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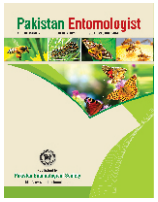

SEASONAL ABUNDANCE OF NON-TARGET NATURAL ENEMIES IN TRANSGENIC BT AND CONVENTIONAL COTTON

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ABSTRACT

Transgenic Bt cotton has now become a potential source for raising cotton yield due to its targeted control of bollworms, thus decreasing the dependence on insecticides. However, the impact of transgenic Bt crops on non-target natural enemies may be beneficial or harmful. A field experiment was conducted to evaluate the abundance of beneficial insects (predators and parasitoids) in Bt and non-Bt cotton under unsprayed condition. The available Bt (NIBGE-IR-3701, AARI-FH-114 and 4B-Tarzan-1) and non-Bt (NIBGE-NN3, NIAB-112 and AARI-FH-942) cotton cultivars were evaluated for the abundance of insect predators (*Geocoris* spp., *Coccinella septempunctata, Menochilus sexmaculata, Chrysoperla carnea*) and parasitoids (*Trichogramma* spp., *Apanteles*s pp.) throughout the growing season by sweep net methods. The results revealed no significant differences in the abundance of predators and parasitoids among Bt and non-Bt cotton, which indicate that transgenic Bt cotton has no impact on the abundance of non-target natural enemies. We can say that Bt cotton can be an important component of integrated pest management program in cotton agro-ecosystem.

Keywords: Bt cotton, Insect predators, Parasitoids

INTRODUCTION

Cotton has been genetically modified through recombinant DNA from *Bacillus thuringiensis* that contains delta endotoxin protein (Perlak *et al*., 1991) which is toxic to specific lepidopterous pests. Transgenic Bt cotton is grown extensively and preferred due to targeted control, less dependence on insecticides, yield maximization and higher production potential. Biological control has been a safer and long term solution for all of the insect pest problems mainly because of the environment friendly and self-perpetuating nature (Bale *et al*., 2008). Insect predators are important biological control agents (Sathe and Bhosle, 2001). Cotton crop hosts a rich diversity of beneficial insects that attack egg, larval, pupal and adult stages of different insect pests. Population of natural enemies is directly correlated with the host population, i.e. increase in one host species causes a proportional increase in its natural enemies and vice versa (Solangi *et al*., 2005).

Valuable research have been done to evaluate the impact of field grown Bt cotton on the non-target arthropods (Dutton *et al*., 2002; Torres and Ruberson, 2005, 2006; Sisterson *et al*., 2007). The non-significant impact of Bt toxin on the biology of insect predators and parasitoids has been well reported in literature (Wu and Guo, 2005). The higher abundance of predators (Green lace wing *Geocoris* spp.) and parasitoids (parasitic wasps) have been reported in transgenic Bt as compared to conventional cotton (Moar *et al.,* 2002). However, a number of studies have shown the negative impact of Bt cotton on the beneficial insects in laboratory (Hillbeck *et al*., 1999; Ponsard *et al*., 2002) and field conditions (Men *et al*. 2003; Pilcher *et al*., 2005). The increase

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in abundance of beneficial insects may be due to less use of insecticide in transgenic cotton (Cattaneo *et al*., 2006), however the decreased abundance may be correlated with the non-availability of host insects (Strickl and Annells, 2005; Torres and Ruberson, 2005). It is very difficult to extrapolate the laboratory studies to field conditions because Bt toxin responds much better in control condition due to greater exposure to Bt toxins than field conditions (Sears *et al.*, 2001). As cultivation of Bt cotton may or may not affect the natural beneficial insect's community, the present study was carried out to evaluate the abundance of insect predators and parasitoids in Bt and non-Bt cotton fields.

MATERIALS AND METHODS

The field experiment was conducted at Entomological Research Area, Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad. The experiment was laid out in a Randomized Complete Block Design (RCBD), consisting of two treatment sets of Bt cotton and non-Bt cotton varieties each with three replications. In one set three transgenic Bt cotton varieties viz., NIBGE-IR-3701, AARI-FH-114, 4B-Tarzan-1 and three non-Bt cotton varieties viz., NIBGE-NN3, NIAB-112, AARI-FH- 942 were sown in the 2nd week of April, 2012.The data regarding the abundance of beneficial insects (insect predators and parasitoids) were initiated at June 01 after each 15 days interval and continued up to the November 15, which result in 12 sampling dates. Sweep net method was done for measuring the abundance of canopy and foliage dwelling beneficial insects and sampling was done early in the morning because most of insects become active when temperature reach at 25-30°C (Garcia *et al.,* 1982). A standard sweep net (38-cm diameter) was swung in a figure-eight pattern (Naranjo, 2005). A total of 50 sweeps in each six varieties of cotton were taken randomly throughout the season at 15 days interval. All collected fauna per 50 sweeps were put into a plastic bag with a label and taken in the laboratory. The insect specimens were killed for sorting, identification and counting.

All data on population abundance of beneficial insects in both Bt and non Bt treatments were analyzed using analysis of variance (ANOVA) and means were compared by using Tucky's honestly significance difference (HSD) test.

RESULTS AND DISCUSSION

Insect predators observed in this study were *Coccinella septempunctata*, *Menochilus sexmaculata, Geocoris* spp. and *Chrysoperla carnea.* The parasitoids observed were *Trichogramma* spp. and *Apanteles* spp. The population of *Geocoris* spp. was recorded from June 15 and reached highest in numbers (3.22/50 sweeps) on September 01 and then these numbers declined onward to the last observation which was taken on November 15 (Table 1). Almost the same numbers (1.28/plant) were observed by Solangi *et al*. (2008) and Mari *et al*. (2007) for *Geocoris punctipes* while maximum population was observed from June to September by Khuhro *et al.* (2002). The average mean of all observation dates showed non-significant difference in the *Geocoris* abundance between Bt (1.37/50 sweeps) and non-Bt (1.26/50 sweeps) cotton (Table 1, Fig. 1). While Moar *et al*. (2002) observed higher abundance of predators (*Geocoris* spp., *Orius* sp., spiders, and green lacewings) and parasitoids (parasitic wasps, *Nabis* spp.) in transgenic Bt cotton as compared to the non-transgenic cotton. In another study Head *et al.* (2005) observed non-significant adverse impacts of Bt cotton on natural enemies population (*Geocoris* spp., lady beetles, *Orius* spp. and spiders) in comparison to insecticide-treated non-Bt cotton.

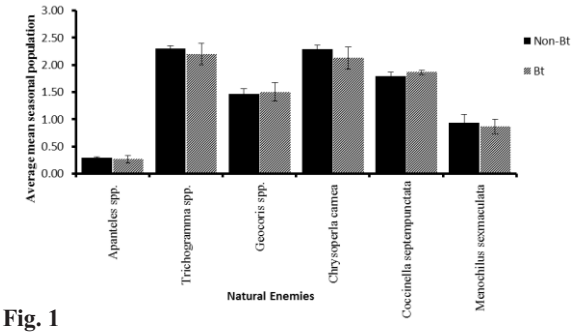

Fig. 1
Mean seasonal abundance of natural enemies in Bt and non-Bt cotton.

We observed *C. carnea* from August 01 which gradually reached peak population by September 15 (3.83/50 sweeps) and then these numbers declined onward (Table 1). Khuhro *et al*. (2002) observed *C. carnea* in 1st week of July while Mari *et al*. (2007) reported *C. carnea* as 2.07/plant in early September. The results showed a similar trend of population level in Bt and non-Bt cotton fields. The overall mean of all observation dates showed a non-significant difference of population abundance for *C. carnea* (Fig. 1) in Bt (2.07/50 sweeps) and non-Bt cotton (2.16/50 sweeps). Similar to our results Sisterson *et al*. (2007) observed no possible effects of Bt toxin on *C. carnea* abundance. Contrary to our results Wu *et al*. (2005) reported higher numbers of *C. carnea* in non-Bt than Bt cotton. Both coccinellid beetles, *C. septempunctata* and *M. sexmaculata* were observed in September 15 and increased gradually up to 2.56/50 sweeps in October 15 (2.56/50 sweeps) and then their numbers declined upto November 15 (Table 1). However, Khuhro *et al*. (2002) observed population of *Coccinella* spp. from June to September with maximum on 3rd week of July. While Ashfaq *et al.* (2011) observed the population of *C. septempunctata* from June 30 to September 29 with the maximum 1.42/leaf on August 10. The overall mean seasonal population showed no significant difference between Bt (*C. septempunctata* 1.46/50 sweeps, *M. sexmaculata* 0.82/50 sweeps) and non-Bt cotton (*C. septempunctata* 1.38/50 sweeps, *M. sexmaculata* 0.78/50 sweeps) (Fig.1). In support to our findings Head *et al*. (2005) reported a non-significant difference between the population dynamics of coccinellid beetles in the Bt and non-Bt cotton.

Parasitic wasp *Apanteles* spp. was noted during July 01 to November 15 and were higher on September 15 (2/50 sweeps) (Table 2). Mean seasonal population recorded was non-significantly differ with respect to Bt (0.92/50 sweeps) and non-Bt (0.86/50 sweeps) cotton varieties. Contrary to our results Pilcher *et al*. (2005) reported low parasitoids population in transgenic than that of non-transgenic cotton. Parasitoid wasp *Trichogramma* spp. was recorded from July

Table 1

Seasonal abundance of insect predators (per 50 sweeps) on Bt and non-Bt cotton at NIAB – Faisalabad Pakistan.

		Dates of observations										
Insects	Treatments	15/06/2012	1/7/2012	15/07/2012	1/8/2012	15/8/2012	1/9/2012	15/09/2012	1/10/2012	15/10/2012	1/11/2012	15/11/2012
Geocoris spp.	Bt varieties	0.11 ± 0.11	0.89 ± 0.29	1.22 ± 0.22	1.22 ± 0.22	2.89 ± 0.80	3.44 ± 0.29	2.67 ± 0.33	1.33 ± 0.33	0.67 ± 0.19	0.33 ± 0.19	0.33 ± 0.19
	Non-Bt varieties	0.33 ± 0.33	0.56 ± 0.11	1.00 ± 0.19	1.56 ± 0.29	2.78 ± 0.59	3.00 ± 0.33	2.11 ± 0.22	1.00 ± 0.38	1.00 ± 0.51	0.44 ± 0.11	0.11 ± 0.11
	F-calculated	0.31	0.73	4.00	1.00	0.23	4.00	1.00	2.97	0.75	0.24	0.58
	P-Value	0.63	0.48	0.18	0.42	0.68	0.18	0.42	0.22	0.47	0.67	0.52
	Tukey HSD	-	-	-	-	-	-	-	-	-	-	-
Chrysoperla carnea	Bt varieties	-	-	-	0.33 ± 0.19	1.00 ± 0.51	2.89 ± 0.80	4.00 ± 0.51	3.00 ± 0.19	2.11 ± 0.48	1.22 ± 0.22	-
	Non-Bt varieties	-	-	-	0.22 ± 0.22	1.78 ± 0.11	2.78 ± 0.59	3.67 ± 0.33	2.89 ± 0.29	2.22 ± 0.62	1.56 ± 0.29	-
	F-calculated				0.07	3.07	0.23	2.97	0.15	0.07	1.00	-
	P-Value				0.81	0.22	0.68	0.22	0.73	0.82	0.42	-
	Tukey HSD				-	-	-	-	-	-	-	-
Coccinella septempunctata	Bt varieties							0.44 ± 0.11	1.89 ± 0.29	2.44 ± 0.22	2.00 ± 0.19	0.56 ± 0.29
	Non-Bt varieties							0.56 ± 0.11	1.56 ± 0.11	2.67 ± 0.19	1.67 ± 0.19	0.44 ± 0.11
	F-calculated							1.00	3.00	4.00	0.75	0.08
	P-Value							0.42	0.22	0.18	0.47	0.8
	Tukey HSD							-	-	-	-	-
Menochilus sexmaculata	Bt varieties							0.11 ± 0.11	0.89 ± 0.22	0.89 ± 0.29	1.56 ± 0.11	0.67 ± 0.19
	Non-Bt varieties							0.22 ± 0.11	0.78 ± 0.11	0.56 ± 0.11	1.22 ± 0.29	1.00 ± 0.51
	F-calculated							0.25	1.00	0.73	3.06	0.75
	P-Value							0.66	0.42	0.48	0.22	0.47
	Tukey HSD							-	-	-	-	-

Table 2

Seasonal abundance of insect parasitoids (per 50 sweeps) on Bt and non-Bt cotton at NIAB – Faisalabad Pakistan.

		Dates of observations									
Insect pests	Treatments	1/7/2012	15/07/2012	1/8/2012	15/8/2012	1/9/2012	15/09/2012	1/10/2012	15/10/2012	1/11/2012	15/11/2012
Trichrogramma spp.	Bt varieties	0.11 ± 0.11	1.11 ± 0.11	1.78 ± 0.40	2.33 ± 0.33 A	3.22 ± 0.29	3.67 ± 0.38	3.22 ± 0.11	2.33 ± 0.69	2.11 ± 0.22	0.89 ± 0.22
	Non-Bt varieties	0.22 ± 0.11	0.78 ± 0.29	2.44 ± 0.29	2.89 ± 0.29 B	3.00 ± 0.33	3.56 ± 0.40	2.44 ± 0.29	2.67 ± 0.00	1.33 ± 0.38	0.78 ± 0.11
	F-calculated	0.25	2.97	11.88	15.00	4.00	0.06	12.09	0.24	12.09	1.00
	P-Value	0.66	0.22	0.07	0.03	0.18	0.83	0.07	0.67	0.07	0.42
	Tukey HSD	-	-	-	5.16	-	-	-	-	-	-
Apanteles spp	Bt varieties	0.33 ± 0.19	0.33 ± 0.19	0.44 ± 0.11	1.11 ± 0.11	1.33 ± 0.33	1.78 ± 0.48	1.56 ± 0.29	1.11 ± 0.11	0.56 ± 0.11	0.67 ± 0.33
	Non-Bt varieties	0.00	0.22 ± 0.11	0.56 ± 0.29	0.78 ± 0.19	1.89 ± 0.48	2.22 ± 0.29	1.22 ± 0.29	0.78 ± 0.29	0.67 ± 0.19	0.33 ± 0.19
	F-calculated	2.97	0.15	0.26	0.14	0.48	1.00	0.75	2.97	1.00	0.43
	P-Value	0.22	0.73	0.66	0.74	0.55	0.42	0.47	0.22	0.42	0.58
	Tukey HSD	-	-	-	-	-	-	-	-	-	-

to November with maximum numbers recorded on September 15 (3.61/50 sweeps) (Table2). Similar to our findings Ahmad *et al*. (1998) observed the population of *Trichogramma* spp. in cotton from August to October. In our results mean seasonal population of all dates were found non-significantly different among Bt (2.07/50 sweeps) and non-Bt cotton (1.98/50 sweeps) (Fig.1). However, Wu and Guo (2005) observed higher population of predators and less population of parasitic wasp viz., *Microplitis*, *Campoletis* and *Trichogrammatids* in Bt as compared to non-Bt cotton. Our results indicate that cultivation of Bt cotton had no significant impacts on non-target generalist predators and parasitoids, we can say that Bt cotton can be an important component of integrated pest management in cotton agro-ecosystem.

REFERENCES

Ahmad N., M. Ashraf, B. Fatima and Nasrullah, 1998. Potential of *Trichogramma chilonis* to parasitize eggs of Pink, Spotted and Spinny bollworms of cotton. Pak. J. Zool., 30: 39-40.

Ashfaq, S., I.A. Khan, A.U.R. Saljoqi, S. Ahmad, F. Manzoor, K. Sohail, K. Habib and A. Sadozai, 2011. Population dynamics of insect pests of cotton and their natural enemies. Sarhad J. Agric., 27(2): 251-253.

Bale, J.S., J.C. Van Lenteren and F. Bigler, 2008. Biological control and sustainable food production. Phil. Trans. R. Soc. B., 363: 761–776.

Cattaneo, M.G., C. Yafuso, C. Schmidt, C. Huang, M. Rahman, C. Olson, C. Ellers-Kirk, B.J. Orr, S.E. Marsh, L. Antilla, P. Dutilleul and Y. Carriere, 2006. Farm-scale evaluation of the impacts of transgenic cotton on biodiversity, pesticide use, and yield. Proc. Natl. Acad. Sci. U.S.A., 103(20): 7571-7576.

Dutton, A., H. Klein, J. Romies and F. Bigler, 2002. Uptake of Bt toxin by herbivores feeding on transgenic maize and consequences for the predators *Chrysoperla carnea*. Ecol. Entomol., 27(4): 441-447.

Garcia, A., D. Gonzalez, and T.F. Leigh, 1982. Three methods for sampling arthropod numbers on California cotton. Environ. Entomol., 11: 565-572.

Head, G., M. Moar, M. Eubanks, B. Freeman, J. Ruberson, A. Hagerty and S. Turnipseed, 2005. A multiyear large scale comparison of arthropod population on commercially managed Bt and non-Bt cotton fields. Environ. Entomol., 34(5): 1257-1267.

Hillbeck, A., W.J. Moar, M. Pusztai-Carey, A. filippini and F. Bigler, 1999. Prey mediated effects of Cry1Ac toxin and Cry2Ac protoxin on the predator *Chrysoperla carnea*. Entomol. Exp. Et. Applicata., 91(2): 305-316.

Khuhro R.D., I.A. Nizamani and M.A. Talpur, 2002. Population abundance of predators in alfalfa and cotton fields at Tandojam. Pak. J. App. Sci., 2(3): 300-303.

Mari J.M., S.M. Nizamani and M.K. Lohar, 2007. Population fluctuation of sucking insect pests and predators in cotton ecosystem. African Crop Sci. Conf. Proc., 8: 929-934.

Men, X.Y., F. Ge, X.H. Liu and E.N. Yardim, 2003. Diversity of arthropod communities in transgenic Bt cotton and non-transgenic cotton agro ecosystems. Environ. Entomol., 32(2): 270-275.

Moar, W.J., M. Eubanks, B. Freeman, S. Turnipseed, J. Ruberson and G. Head, 2002. Effect of Bt cotton on biological control agents in the Southern United States. Paper presented at the first Int. Symp. on Biological Control of Arthropods, Honolulu, Hawaii, U.S. Department of Agriculture, Forest Service, Morgantown, West Virginia, USA., 14-18 January, 2002.

Naranjo, S.E., 2005. Long-term assessment of the effects of transgenic Bt cotton on the abundance of non-target arthropod natural enemies. Environ. Entomol., 34(5): 1193-1210.

Perlak, F.J., R.L. Fuchs, D.A. Dean, S.L. Mcpherson and D.A. Fischhoff, 1991. Modification of the coding sequence enhances plant expression of insect control protein genes. Proc. Nat. Acad. Sci., USA., 88(8): 3324-3328.

Pilcher, C.D., M.E. Rice and J.J. Obrycki, 2005. Impact of transgenic *Bacillus thuringiensis* corn and crop technology on five non-target arthropods. Environ. Entomol., 34(5): 1302-1316

Ponsard, S., A.P. Gutierrez and N.J. Mills, 2002. Effects of Bt toxin (Cry1Ac) in transgenic cotton on the adult longevity of four heteropteran predators Environ. Entomol., 31(6): 1197-1205.

Sathe, T.V. and Y.A. Bhosle, 2001. Insect pests' predators. Daya publishing house. pp. 1-69.

Sears, M.K., R.L. Hellmich, D.E. Stanley-Horn, K.S. Oberhauser, J.M. Pleasants, H.R. Mattila, B.D. Siegfried and G.P. Dively. 2001. Impact of Bt corn pollen on monarch butterfly populations: a risk assessment. Proc. Natl. Acad. Sci. U.S.A. 98: 11937-11942.

Sisterson, M.S., Y. Carrière, T.J. Dennehy and B.E. Tabashnik, 2007. Non-target effects of transgenic insecticidal crops: implications of source-sink population dynamics. Environ. Entomol., 36: 121–127.

Solangi, B.K., M.A. Talpur and I.A. Nizamani, 2005. Population of spotted bollworm *Earis* spp. and its predators (natural enemies) on cotton. J. App. Sci., 5 (8): 1402-1404.

Solangi G.S., G.M. Mahar and F.C. Oad, 2008. Presence and abundance of different insect predators against sucking insect pest of cotton. J. Entomol., 5(1): 31-37.

Strickl, G.R. and A.J. Annells, 2005. The seasonal dynamics of arthropods in conventional, Ingard® and Bollgard II® cotton genotypes in a winter production system at Kununurra, Bentley Delivery Centre WA 6983 © State of Western Australia, pp. 1-13.

Torres, J.B. and J.R. Ruberson, 2005. Canopy and ground-dwelling predatory arthropods in commercial Bt and non-Bt cotton fields: Patterns and mechanism. Environ. Entomol., 34(5):1242-1256.

Torres, J.B. and J.R. Ruberson, 2006. Interactions of Bt-cotton and the omnivorous big-eyed bug *Geocoris punctipes* (Say), a key predator in cotton fields. Biol. control, 39: 47-57.

Wu, K., K. Lin, J. Maio and Y. Zhang, 2005. Field abundance of insect predators and insect pests on delta endotoxin-producing transgenic cotton in northern China.2nd inter. Symp. Biol. Cont. Arthrop., Davos, Switzerland, 12-16 Sept., 362-368.

Wu, K.M and Y.Y. Guo, 2005. The evolution of cotton pest management practices in China. Annu. Rev. Entomol., 50: 31-52.