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Comparative studies on the pollinator fauna and foraging activity of honey bees on Bt and non-Bt cotton hybrids*

VINAYAK PISE AND SHASHIDHAR VIRAKTAMATH

Department of Agricultural Entomology, College of Agriculture, Dharwad
University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India
E-mail: shashiv777@gmail.com

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Abstract: Comparative studies on the pollinator fauna and foraging activity of honey bees were made on Bt (NCS-145) and non-Bt (DHH-11) cotton genotypes during *kharif,* 2010 at Dharwad, Karnataka. Eighteen species of pollinators were found foraging on Bt and non-Bt cotton blossoms. Of these, nine species belonged to the order Hymenoptera, eight to Lepidoptera and one to Diptera. Among Hymenoptera, *Apis dorsata* F. was the most dominant with a relative abundance of 29.83 per cent followed by *Apis cerana* F. (25.21%) and *Apis florea* F. (22.54%). The remaining pollinators constituted 22.42 per cent. Foraging activity of honey bees was seen throughout the day with peak activity at 12.00 h and throughout the flowering period in both Bt and non-Bt cotton hybrids. However, there was no significant difference among Bt and non-Bt cotton hybrids with respect to foraging activity of honey bees.

Key words: Bt cotton, Foraging activity, Honey bees, Non-Bt cotton, Pollinator fauna

Introduction

Cotton is generally treated as a self-pollinated crop but often cross pollinated by the bees (Ward and Ward, 2002; Dastagiri *et al.,* 2013). Pollen grains of cotton are relatively heavy and sticky in nature. Therefore, wind is not a factor in the pollination of cotton. About 50 ovules must be fertilized if full complement of seeds is to be produced. Hence, at least 50 viable pollen grains must contact the stigma (McGregor, 1976). Cotton is known to be the excellent source of nectar from flowers, circumbracts, sub bracts and unipapilla (Punit *et al.,* 1999; Delaplane and Mayer, 2000). Introduction of Bt cotton hybrids has dramatically reduced insecticidal sprays on cotton. This has opened an avenue to utilize bees for pollination of Bt cotton. Bt genotypes had no impact on insect abundance and diversity compared to non Bt plants (Hofs *et al.,* 2008). Hence, the present studies were made to compare the pollinator fauna and foraging activity of honey bees on Bt and non-Bt cotton hybrids under Indian conditions.

Material and methods

The investigations were carried out at the Main Agricultural Research Station of the University of Agricultural Sciences, Dharwad. Two cotton genotypes namely Bt cotton NCS-145 BG-II and non-Bt cotton DHH-11 were grown in two plots of one acre each separately during *kharif* 2010 by following recommended package of practices. No plant protection measures were taken during entire flowering period in both the genotypes. In each cropped area three plots of 10 x 10 m were selected.

Different pollinator species visiting during peak activity period *i.e.* from 1000 h to 1200 h and 1400 h to 1600 h were recorded for five minutes in each of these plots. Different honey bee species visiting flowers were identified and counted in the field itself. Other pollinators visiting Bt and non-Bt cotton flowers were also collected using hand net and were identified subsequently.

The comparative study on foraging activity of different species of honey bees was made by selecting ten flowers randomly in each of the selected plot and the number of different pollinators visiting these flowers per minute were recorded from 0800 to 1600 h at two hourly intervals in both the genotypes separately. These observations were made on alternate days starting from second day to 50th day of flowering period. The data was subjected to ANOVA after $\sqrt{x+0.5}$ transformations.

Results and discussion

As many as 18 species of pollinators were recorded visiting Bt and non-Bt cotton blossoms (Table 1). Among these, nine species belonged to the order Hymenoptera, eight to Lepidoptera and one to Diptera. These pollinators were common in both Bt and non-Bt cotton hybrids. Among Hymenoptera, *A. dorsata* formed the most dominant pollinator with a relative abundance of 29.83 per cent followed by *A. cerana* (25.21%) and *A. florea* (22.54%). The remaining pollinators constituted 22.42 per cent.

The present investigations are in close agreement with the reports of McGregor (1976), Tanda (1984) and Delaplane and Mayor (2000) who reported that Hymenopterans were more abundant than any other pollinators on cotton. Similarly, El-Sarrang *et al.* (1993) noticed that Hymenopterans constituted 56 per cent of total insect visitors on cotton flowers. Mohana Rao *et al.* (1996) reported that pollinating insects that visited cotton blossoms were *A. dorsata, A. cerana, A. florea* and solitary bees. The results are also in line with Nachappa (2004) who reported that honey bees constituted 75 per cent of the total visitors of Bt cotton. Similarly, Ganapathi (2005) and Naik (2010) found honey bees as the dominant pollinators of Bt cotton. Pollinator fauna in Bt as well as non-Bt cotton did not vary.

Foraging activity of all the honey bees was found throughout the day starting from 0800 to 1600 h in both Bt and

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Table 1. Pollinator fauna of Bt (NCS-145, BG II) and non-Bt cotton (DHH-11) hybrids

Sl. No.	Pollinators	Systematic position	Relative abundance (%)
1.	*Apis dorsata* Fabricius	Hymenoptera : Apidae	29.83
2.	*Apis cerana* Fabricius	Hymenoptera : Apidae	25.21
3.	*Apis florae* Fabricius	Hymenoptera : Apidae	22.54
4.	*Xylocopa verticalis* Lapel	Hymenoptera : Apidae	22.42
5.	*Ceratina* sp.	Hymenoptera : Apidae	
6.	*Thyreus* sp.	Hymenoptera : Apidae	
7.	*Megachile lanata* (Fabricius)	Hymenoptera : Megachilidae	
8.	*Megachile* sp.	Hymenoptera : Megachilidae	
9.	*Vespa* sp.	Hymenoptera : Vespidae	
10.	*Hypolimnas missipus* (Linneaus)	Lepidoptera : Nymphalidae	
11.	*Byblia ilithyia* (Drury)	Lepidoptera : Nymphalidae	
12.	*Melanitis leda* (Linn.)	Lepidoptera : Nymphalidae	
13.	*Ariadane merione* (Cramer)	Lepidoptera : Nymphalidae	
11.	*Catopsilia pyranthe* (Linnaeus)	Lepidoptera : Pieridae	
15.	*Danaus chrysippus* (Linnaeus)	Lepidoptera : Danaidae	
16.	*Amata* sp.	Lepidoptera : Arctiidae	
17.	*Acherontia styx* (Westwood)	Lepidoptera : Noctuidae	
18.	*Eristalis* sp.	Diptera : Syrphidae	

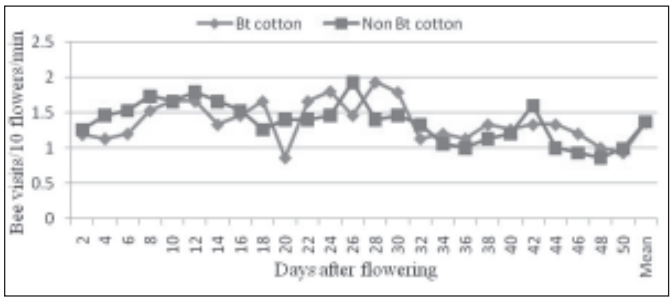

Fig. 1. Foraging activity of *Apis dorsata* on Bt (NCS-145) and non-Bt (DHH-11) cotton

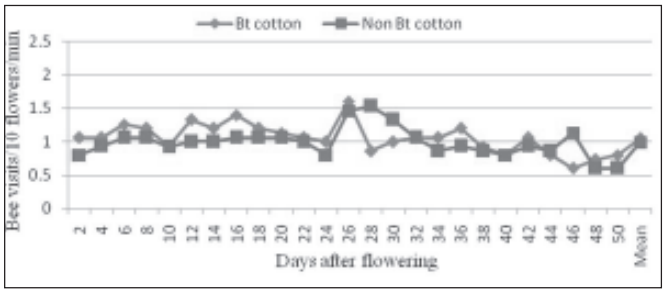

Fig. 2. Foraging activity of *Apis ceranaon* Bt (NCS-145) and non-Bt (DHH-11) cotton

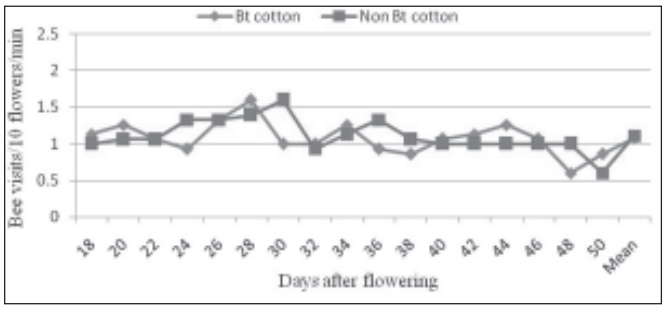

Fig. 3. Foraging activity of *Apis dorsata* on Bt (NCS-145) and non-Bt (DHH-11) cotton

non-Bt cotton hybrids. However, the peak activity was noticed at 1200 h (Table 2) which indicated that bees were attracted to nectar secreted by cotton flowers in the afternoon as the glands secreting the nectar would be active during mid-day. The mid-day activity of bees due to more secretion of concentrated honey in cotton has already been evidenced earlier by several researchers (Wafa and Ibrahim, 1960; Mahamood *et al.,* 1990). Mohana Rao *et al.* (1996) also reported the foraging activity of *A. dorsata* and *A. cerana* throughout the day in seed production fields of cotton. Ganapathi (2005) observed the peak activity of *A. dorsata, A. mellifera, A. cerana* and *A. florea* at 1200 h.

All the bees were found foraging on cotton blossoms uniformly in both the cotton genotypes during the entire flowering period (Figs 1 to 3). This was due to a longer flowering periods with staggered pattern of blossoming in cotton. This pattern of flowering provides a new flush of flowers daily during the entire flowering period for honey bees. These observations corroborate with the findings of Naik (2010) and Ganapathi (2005) who reported uniform activity of honey bees on Bt cotton hybrid throughout the day during the entire flowering period.

The overall mean bee visits of *A. dorsata, A. cerana* and *A. florea* in Bt cotton (1.37, 1.05 and 1.08 bees/10 flowers/min,

Table 2. Comparative foraging activity of *Apis dorsata, Apis cerana* and *Apis florea* on Bt cotton (NCS-145 BG II) and non Bt cotton (DHH-11)

Treatments	Bees /10 flowers/min on								
	Apis dorsata			*Apis cerana*			*Apis florea*		
	Bt cotton	Non-Bt cotton	Mean*	Bt cotton	Non-Bt cotton	Mean*	Bt cotton	Non-Bt cotton	Mean*
0800 h	1.05(1.24)	0.94(1.18)	0.99(1.20)^{c}	0.70(1.09)	0.57(1.02)	0.64(1.05)^{c}	1.02(1.21)	1.15(1.27)	1.09(1.24)^{c}
1000 h	1.90(1.54)	1.98(1.57)	1.94(1.55)^{b}	1.70(1.48)	1.56(1.42)	1.63(1.45)^{b}	1.62(1.45)	1.53(1.42)	1.58(1.43)^{b}
1200 h	2.65(1.76)	2.69(1.78)	2.67(1.77)^{a}	2.02(1.58)	1.93(1.55)	1.98(1.56)^{a}	2.00(1.57)	1.90(1.54)	1.95(1.55)^{a}
1400 h	0.74(1.10)	0.65(1.06)	0.69(1.08)^{d}	0.50(0.99)	0.48(0.98)	0.49(0.98)^{d}	0.47(0.97)	0.52(1.01)	0.50(0.99)^{d}
1600 h	0.49(0.99)	0.54(1.01)	0.51(1.00)^{e}	0.33(0.90)	0.41(0.94)	0.37(0.92)^{d}	0.29(0.88)	0.43(0.95)	0.36(0.92)^{d}
Mean	1.37(1.33)	1.36(1.32)	-	1.05(1.21)	0.99(1.18)	-	1.08(1.22)	1.10(1.24)	-
		S.Em.±	C.D. (0.05)		S.Em.±	C.D. (0.05)		S.Em.±	C.D. (0.05)
Treatment (T)		0.02	0.06		0.02	0.06		0.02	0.07
Variety (V)		0.01	NS		0.01	NS		0.01	NS
Treatment x Variety (T x V)		0.03	NS		0.03	NS		0.03	NS

NS - Non significant, Figures in parentheses are $\sqrt{(x + 0.5)}$ transformed values, *Means of all the observations of Bt and non-Bt cotton.

respectively) was statistically on par with the overall mean bee visitation on non-Bt cotton with 1.36, 0.99 and 1.10 bees/10 flowers/min, respectively (Table 2). This showed that there was no effect on foraging activity of honey bees due to transgenic cotton and also indicated that honey bees have equal preference for Bt as well as non-Bt cotton hybrids. Similar conclusion has also been made by Nachappa and Viraktamath (2004) and Nachappa (2004). The mean bee visitation did not differ between Bt and non-Bt cotton. Similarly, Hofs *et al.* (2008) reported that Bt genotypes had no impact on insect abundance and diversity compared to non-Bt plants.

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