	(1.05)	0.15	(1.07)	11.54	0.10	(1.05)	0.10	(1.05)	0.11	(1.05)	11.22
IT 905 <i>Bt</i>	0.00	11.09	0.01	(1.00)	0.07	(1.03)	13.57	0.00	(1.00)	0.00	(1.00)	0.10	(1.05)	<b>13.14</b>
HHH 223 (LC)	0.00	9.55	0.10	(1.05)	0.17	(1.08)	11.09	0.00	(1.00)	0.01	(1.01)	0.16	(1.08)	11.17
H 1226 (LC)	0.12	12.65	0.18	(1.09)	0.22	(1.11)	9.55	0.08	(1.04)	0.20	(1.10)	0.21	(1.10)	9.37
<b>Mean</b>	<b>0.01</b>	<b>(0.30)</b>	<b>0.09</b>	<b>12.65</b>	<b>0.02</b>	<b>0.04</b>	<b>12.65</b>	<b>11.48</b>						
P=0.05	(0.01)	(0.02)	(0.03)	(0.30)	(0.01)	(0.01)	(0.30)	(0.43)						

Figures in parentheses are  $n+1$  transformation

pink bollworm at 80,110 and 140 DAS. At 140 DAS, maximum larval population was recorded on H1226 (0.21 l/green boll) and it was statistically on par with KDCHH 441 BG II, VBCH 1006 *Bt*. Similarly, Vennila *et al.* (2004) and Kumar and Stanley (2006) reported that *Bt* hybrids suffered significantly lower damage than their non *Bt* counterparts providing the overall efficacy of *Bt* cotton hybrids against bollworms including pink bollworm.

**Abiotic factors:** Pink bollworm population significantly negatively correlated with temp ( $r = -0.92$  in 2008,  $r = -0.65$  in 2009 and  $r = -0.83$  in pooled data), relative humidity ( $r = -0.97$  in 2008 and  $r = -0.86$  in pooled data), rainfall ( $r = -0.74$  in 2008,  $r = -0.28$  in 2009 and  $r = -0.93$  pooled data), wind speed ( $r = -0.99$  in 2008 and  $r = -0.79$  in pooled data) and significantly positively correlated with sunshine h ( $r = 0.69$  in 2008,  $r = 0.98$  in 2009 and  $r = 0.52$  in pooled data) (Table 4). The results of present findings are in agreement with Dhaka and Pareek (2008) who reported that minimum temp and relative humidity were negatively correlated with pink bollworm incidence.

**Yield of seed cotton :** Observations recorded during 2008 (1<sup>st</sup> crop season), amongst genotypes revealed that maximum yield was in VBCH 1504 BG II (20.06 q/ha) followed by VBCH 1501 BG II (14.26 q/ha) and MRC 7031 BG II (14.10 q/ha). Minimum yield was realized from H 1226 (9.55 q/ha) (Table 3). Whereas during 2009 (2<sup>nd</sup> crop season), maximum yield was recorded in TULSI 45 BG II (13.48 q/ha) followed by IT 905 *Bt* (13.14 q/ha) and SIGMA *Bt* (12.87 q/ha). Minimum yield was realized from H 1226 (9.37 q/ha). *Bt* genotypes were significantly superior over non *Bt* genotypes in yield during both crop seasons.

The results of the present study indicated that *Bt* genotypes were significantly superior over non-*Bt* genotypes in yield during both crop seasons. These observations are supported by Qaim and Zilberman (2003) reported significantly higher seed cotton yield of *Bt* genotypes.

**Table 4.** Correlation coefficient (r) of pink bollworm incidence with abiotic factors

Weather parameters	Pink bollworm		
	2008	2009	Pooled
Temp (°C)			
Maximum	+0.97**	-0.60**	<b>-0.40**</b>
Minimum	-1.00**	-0.71**	<b>-0.92**</b>
<b>Average</b>	<b>-0.92**</b>	<b>-0.65**</b>	<b>-0.83**</b>
Relative humidity (%)			
Morning	-1.00**	+0.44**	<b>+0.12</b>
Evening	-0.96**	-0.25	<b>-0.99**</b>
<b>Average</b>	<b>-0.97**</b>	<b>+0.11</b>	<b>-0.86**</b>
Other factors			
Rainfall (mm)	-0.74**	-0.28*	<b>-0.93**</b>
Sunshine (h)	+0.69**	+0.98**	<b>+0.52**</b>
Wind speed(Km/h)	-0.99**	+0.57**	<b>-0.79**</b>

\*Significant at 5 per cent \*\*Significant at 1 per cent

## REFERENCES

- Cui, J. J. and Xia, J. Y. 2000.** Effects of *Bt* (*Bacillus thuringiensis*) transgenic cotton on the dynamics of pest population and their enemies. *Acta Phyto. Sinica* **27**: 141-45.
- Dhaka, S. R. and Pareek, B. L. 2008.** Weather factors influencing population dynamics of major insect pests of cotton under semi arid agro-ecosystem. *Indian J. Entomol.* **70**: 157-63.
- Kumar, K. R. and Stanley, S. 2006.** Comparative Efficacy of Transgenic *Bt* and Non- transgenic Cotton against Insect pest of cotton in Tamil Nadu, India. *Resistant pest manag. newsl.* **15**: 38-43.
- Mohapatra, L. N. 2004.** Relative abundance of different bollworm species in relation to growth stages of cotton. *J. Cotton Res. Dev.* **18**: 227-28.
- Qaim, M. and Zilberman, D. 2003.** Yield effects of genetically modified crops in developing countries. *Science* **299**: 900-02.
- Vennila, S., Biradar, V. K., Gadpayle, G., Panchbhai, P. R., Ramteke, M. S., Deole, S. A. and Karanjkar, P. P. 2004.** Field evaluation of *Bt* transgenic cotton hybrids against sucking pests and bollworms. *Indian J. Plant Prot.* **32** : 1-10.

Received for publication : June 4, 2013

Accepted for publication : December 9, 2013