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Impact of Transgenic and Non-Transgenic Cotton on Insect Pests and Natural Enemies

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Abstract: The present field study was conducted at the Regional Agricultural Research Station in Lam, Guntur, to assess the effects of transgenic cotton on insect pests and associated natural enemies in comparison to non-*Bt* cotton. The findings showed that there was no difference in the egg-laying pattern of *Helicoverpa armigera* between *Bt* (12.68/plant) and non-*Bt* (13.07/plant). However, the number of larvae in the non-transgenic population was higher (6.33 larvae/plant) than in the transgenic population (2.30 larvae/plant). The boll damage caused by pink bollworm was lower in *Bt* cotton (27.68%) than in non-*Bt* cotton (36.33%). Populations of sucking pests, particularly leafhoppers, showed similar trends across Bt (15.82/three leaves) and non-Bt cotton (13.64/three leaves), with no major differences observed for aphids, thrips, or whiteflies. There were no discernible changes between transgenic and non-transgenic cotton in terms of natural enemies. Spider populations on *Bt* and non-*Bt* plants were 4.35 and 5.03 per plant, respectively. In contrast, the numbers of ladybird beetles and chrysopids were 1.12 and 1.39 per plant, respectively, in *Bt* cotton, while they were 0.93 and 1.10 per plant, respectively, in non-*Bt* cotton. The findings suggest that Bt cotton effectively suppresses bollworm infestation without negatively influencing the abundance of natural enemies, thereby supporting its continued role in integrated pest management.

Keywords: *Bt* and non *Bt* Cotton, Dynamics, Insect pests, Natural enemies, Population

Cotton, *Gossypium hirsutum* L. (Family Malvaceae), is an important commercially fiber crop in the world and grown in both tropical and warm temperate regions. About 25% of the world's cotton production comes from India, where cotton (*Gossypium hirsutum* L.) is a significant commercial crop. With 12.07 million hectares of land and 362.18 lakh bales produced per year, India leads the world in both cotton production and area (COCPC 2025). That makes it the world's largest producer of cotton. The cotton pests showed their time to time epidemic appearance and resulted into quantitative and qualitative crop losses in cotton growing states such as Maharashtra, Punjab, Karnataka, Gujrat, Haryana, Rajasthan, Madhya Pradesh, Andhra Pradesh and Telangana (Patil et al., 2004). India's production, however, is only 510 kg/ha, far lower than the global average of 808 kg/ha. This is because plants are under stress from a variety of biotic and abiotic stimuli. Numerous insect pests infest cotton crops at various phenological stages, which is one of the primary factors limiting yield (Sahito et al., 2017).

There are around 1300 plant-feeding insects in cotton systems worldwide, but only a small number of them are common residents and even fewer are economically significant. The large collection of cotton pests is divided into two categories: sucking pests and bollworms. Aphids (*Aphis gossypii*; Glover); leafhoppers (*Amrasca biguttula biguttula*; Ishida); thrips (*Thrips tabaci*; Lind.); and whiteflies (*Bemisia tabaci*; Genn.) are among the sucking pests that are most significant (Williams 2006). Cotton ecosystems also attract a variety of natural enemies that help regulate pest populations (Chi et al., 2021). Key predators include coccinellid beetles such as *Coccinella septempunctata* (Linnaeus) and *Cheilomenes sexmaculatus* (Fabricius), the green lacewing *Chrysoperla carnea* (Stephens), and several species of spiders including the lynx spider (*Oxyopes javanus*), orb spider (*Argiope minuta*), wolf spider (*Lycosa pseudoannulata*), long-jawed spider (*Tetragnatha javana*), *Neoscona theisi*, and *Peucetia viridana* (Stoliczka). Pesticide use has also been linked to detrimental environmental effects, including decreased biodiversity, pesticide resistance, harm to non-target species (such as natural enemies), and the emergence of secondary pests (Singh 2018). The cropping system is the present situation are very diversified and consist of several crops that serve as alternate and collateral hosts of the major insect pests. With the diversifies and multiplicity of cropping patterns the performance and interactions of transgenic crops in different agro-ecosystem are likely to be quite complex (Dhillon and Sharma, 2013). Since many other predators, including parasitoids, in arable systems are susceptible to environmental changes brought about by human involvement, the main worry regarding transgenic crops is their impact on non-target creatures.

Bt cotton has a mixed impact on natural enemies: while reduced insecticide use in Bt fields can lead to higher populations of beneficial insects, some studies indicate potential negative effects from predators consuming Btintoxicated prey. However, most research suggests the overall effect on natural enemy diversity and function is not significantly adverse, and the benefits of reduced broad-spectrum insecticide use often outweigh the drawbacks. In order to understand and compare the diversity of arthropods, including the harm caused by insect pests and their natural enemies, the current field research were conducted.

MATERIAL AND METHODS

The *Bt*-transgenic and non-transgenic cotton hybrids were cultivated under field conditions on deep black soils at the Regional Agricultural Research Station, Lam, Guntur Andhra Pradesh, following normal agronomic practices recommended for raising the crop mentioned in the package of practices of cotton. The *Bt*-transgenic and their non-transgenic versions of Tulasi 171 BGII were planted July with a spacing of 105 cm X 60 cm individually with an area of 500 m^2 each respectively and were divide further in to five sub plots as replicates and leaving the boundary rows to exclude from sampling. The crop was raised under rainfed conditions following suitable agronomic practices as recommended by the university. No plant protection measures were applied during the experimental period in both *Bt* and Non *Bt* cotton fields.

The observations were recorded on the abundance of sucking pests, cotton bollworm, non-target insect pests, and the generalist predators on randomly tagged plants in the middle two rows of each plot at fortnightly intervals starting from 30 days after sowing. Leafhopper and whitefly adults and nymphs were recorded on the under surface of the top five fully expanded leaves, while the rest of the insects were recorded on the whole plant. Numbers of all the insect pests and the generalist predators were expressed as numbers, while the plants infested with aphids were recorded in percentage. The data on total numbers of mature bolls, and those damaged by bollworms were recorded on 15 tagged plants. The data was further subjected to statistical analysis (t-test) using XLSTAT version 16.0.

RESULTS AND DISCUSSION

With respect to oviposition of *H. armigera* there were no significant differences in female moth on *Bt* (12.68) and Non *Bt* cotton (13.07) and the damage due to *H. armigera* and larval population varied significantly with highest in Non Bt (6.33) and in Bt (2.30). The variation in *H. armigera* larval density on Bt and non Bt cotton was significant across the environments. More egg laying by *H. armigera* on *Bt* plants might be because of better crop growth as a result of reduced damage by other insect pests. Similar results were also obtained in earlier studies by Sharma and Pampapathy (2006) and Dhillon and Sharma (2009). Arshad et al. (2011) reported that there was no difference in oviposition between Bt and non Bt cotton. However, Wu et al. (2003) and Vennila et al. (2006) observed significant differences in egg laying. Arshad et al. (2011) who reported that the incidence of *H. armigera* larvae was very low on Bt cotton cultivars compared to their corresponding non *Bt* cultivars.

Larval population of pink bollworm in *Bt* cotton was 2.33 and in its counterpart non Bt was 10.67 larvae per plant, the pink bollworm larval population is generally higher in non-*Bt* cotton than in *Bt* cotton because the *Bt* toxin is engineered to kill the larvae leading to much higher mortality rates and lower overall populations compared to non-*Bt*. *T*he non *Bt* plots attract more bollworms than the *Bt* genotypes, this might have been the reason for the difference in damage of squares (Kumar and Stanley 2006). Marchosky et al. (2001) alsoreported that the BG-I and BG-II hybrids had consistently fewer PBW larvae compared to non Bt cotton.

There was significant differences in the population of leafhoppers, between Bt (15.82and Non Bt cotton (13.64). Similarly, the thrips population was greater on Bt than on non Bt cotton plants (Table 1). There was significant difference among *Bt* and non *Bt* cotton with respect to population of whiteflies. Aggrawal and Dhawan (2009) observed that population of thrips was slightly higher on transgenic cotton in the last two years due to a reduced number of insecticide sprays against lepidopterous pests compared with the

Table 1. Population of major insect pests and natural enemies in Bt and Non Bt cotton

Type of arthropods	Transgenic Bt cotton	Non-transgenic Bt cotton	CD @ 5%
Insect pests			
Helicoverpa armigera eggs	12.68±1.24	13.07±1.30	NS
Helicoverpa armigera larvae	2.30±0.54	6.33±1.10	1.84
Pink bollworm larvae	2.33±0.38	10.67±1.57	2.56
Leaf hoppers/ 3 leaves	15.82±1.85	13.64±0.93	1.10
Thrips/ 3 leaves	31.47±3.15	28.36± 2.73	1.29
Whiteflies/ 3 leaves	5.3±1.10	4.6±0.85	NS
Natural Enemies			
Spiders	4.35±0.55	5.03±0.74	NS
Ladybird beetles	1.12±0.35	0.93±0.26	NS
Chrysopids	1.39±0.28	1.10±0.30	NS
Damage and Yield			
Number of fallen squares (%)	23.67±2.67	24.47±3.45	NS
Square Damage (%)	18.67±1.50	34.33±2.40	6.18
Boll damage (%)	27.68±1.70	36.33±2.85	5.05
Locule damage (%)	6.82±0.25	17.34±1.10	3.26

* Values are means ± SE

number of sprays in the normal cotton. Udikeri et al. (2012) while assessing the impact of Bt cotton on dynamics of aphid in RCH 2 Bt and non-Bt cotton hybrids, reported aphid population range as 8.58 /leaf (34 ISW)-42.15/leaf (50 ISW) in RCH 2 Bt and 6.22-37.08/leaf (46 ISW) in RCH 2 Non-Bt cotton, respectively, indicating no significant variation. Sarwar et al. (2013) explained that in general Bt cotton showed equal or higher sucking pest population than non Bt cotton verities. Mohapatra and Nayak (2014) reported that Sudarshan BGII was found highly susceptible to jassid, harbouring a maximum population of leaf hoppers. Since Bt cotton hybrids are shown to be resistant to the bollworm complex, the increasing prevalence of sucking pest populations may be the result of less interspecific competition among sucking pests. Kaur et al. (2016) reported that population of sucking pests on Bt and non Bt hybrids did not differ significantly.

Spiders, ladybird beetles, and other natural enemies were also observed on Bt and non-Bt cotton plants. The population of natural enemies did not differ statistically, but there were numerical differences between the populations of natural enemies in the Bt and non-Bt cotton ecosystems. Earlier field trials have also demonstrated that by mid-season, the population densities of generalist predators in *Bt*-cotton are significantly higher than in conventional cottons treated with insecticides for control of *H. armigera* (Pray et al., 2002, Sharma et al., 2007). No significant influence of *Bt* cotton on abundance of natural enemies of crop pests *viz.,* chrysopids, ladybird beetles was observed suggesting that there were no adverse effects of *Bt*-cotton on the natural fauna under field conditions (Dhillon and Sharma 2013).

There were no significant differences between *Bt* (23.67) and non *Bt* (24.47) cottons with respect to the shedding of squares, but when the squares were considered with the damage due to boll worm there were significantly more in Non *Bt* (36.33) than in *Bt* cotton (27.68). The bollworm damaged in green bolls between the *Bt* and Non *Bt* cotton was significant. The locule damage was more in Non *Bt* compared to that of *Bt* and differed statistically. In non-*Bt* fields, bollworm populations can grow exponentially, while in *Bt* fields, the survival rate for larvae is very low. Development of transgenic cotton made a significant contribution in reducing the dosage and frequency of insecticide application and reduce the yield losses due to insect pests (Brooks and Barfoot 2008). Bt cotton hybrids exhibited significant reduction in bollworm infestation as against non Bt indicating the superiority of transgenic Bt cotton. These findings are also endorsed by Gujar et al. (2011) and Nadaf and Goud (2015). Chinna Babu Naik et al. (2019) observed that RCH 2 Bt, JK Durga Bt, and Nath baba Bt events had very low incidences of pink bollworm larvae, but they were better than their comparable non-Bt hybrids, which had high incidences of pink bollworm larvae. The population of *H. armigera* was considerably lower in *Bt* cotton than in non-*Bt* cotton, although there were no appreciable variations in the number of eggs laid by H*. armigera*.

CONCLUSION

Target bollworms are effectively controlled by Bt cotton, which greatly reduces the use of insecticides. This benefits natural enemies (predators/parasitoids) by maintaining their populations, resulting in better biological control and a more balanced ecosystem. However, this reduced spraying can occasionally allow secondary pests to flourish, necessitating integrated pest management (IPM) strategies. Bt toxins are specific to certain pests (like bollworms) and generally harmless to beneficial insects, as they lack the required gut receptors. The long-term challenge is managing pest resistance to the Bt toxin.

AUTHORS CONTRIBUTION

L.R.C wrote the draft and designed the study; L.R.C., N.J., R.C., S.B., C.N. and VM analyzed the data and revised the manuscript; NVSSD and SR revised the manuscript; LRC conducted the experiment; L.R.C., N.V.V.S.D and SR reviewed and edited the manuscript.

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