

Survival and development of Pink Bollworm *P. Gossypiella* on Different *Bt* cotton Hybrids

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Abstract

This study was done at the Post Graduate Laboratory, Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra-India during 2018-19. The bioassay was conducted on *Bt* cotton plant parts i.e., squares and bolls by using different larval instars of *P. gossypiella* by feeding them on squares and bolls of six *Bt* cotton hybrids (AJEET-155, BHAKTI NCS-245, JAY, YUVA 7215-2, RCH-2, Dr. BRENT MRC-7347) and one non-*Bt* cotton hybrid (NHH-44) as a control. Results of bio assay studies revealed that the mortality of early larval instars of *P. gossypiella* fed on squares and bolls of different *Bt* cotton hybrids was higher than the later instars. Exposure of later instar larvae to different plant parts of different *Bt* cotton hybrids also exhibited adverse effects on the growth and development such as reduced larval weights, prolonged larval developmental period, reduced pupation, formation of small pupae with less weight, reduction in adult emergence with low growth and survival indices for *P. gossypiella*. The growth and survival index values were low for the larvae reared on squares compared to bolls of different *Bt* cotton hybrids.

Key words: Transgenic cotton, Pink bollworm, Survival and development, Genotype

Introduction

The yield of cotton mainly depends on weather, pests, diseases and management practices. Unfortunately, cotton is damaged by more than 160 species of insect-pests right from emergence till the final picking^[1,2]. Among which bollworms viz., *Helicoverpa armigera* (Hubner), the green bollworm; *Eariasvittella* (Fabricius), the spotted bollworm; *Eariasinsulana* (Biosdual), the spiny bollworm and *Pectinophora gossypiella* (Saunders), the pink bollworm infested cotton and inflicted 30-80 per cent yield losses^[4]. Even after the introduction of bollworm-resistant *Bt* cotton, which now covers more than 95 per cent of area under cotton, losses caused by insect-pests have been estimated at a whopping 30 per cent. The 87.43 per cent avoidable yield losses were

estimated due to bollworm complex in *Bt* cotton (Jadhav *et al.*, 2019). Worldwide more than US \$ 5 billion per annum accounted for managing the bollworm outbreak and its losses^[1,2].

However, recently many studies exhibited bollworm survive and develop on elite *Bt* cotton hybrids^[5,6,9,10,11,12]. Moreover, severe damage to bolls by *P. gossypiella* and yield-losses were observed in *Bt*-cotton in many regions of Gujarat and some parts of AP, Telangana and Maharashtra during 2014. High *P. gossypiella* larval recovery on *Bt*-II in conjunction with high LC₅₀ values for Cry1Ac and Cry2Ab in major cotton-growing districts of central and southern India provided evidence of field-evolved resistance in *P. gossypiella* to *Bt*-I and *Bt*-II cotton^[4,7,8,10].

Materials and Methods

Extensive studies have been carried out at the Post Graduate Laboratory, Department of Agricultural Entomology, College of Agriculture, Latur (Vasatrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra)-India during 2018. The *Bt* cotton hybrids developed by private sector having different crop durations (AJEET-155 BG-II, BHAKTI NCS-245BG-II, JAY BG-II, YUVA 7215-2 BG II, Dr. BRENT MRC-7347 BG-II, RCH-2 BG-II) and along with one non-*Bt* (NHH-44) genotype were selected for the present investigation. The initial culture of bollworm *viz.*, *Pectinophora gossypiella* Saunders were developed by collecting large number of larvae from the cotton field reared individually in round plastic vials by feeding them on natural diet (flowers, squares and bolls of non-*Bt* cotton) every day till pupation. Pupae were transferred to round clean plastic containers covering top with muslin cloth secured firmly with rubber band. The freshly emerged adults were released into standard oviposition cage covered with black muslin cloth. The proportion of female and male in the cage was 1:5 in order to get fertilized eggs. Cotton swab dipped into 10 per cent honey solution was provided to serve as food for the adults. A strip of cotton cloth toweling (6×17 cm) was hung vertically inside each oviposition cage as oviposition substrate. The eggs on the toweling were

stored in transparent plastic boxes. After hatching, neonate larvae were transferred separately into plastic vials to avoid cannibalism. The different instar larvae obtained were used for further investigations.

The experiment was carried out in completely randomized design (CRD) with three replications using ten larvae per replication by feeding them on squares and bolls of different genotypes of cotton were collected randomly in labelled plastic bags at pre-determined interval of 90, 120 and 150 days old crop. Later laboratory reared different instar larvae of bollworms were released on different cotton structures at the rate of 10 larvae per replication. The vial was covered with a plastic lid for avoiding escape of larvae. The larval mortality of *P. gossypiella* in all the instars was investigated individually by exposing them to different cotton plant structures *viz.*, squares and bolls of different cotton hybrids at 90 and; 120 and 150 days old crop, respectively. The observation on weight of the surviving larvae was recorded after 24, 48 and 72 h of exposure and the weight of pupae was also recorded from each treatment. In addition, other parameters *viz.*, per cent pupation and adult emergence from the surviving larvae were observed. The growth and survival index were calculated for each bollworm on different treatments.

$$\text{Growth index} = \frac{\text{Per cent pupation}}{\text{Larval developmental period (days)}}$$

$$\text{Survival index} = \frac{\text{Number of moths emerged}}{\text{Total number of neonates tested}}$$

The data in respect of survival and development of bollworms on *Bt cotton* hybrids of different events was statistically

Results and Discussion

Effect of different plant parts of different *Bt cotton* hybrids on larval mortality of *P. gossypiella*

The mortality of *P. gossypiella* larvae was noticed during first, second and third instars only, when fed on squares of different *Bt cotton* hybrids at 90 days old crop evidenced that the larvae of *P. gossypiella* fed on squares of Dr. BRENT MRC-7347 BG-II registered maximum mortality. The mortality of *P. gossypiella* decreased gradually with development in the age of the larvae. At 120 days old crop evidenced that the maximum larval mortality was recorded on all the *Bt cotton* hybrids under investigation compared to NHH-44 non-*Bt cotton* hybrid. The mortality of *P. gossypiella* larvae was noticed during first, second and third instars only, when fed on bolls of different *Bt cotton* hybrids. The larvae of *P. gossypiella* fed on bolls of JAY BG-II revealed maximum mortality. At 150 days old crop evidenced that the larval mortality was recorded on all the *Bt cotton* hybrids under investigation compared to NHH-44 non-*Bt cotton* hybrid. The mortality of *P. gossypiella* larvae was observed during first and second instar only, when fed on bolls of different *Bt cotton* hybrids. The larvae of *P. gossypiella* fed on bolls of YUVA 7215-2 BG-II noticed maximum mortality.

The results on the per cent mortality of different larval instars of *P. gossypiella* fed on squares and bolls of different *Bt cotton* hybrids at pre-determined intervals proved that the

Effect of different plant parts of different *Bt cotton* hybrids on larval weight of *P. gossypiella*

analyzed by standard 'analysis of variance'. The null hypothesis was tested by 'F' test of significance at 5 per cent level.

mortality of early larval instars of *P. gossypiella* fed on squares and bolls of *Bt cotton* hybrids of different event was higher than the later instars. Among the *Bt cotton* hybrids of different events, NCS-207 BG-II registered maximum larval mortality over rest of *Bt cotton* hybrids^[6]. The rate of mortality decreased gradually with advance in the age of the larvae. Among the *Bt cotton* hybrids of different events, BG-II cotton hybrids revealed superior results over BG-I. It was earlier indicated that the larval mortality of *P. gossypiella* was varied from 92.9 to 69.1 per cent considering different days of observation^[3]. Tulasi 4 BG-II remained significantly superior over the rest. The impact of Cry1Ac irrespective of events was similar and statistically on par with GFM event. MH event had comparatively lower resistance at 125 and 135 DAS. Naik *et al.* (2014) stated that the mortality of early larval instars of *P. gossypiella* was higher than the later instars fed on bolls of 130 days old crop compared to those fed on bolls of 150 days old crop for all the *Bt* event hybrids. Similarly, Soujanya *et al.* (2010) exhibited that the mortality of early larval instars of *P. gossypiella* was higher than the later instars when fed on 130 days old bolls compared to 150 days old bolls for all the larval instars. It was indicated in the past that the average larval mortality of *P. gossypiella* was 91.47 and 91.12 per cent in RCH-2 and Bunny BG-II as compared to RCH-2 *Bt* and Bunny *Bt* (82.15 and 81.7 per cent), respectively from 60 to 120 DAS^[12].

The data on mean weight of *P. gossypiella* larval instars that survived beyond 24, 48 and 72 h after exposure on squares of different *Bt* cotton hybrids at 90 days old crop evidenced that the minimum larval weight was recorded on all the *Bt* cotton hybrids under investigation compared to NHH-44 non-*Bt* cotton hybrid. The Dr. BRENT MRC-7347 BG-II hybrid was proved less palatable to *P. gossypiella* as the larval weight was very less compared to other *Bt* and NHH-44 non-*Bt* cotton hybrids. At 120 days old crop evidenced that the minimum larval weight was recorded on all *Bt* cotton hybrids under investigation compared to NHH-44 non-*Bt* cotton hybrid. The JAY BG-II cotton hybrid was confirmed to be less palatable to *P. gossypiella* as the larval weight was very less compared to other *Bt* and NHH-44 non-*Bt* cotton hybrids. At

Effect of different plant parts of different *Bt* cotton hybrids on pupation of *P. gossypiella*

The data on per cent pupation of surviving larval instars of *P. gossypiella* fed on squares of different *Bt* cotton hybrids at 90 days old crop revealed that the lowest pupation was noticed on all the *Bt* cotton hybrids under investigation compared to NHH-44 non-*Bt* cotton hybrid. The first, second and third instar larvae of *P. gossypiella* fed on squares of Dr. BRENT MRC-7347 BG-II registered lowest pupation. The per cent pupation varied with the instars. The gradual increase in per cent pupation of *P. gossypiella* was recorded in I-III instar larvae fed on squares of different *Bt* cotton hybrids. At 120 days old crop revealed that the lowest pupation was noticed on all the *Bt* cotton hybrids under investigation compared to NHH-44 non-*Bt* cotton hybrid. The first, second and third instar larvae of *P. gossypiella* fed on bolls of JAY BG-II registered lowest pupation. The gradual increase in per cent pupation

150 days old crop evidenced that the minimum larval weight was recorded on all the *Bt* cotton hybrids under investigation compared to NHH-44 non-*Bt* cotton hybrid. The YUVA 7215-2 BG-II hybrid was found to be less palatable to *P. gossypiella* as the larval weight was very less compared to other *Bt* and NHH-44 non-*Bt* cotton hybrids.

The results on mean weight of *P. gossypiella* larvae that survived beyond 24, 48 and 72 h after exposure on squares and bolls of different *Bt* cotton hybrids at 90, 120 and 150 days old crop. Among the *Bt* cotton hybrids of different events, NCS-207 BG-II was found significantly superior over rest of *Bt* cotton hybrids. Similarly, the larval weight of *P. gossypiella* was found to be lowest on all *Bt* cotton hybrids of different events compared to NHH-44 non-*Bt* cotton hybrid^[6,10,12].

of *P. gossypiella* was recorded in I-III instar larvae fed on bolls of different *Bt* cotton hybrids. At 150 days old crop revealed that the lowest pupation was noticed on all the *Bt* cotton hybrids under investigation compared to non-*Bt* cotton hybrid. The first and second instar larvae of *P. gossypiella* fed on bolls of YUVA 7215-2 BG-II registered lowest pupation. The gradual increase in per cent pupation of *P. gossypiella* was recorded in I and II instar larvae fed on bolls of different *Bt* cotton hybrids.

The results on the per cent pupation of surviving larvae of different instars of *P. gossypiella* fed on bolls of different *Bt* cotton hybrids at pre-determined intervals are in close conformity with the findings of earlier workers who evidenced that *P. gossypiella* larvae fed on squares and bolls of *Bt* cotton hybrids of different events exhibited adverse effects on the growth and

development with reduced pupation and formation of small pupae with less weight. Among the *Bt* cotton hybrids of different events, NCS-207 BG-II was found superior over rest of *Bt* cotton hybrids. Analogously, Likhitha (2017) revealed that

Effect of different plant parts of different *Bt* cotton hybrids on pupal weight of *P. gossypiella*

The data on mean pupal weight of *P. gossypiella* reared on squares of different *Bt* cotton hybrids at 90 days old crop evidenced that the minimum pupal weight was recorded on all the *Bt* cotton hybrids under investigation compared to NHH-44 non-*Bt* cotton hybrid. The weight of pupae was less on squares compared to bolls. At 120 days old crop evidenced that the minimum pupal weight was recorded on all the *Bt* cotton hybrids under investigation compared to NHH-44 non-*Bt* cotton hybrid. At 150 days old crop evidenced that the minimum pupal weight was recorded on all the *Bt* cotton hybrids under investigation compared to NHH-44

Effect of different plant part of different *Bt* cotton hybrids on adult emergence of *P. gossypiella*

The data on per cent adult emergence of *P. gossypiella* reared on squares of different *Bt* cotton hybrids at 90 days old crop evidenced that the minimum adult emergence was recorded on all the *Bt* cotton hybrids under investigation compared to NHH-44 non-*Bt* cotton hybrid. The first, second and third instar larvae of *P. gossypiella* fed on squares of Dr. BRENT MRC-7347 BG-II registered lowest adult emergence. The per cent adult emergence varied with the instars. The gradual increase in per cent adult emergence of *P. gossypiella* was recorded in I, II and III instar larvae fed on squares of different *Bt* cotton hybrids. At 120 days old crop evidenced that the minimum adult emergence was recorded on all the *Bt* cotton hybrids under investigation

different instar larvae of *P. gossypiella* fed on bolls of *Bt* cotton hybrids of different event showed adverse effects on pupation with formation of small pupae having less weight^[10,12].

non-*Bt* cotton hybrid. The pupal weight was less on squares compared to bolls.

The results on mean pupal weight of *P. gossypiella* reared on squares and bolls of different *Bt* cotton hybrids at 90,120 and 150 days old crop are in acquiescence with the findings of others who demonstrated that *P. gossypiella* larvae fed on squares and bolls of *Bt* cotton hybrids of different events exhibited adverse effects on the growth and development and produced small pupae with less weight. Among the *Bt* cotton hybrids of different events, NCS-207 BG-II was found superior over rest of *Bt* cotton hybrids^[10,12].

compared to NHH- 44 non-*Bt* cotton hybrid. The first, second and third instar larvae of *P. gossypiella* fed on bolls of JAY BG-II registered lowest adult emergence. The gradual increase in per cent adult emergence of *P. gossypiella* was recorded in I, II and III instar larvae fed on bolls of different *Bt* cotton hybrids. At 150 days old crop evidenced that the minimum adult emergence was recorded on all the *Bt* cotton hybrids under investigation compared to non-*Bt* cotton hybrid. The first and second instar larvae of *P. gossypiella* fed on bolls of YUVA 7215-2 BG-II registered lowest adult emergence. The per cent adult emergence varied with the instars. The gradual increase in per cent adult emergence of *P. gossypiella* was recorded in I and II instar

larvae fed on bolls of different *Bt* cotton hybrids.

The results on adult emergence of *P. gossypiella fed* on squares and bolls of different *Bt cotton* hybrids at 90, 120 and 150 days old crop are comparable with the

Growth and survival indices of *P. gossypiella* reared on different plant part of different *Bt* cotton hybrids

The growth and survival indices for *P. gossypiella* were very low when reared on squares and bolls of different *Bt* cotton hybrids compared to non-*Bt cotton* hybrid. The low growth and survival indices can be attributed to longer developmental period, low per cent pupation and less adult emergence on *Bt* hybrids.

The results on growth and survival indices of different larval instars of *P. gossypiella fed* on squares and bolls of

findings of many others who claimed that different instar larvae of *P. gossypiella fed* on squares and bolls of *Bt* cotton hybrids of different events exhibited significant reduction in adult emergence.

different *Bt* cotton hybrids. The growth and survival index values were low for the larvae of *P. gossypiella fed* on squares and bolls of *Bt cotton* hybrids. Among the *Bt* cotton hybrids of different events, NCS-207 BG-II was found significantly superior over rest of *Bt* cotton hybrids. Similarly, it was found that the growth and survival index^[7] values were low for the larvae of *P. gossypiella* reared on bolls of *Bt cotton* hybrids^[10,12].

Table 1 Growth indices of *P. gossypiella* reared on plant part of different *Bt* cotton hybrids

Treatments	Growth Index		
	Squares (90 days old crop)	Bolls (120 days old crop)	Bolls (150 days old crop)
AJEET-155 BG-II	9.56	9.72	9.76
BHAKTI NCS-245 BG –II	9.58	10.93	10.57
JAY BG-II	8.33	9.00	9.88
YUVA 7215-2 BG-II	9.39	9.41	9.60
Dr. BRENT MRC- 7347 BG-II	7.49	9.22	10.13
RCH-2 BG-II	9.41	10.41	10.00
NHH-44 non- <i>Bt</i>	10.81	11.11	11.42

Table 2 Survival indices of *P. gossypiella* reared on different plant part of different *Bt* cotton hybrids

Treatments	Survival Index		
	Square (90 days old crop)	Bolls (120 days old crop)	Bolls (150 days old crop)
AJEET-155 BG-II	0.47	0.48	0.65
BHAKTI NCS-245 BG-II	0.50	0.57	0.71
JAY BG-II	0.40	0.37	0.63
YUVA 7215-2 BG-II	0.44	0.45	0.57
Dr. BRENT MRC 7347 BG-II	0.30	0.39	0.58
RCH-2 BG-II	0.35	0.52	0.70
NHH-44 non- <i>Bt</i>	1.00	1.00	1.00

Conclusion

From the present investigation it can be concluded that the mortality of early larval instars of *P. gossypiella* fed on squares and bolls of different *Bt* cotton hybrids was higher than the later instars. Exposure of later instar larvae to different plant parts of different *Bt* cotton hybrids also exhibited adverse effects on the growth and development such as reduced

larval weights, prolonged larval developmental period, reduced pupation, formation of small pupae with less weight, reduction in adult emergence with low growth and survival indices for *P. gossypiella*. The growth and survival index values were low for the larvae reared on squares compared to bolls of different *Bt* cotton hybrids.

References

1. Dhaliwal, G.S., Jindal, V. and Dhawan, A.K. (2010). Insect pest problems and crop losses: Changing trends. *Indian Journal Ecology*, **77**: 1-7.
2. Dhaliwal, G.S., Jindal, V. and Mohindru B. (2015). Crop losses due to insect pests: Global and Indian Scenario. *Indian Journal Ecology*, **77**: 165-168.
3. Hallad, A.V., Udikeri, S.S., Patil, S.B., Biradar, D.P. and Khadi, B.M. (2014). Characterization of resistance to all bollworms and *Spodoptera litura* (Fab.) in different *Bt* transgenic events of cotton. *International Journal of Current Microbiology and Applied Science*, **3** (3): 594-600.
4. Kranthi, K.R. (2016). Possible implications of a recent gazette notification on *Bt*-cotton scenario in India. *Current Science*, **111**(10):1588-1590.

5. Kranthi, K.R., Kranthi, S., Ramesh. K., Nagrare, V.S. and Barik, A. (2009). Advances in cotton IPM, Technical Bulletin. Central Institute for Cotton Research, Nagpur: 1-27.
6. Likhitha, P. and Bhamare, V.K. (2018a). Survival and development of American bollworm *H. armigera* on *Bt* cotton hybrids of different events. *International Journal of Current Microbiology and Applied Science*, **6**: 1130-1139.
7. Likhitha, P. and Bhamare, V.K. (2018b). Survival and development of spotted bollworm *Eariasvittella* (Fabricius) on *Bt* cotton hybrids of different events. *International Journal of Current Microbiology and Applied Science*, **6**: 1393-1407.
8. Liu, L., Gao, M., Yang, S., Liu, S., Yves Carrière, Y.W. and Yang, Y. (2017). Resistance to *Bacillus thuringiensis* toxin Cry 2Ab and survival on single-toxin and pyramided cotton in cotton bollworm from China. *Evolutionary Applications*, **10**: 170-179.
9. Mahalakshmi, M.S. and Prasad, N.V.V.S.D. (2013). Survival and development of American Bollworm (*Helicoverpa armigera*) on transgenic *Bt* cotton. *Indian Journal Agriculture Research*, **48** (3):177-184.
10. Naik, V.C.B., Kumbhare, S., Kranthi, S., Satija, U. and Kranthi, K.R. (2018). Field-evolved resistance of pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae), to transgenic *Bacillus thuringiensis* (*Bt*) cotton expressing crystal 1Ac (Cry 1Ac) and Cry 2Ab in India. *Pest Management Science*, **74**: 2544-2554.
11. Shera, P.S. and Arora, R. (2016a). Survival and development of spotted bollworm, *Eariasvittella* (Fabricius) (Lepidoptera: Nolidae) on different transgenic *Bt* and isogenic non-*Bt* cotton genotypes. *Phytoparasitica*, **44**: 99-113.
12. Soujanya, P.L., Prasad, N.V.V.S.D. and Rao, P.A. 2010. Effects of stacked *Bt* (Cry 1Ac + 2Ab) and *Bt* (Cry 1Ac) cottons on survival and development of Pink Bollworm. *Indian Journal of Plant Protection*, **38**: 1-5.