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Effect of Bt-cotton on biodiversity of natural enemies

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ABSTRACT: **Studies on the biodiversity of natural enemies on Bt (RCH 134) and non-Bt (RCH 134 and LHH 144) cotton hybrids were carried out during *Kharif* 2003 at Punjab Agricultural University, Ludhiana. Overall population of natural enemies remained low during the season. Pooled data of all the observations revealed that Bt cotton hybrid RCH 134 recorded significantly higher population of *Chrysoperla carnea*, spiders, *Geocoris* bug and yellow wasps, *Polistes hebraeus* (Fabricius) (0.76, 1.87, 1.45 and 0.65/plant) than non-Bt hybrid RCH 134 (0.43, 1.05, 0.89 and 0.46/plant) and LHH 144 (0.44, 1.08, 1.12 and 0.47/plant). The population of coccinellid beetles was very low and there was non-significant differences in its populations in Bt and non-Bt cotton hybrids. The value of general diversity index (Shannon Weaver's index) was comparatively higher in Bt cotton hybrid RCH 134 as compared to non-Bt hybrids RCH 134 and LHH 144 in most of the observations. However, higher value of diversity index was recorded in LHH 144 i.e. 1.349 and 1.340 on Sept 1 and 10, respectively. Higher population of natural enemies recorded in Bt cotton hybrids may be ascribed to reduction in number of insecticidal sprays (only one application) as compared to non-Bt hybrids, which received higher number of insecticidal sprays (six applications).**

KEY WORDS: Bio-diversity, Bt cotton, natural enemies, Shannon Weaver Index

INTRODUCTION

Cotton is an important cash crop of India and it is attacked by numerous insect pests that are mainly responsible for decreasing its production and productivity. According to Singhal (1999), for controlling these pests, 45 per cent of the total pesticides used in all the crops are used in cotton alone. So this leads to high economic and ecological damages in terms of backlashes of these pesticides such as insecticide resistance, pest resurgence, effect on non-target species, environmental pollution and health hazards. In this way chemicals disturb the ecological equilibrium as these are non-selective and reduce the diversity of natural enemies also (Singh and Sidhu, 1982; Singh, 1984). Genetically modified organisms in case of *Bt* cotton is practically known to reduce the pesticide load from 50 to 70 per cent in different parts of the world, as there is less need of insecticidal sprays for controlling bollworms. In China some work has been done to find the influence of Bt cotton on natural enemies (Cui and Xia, 1997, 1998, 2000a and b; Ning *et al.*, 2001). But in India no such reference related

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to effect of Bt cotton on the biodiversity of natural enemies is available, hence the present studies were undertaken.

MATERIALS AND METHODS

The experiment was conducted at experimental area of Cotton Section, Department of Plant Breeding, Genetics & Biotechnology, Punjab Agricultural University, Ludhiana during *Kharif*, 2003. Bt and non-Bt hybrids of American cotton i.e. RCH 134 (Bt), RCH 134 (non-Bt) and PAU recommended hybrid LHH 144 were sown in a randomized block design in plots measuring 7.45 X 9.75 m which were replicated 6 times. Crop was protected against bollworms and sucking pests by giving 6 sprays of recommended insecticides based on economic threshold levels. One spray of Confidor 200 SL (Imidacloprid) was given on 11.7.2003 for controlling sucking pests both in Bt and non-Bt hybrids. For the control of bollworms on non-Bt hybrids (RCH 134 non-Bt and LHH 144) five sprays of endosulfan 35 EC (5.8.2003), E-mite 50 EC (24.8.2003), acephate 75 SP (28.8.2003), quinalphos 25 EC (11.9.2003) and acephate 75 SP (15.9.2003) were given, whereas Bt cotton hybrids RCH 134 required no spray.

To determine the comparative biodiversity on Bt and non-Bt hybrids population of five natural enemies *viz.* green lacewing (*Chrysoperla carnea*), spiders, *Geocoris* spp., yellow wasp [*Polistes hebraeus* (Fabricius)] and coccinellids [*Coccinella septempunctata* Linnaeus, *Brumoides suturalis* (Fabricius), *Cheilomenes sexmaculata* (Fabricius)] were recorded on whole plant basis from five plants selected at random in each replication at an interval of 10 days. While recording observations all the stages of *C. carnea* were taken into consideration.

Shannon and Weaver index of general diversity was also worked out from the data recorded on the population of natural enemies as per formula given by Shannon and Weaver (1963):

$$\text{Shannon Weaver's index } \left(\overline{H}\right) = -\text{''}p_i \log_e p_i$$

Where,

p_i = importance probability of each species (n_i/N)

n_i = importance value for each species

N = total of importance value

RESULTS AND DISCUSSION

Population of *Chrysoperla carnea*

The mean number of *C. carnea* (all stages) recorded on Bt and non-Bt hybrids varied from 0.23 to 0.97 per plant during the period of observations (Table 1). The differences in mean number of *C. carnea* per plant on Bt and non-Bt cotton hybrids were non-significant in first three observations (July 10, July 21 and August 1, 2003) although it was numerically higher in RCH 134 (Bt) hybrid than non-Bt hybrids on July 21 and August 1. In the subsequent observations recorded on 12th August onwards, the mean population was significantly higher on Bt hybrid RCH 134 (0.83 to 0.97/plant) than non-Bt RCH 134 (0. 40 to 0.47/plant) and LHH 144 (0.23 to 0.73/plant) except on 20th September where RCH 134 (Bt) hybrid recorded population (0.63/plant) at par with LHH 144 (0.50/plant). Pooled data of all the observations showed that the mean population of *C. carnea* per plant was significantly higher in RCH 134 Bt hybrid (0.76/plant) than non-Bt cotton hybrids i.e. RCH 134 (0.43/plant) and LHH 144 (0.44/plant). However, the non-Bt hybrids recorded *C. carnea* population on par with each other.

Population of spiders

The mean number of spiders recorded on Bt and non-Bt cotton hybrids varied from 0.47 to 3.47 per plant during the observation period (Table 1). During first three observations (July 10, July 21 and August 1, 2003) the mean spider population varied from 0.47 to 1.30 per plant and showed non significant differences among Bt and non-Bt hybrids, though RCH 134 (Bt) recorded numerically higher population than non-Bt hybrids. In the next five observations recorded on Aug 12, Aug 22, Sept 1, Sept10 and Sept 20, 2003, the mean population was significantly higher in RCH 134 (Bt) hybrid (1.53

Table 1. Population of *C. carnea* and spiders on Bt and non-Bt cotton hybrids at Ludhiana during *kharif* 2003

Hybrids	Dates of Observations								
	10.7.03	21.7.03	1.8.03	12.8.03	22.8.03	1.9.03	10.9.03	20.9.03	Mean
Mean number of #*Chrysoperla carnea* per plant									
1. RCH 134 (*Bt*)*	0.50	0.67	0.77	0.83 (1.35)	0.83 (1.35)	0.87 (1.36)	0.97 (1.40)	0.63 (1.28)	0.76 (1.33)
2. RCH 134 (non-*Bt*)**	0.57	0.30	0.40	0.47 (1.21)	0.40 (1.18)	0.47 (1.21)	0.47 (1.21)	0.33 (1.15)	0.43 (1.19)
3. LHH 144**	0.43	0.30	0.47	0.30 (1.14)	0.23 (1.11)	0.73 (1.32)	0.53 (1.24)	0.50 (1.22)	0.44 (1.20)
CD (p=0.05)	NS	NS	NS	(0.10)	(0.15)	(0.10)	(0.06)	(0.07)	(0.03)
Mean number of Spiders per plant									
1. RCH 134 (*Bt*)*	0.57	1.23	1.30	2.97 (1.99)	3.47 (1.74)	2.03 (1.74)	1.83 (1.68)	1.53 (1.59)	1.87 (1.69)
2. RCH 134 (non-*Bt*)**	0.50	1.07	1.13	1.83 (1.68)	1.00 (1.41)	0.97 (1.40)	0.87 (1.36)	0.97 (1.40)	1.05 (1.43)
3. LHH 144**	0.47	0.87	1.03	1.40 (1.55)	1.40 (1.55)	1.47 (1.57)	0.93 (1.39)	1.07 (1.44)	1.08 (1.44)
CD (p=0.05)	NS	NS	NS	(0.06)	(0.08)	(0.11)	(0.09)	(0.06)	(0.03)

Note: Figures in parentheses indicate en+1 transformations.

* Sprayed against sucking pests only {one spray - imidacloprid 200SL (11/7/2003)}

** Sprayed against sucking pests and bollworms {six sprays - imidacloprid 200SL (11/7), endosulfan 35EC (5/8), E-mite 50EC (24/8), acephate 75 SP (28/8), quinalphos 25EC (11/9) and acephate 75 SP (15/9/2003)}.

\# All stages

to 3.47/plant) than non-Bt hybrids RCH 134 (0.87 to 1.83/plant) and LHH 144 (0.93 to 1.47/plant). Highest population of spiders (3.47/plant) was recorded in RCH 134(Bt) on August 22, 2003. The pooled data of all the observations also revealed that RCH 134 (Bt) recorded significantly higher population of spiders (1.87/plant) than other two non-Bt hybrids RCH 134 and LHH 144 (1.05 and 1.08/plant, respectively).

Population of *Geocoris* bug

The population of *Geocoris* bug during the season ranged from 0.07 to 4.1 per plant on Bt and non-Bt hybrids (Table 2). The maximum population of *Geocoris* bug (4.1/plant) was recorded on September 10, 2003 on RCH 134 (Bt) hybrid. In first observation (July 10), the mean population of *Geocoris* bug showed non-significant differences among Bt and non-Bt hybrids. In second observation recorded on July 21 it was significantly higher in non-Bt hybrid RCH 134 (1.4/plant) than RCH 134 Bt (0.67/plant) and LHH 144 (0.60/plant), which were on par with each other. But on Aug 1 and Aug 12, LHH 144 recorded significantly higher population (1.67 and 1.03/plant, respectively) than hybrids RCH 134 (Bt and non-Bt versions) on Aug 1 but on par with RCH 134 (Bt) on August 12. In the observations recorded after 12th August, Bt cotton hybrid, RCH 134 recorded significantly higher population (0.97 to 4.10/plant) than its non-Bt version (0.07 to 1.43/plant) but significantly higher than LHH 144 only on August 22 and September 10, 2003. RCH 134 (Bt) also recorded significantly higher population of *Geocoris* bug (1.47/plant) than its non-Bt version RCH 134 (0.89/plant) and LHH 144 (1.12/plant) on the basis of pooled data.

Population of yellow wasp, *Polistes hebraeus* (Fabricius)

The mean *P. hebraeus* population recorded on Jul 10, Jul 21, Aug 1 and Aug 12, 2003 was very low ranging from 0 to 0.23 per plant and showed non-significant differences between Bt and non-Bt cotton hybrids (Table 2). However, RCH 134 (Bt) recorded numerically higher population in first three observations. Mid August onwards the population of *P. hebraeus* started increasing and in the subsequent observations RCH 134 Bt hybrid recorded significantly higher population (1 to 1.23/plant) than non-Bt hybrids RCH 134 (0.67 to 0.83) and LHH 144 (0.37 to 1.3/plant) except in observations recorded on Aug 22 and Sept 1, where it was on par with that on RCH 134 (non-Bt) and LHH 144, respectively. The pooled data of all the observations also revealed that population of *P. hebraeus* was significantly higher on RCH 134 (Bt) (0.65/plant) than non-Bt hybrids i.e. RCH 134 (0.46/plant) and LHH 144 (0.47/plant).

Population of coccinellids

The Coccinellid [*Coccinella septempunctata* Linnaeus, *Brumoides suturalis* (Fabricius), *Cheilomenes sexmaculata* (Fabricius)] population remained very low during the period of observations, which ranged from 0.00 to 0.07 and the differences between *Bt* and non-*Bt* hybrids were non-significant. The possible reason behind the low population of coccinellid may be very low incidence of aphids during the season. On studying the pooled data of all the observations it can be concluded that the population of natural enemies except coccinellid was significantly higher in RCH 134 (*Bt*) hybrid as compared to its non-Bt version and LHH 144. Population of natural enemies remained low during early crop growth period and comparatively higher population was recorded during months of August and September.

Earlier workers (Cui and Xia, 1997; Wang and Xia, 1997; Tol *et al.*, 1998; Ning *et al.*, 2001) reported that population of natural enemies recorded on Bt cotton and conventional cotton (non-Bt) did not differ significantly. Though sucking pests of cotton were present in less numbers in Bt and non-Bt cotton, it crossed economic threshold level once only during the month of July in both (Bt and non-Bt hybrids). However, in case of non-Bt cotton hybrids the incidence of bollworms crossed economic threshold level five times and required five insecticidal applications as compared to Bt cotton hybrids where incidence remained below economic threshold level and did not warranted any spray against bollworms. The significant difference in natural enemies population in Bt and

Table 2. Population of *Geocoris* bug and yellow wasp, *P. hebraeus* on Bt and non-Bt cotton hybrids at Ludhiana during *kharif* 2003

Hybrids	Dates of Observations								
	10.7.03	21.7.03	1.8.03	12.8.03	22.8.03	1.9.03	10.9.03	20.9.03	Mean
	Mean number of *Geocoris* bug / plant								
1. RCH 134(*Bt*)*	1.00	0.67 (1.29)	0.70 (1.30)	0.73 (1.32)	1.47 (1.57)	0.97 (1.40)	4.10 (2.26)	1.93 (1.71)	1.45 (1.56)
2. RCH 134 (non-*Bt*)**	1.07	1.40 (1.55)	1.00 (1.41)	0.57 (1.25)	0.07 (1.03)	0.40 (1.18)	1.17 (1.47)	1.43 (1.56)	0.89 (1.37)
3. LHH 144**	0.97	0.60 (1.26)	1.67 (1.63)	1.03 (1.42)	0.47 (1.21)	0.90 (1.38)	1.30 (1.52)	2.00 (1.73)	1.12 (1.46)
CD (p=0.05)	NS	(0.13)	(0.10)	(0.12)	(0.09)	(0.11)	(0.08)	(0.07)	(0.03)
	Mean number of Yellow wasps / plant								
1. RCH 134(*Bt*)*	0.23 (1.11)	0.17	0.17	0.13	1.00 (1.41)	1.20 (1.48)	1.07 (1.44)	1.23 (1.49)	0.65 (1.28)
2. RCH 134 (non-*Bt*)**	0.03 (1.02)	0.10	0.17	0.20	0.67 (1.29)	0.80 (1.34)	0.83 (1.35)	0.83 (1.35)	0.46 (1.21)
3. LHH 144**	0.00 (1.00)	0.03	0.10	0.13	0.37 (1.16)	1.30 (1.52)	0.87 (1.37)	0.97 (1.40)	0.47 (1.21)
CD (p=0.05)	(0.06)	NS	NS	NS	(0.15)	(0.10)	(0.05)	(0.05)	(0.03)

Note: Figures in parentheses indicate "n+1 transformations.

* Sprayed against sucking pests only {one spray - imidacloprid 200 SL (11/7/2003)}

** Sprayed against sucking pests and bollworms {six sprays - imidacloprid 200SL (11/7), endosulfan 35EC (5/8), E-mite 50EC (24/8), acephate 75 SP (28/8), quinalphos 25EC (11/9) and acephate 75 SP (15/9/2003)}.

non-Bt cotton is due to more number of insecticidal sprays in non-*Bt* cotton that lead to effective control of pest population along with negative effect on the population of natural enemies. The negative effect of insecticides used for the control of pests on the population of natural enemies under Punjab conditions has already been studied by different workers (Sekhon, 1980; Singh, 1984; Sandhu, 1985) stands in line with the present studies.Cui and Xia (2000b) also reported that population of spiders and lacewing under natural control was 15.9 and 14 per cent and under integrated management practices was 11.8 and 139.5 per cent higher compared to non-Bt transgenic cotton hybrids. Studies conducted by Wu *et al.* (2003) also corroborate the present findings where they have reported that population of natural enemies was significantly higher in Bt cotton fields than those in the conventional cotton fields where insecticides were used for the control of cotton bollworm.

Shannon Weaver's index

Shannon Weaver's index $(\overline{H})$ was calculated from the data on population of natural enemies recorded on different dates in earlier experiment. The value of diversity index was comparatively higher (1.271, 1.296, 1.296 and 1.318) in Bt cotton hybrid RCH 134 as compared to non-Bt hybrids RCH 134 (1.102, 1.155, 1.238 and 1.281) and LHH

Table 3. Index of species diversity of natural enemies recorded on Bt and non-Bt cotton hybrids at Ludhiana during *kharif*, 2003

Hybrids	Shanon Weaver's Index on different dates							
	10.7.03	21.7.03	1.8.03	12.8.03	22.8.03	1.9.03	10.9.03	20.9.03
1. RCH 134(*Bt*)*	1.271	1.296	1.296	1.023	1.151	1.326	1.205	1.318
2. RCH 134 (non-*Bt*)**	1.102	1.155	1.238	1.084	1.141	1.323	1.340	1.281
3. LHH 144**	1.097	1.137	1.093	1.097	1.143	1.350	1.340	1.274

* Sprayed against sucking pests only {one spray - Confidor 200SL (11/7/2003)}

** Sprayed against sucking pests and bollworms {six sprays - imidacloprid 200SL (11/7), endosulfan 35EC (5/8), E-mite 50EC (24/8), acephate 75 SP (28/8), quinalphos 25EC (11/9) and acephate 75 SP (15/9/2003)}.

144 (1.097, 1.137, 1.093 and 1.274) in observations recorded on Jul 10, Jul 21, Aug 1 and Sept 20, 2003, respectively, whereas in rest of the observations it was comparable in Bt and non-Bt hybrids (Table 3). Higher value of index in case of RCH 134 (Bt) shows that general diversity was more in Bt cotton during the early growth period (July-August) and in end September also leading to more complex food chain which resulted in more stability of agro-ecosystem. However, the value of diversity index was maximum in LHH 144 (1.35 and 1.34) on Sept 1 and 10, respectively.

However, earlier workers have reported contrary results. Liu *et al.* (2002) reported more diversity index (0.771) in common cotton field than in Bt cotton field with natural enemies to control pests (0.221). So they reported that stability of arthropod in the common cotton field was better than that of the transgenic Bt cotton field. Men *et al.* (2003) reported that Bt cotton increased the diversity of arthropod communities and pest sub-communities; however, it decreased the diversity of natural enemy sub-communities. The present studies were carried out under similar environmental conditions, but the results of these studies cannot be compared with above references due to geographical differences.

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