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Insect-leafhoppers (Hemiptera: cicadellidae) of BT and non-BT cotton fields

Modala Mallesh*, Ch. Sravanthy
Environmental Biology Lab, Department of Zoology, Kakatiya University, Warangal, Telangana, India

Abstract
This study was conducted to investigate 'Seasonal diversity and abundance of insect-leafhoppers in Bt and non-Bt cotton fields of Nalgonda district of Telangana state, India.' Sweep net and hand-picking method was used for the collection of insect-leafhoppers. we observed two species of insect-leafhoppers in Bt cotton and four species insect-leafhoppers in non-Bt cotton fields during 2018-2019 cotton season and three species insect-leafhoppers in Bt cotton and five species insect-leafhoppers in non-Bt cotton fields during 2019-2020 cotton season. We did not find insect-leafhoppers in July, 1-species of insect-leafhoppers in August, 1- species in September, 1-species in October, 2-species in November, 1-species in December and 1-species in January on Bt cotton and we did not find insect-leafhoppers in July, 1-species in August, 1- species in September, 1-species in October, 3-species in November, 2-species in December and 1-species in January on non-Bt cotton fields during 2018-2019 cotton cropping season and We did not find insect-leafhoppers in July, 1-species in August, 1- species in September, 3-species in October, 3-species in November, 3-species in December and 1-species in January on Bt cotton and We did not find insect-leafhoppers in July, 1-species in August, 1- species in September, 5-species in October, 5-species in November, 3-species in December and 1-species in January on non-Bt cotton fields during 2019-2020 cotton cropping season. Seasonal diversity and abundance of insect-leafhoppers showed lower differences between Bt and non-Bt cotton fields. Ecological indexes were calculated.

Keywords: insect-leafhoppers, Bt cotton, non-Bt cotton, sweep net and seasonal diversity

Introduction
Cotton (*Gossypium hirsutum* L), is a major Kharif crop in India. It is a king of fiber crops, plays a vital role in Indian agriculture-based economy and also is a major source of foreign exchange earnings. In India, during 2019-2020 Acreage under cotton increased by 6% to 133 lakh ha as against 126 lakh ha in 2018-2019 cotton season. As a result, India cotton production has increased by 8% to 357 lakh bales as against 330 lakh bales of 2018-19 (Annual report 50th CCI, 2020). In India, during 2017-2018 Telangana has the largest acreage of 18.97 lakh ha with production and productivity of 55 lakh bales and 492.8 kg ha-1, respectively (Agriculture statistics, Govt of India, 2018). Cotton is grown in almost all districts of Telangana state. It is the prime cash crop of India, growing on large scale in Telangana, Andhra Pradesh, Madhya Pradesh, Punjab, Rajasthan, Haryana, Tamil Nadu, Karnataka, Maharashtra, and Uttar Pradesh. This crop is severely attacked by number of pests (David and Anantha Krishnan, 2004) [6]. Nearly 1326 insects and mites all over the world and about 200 in India have been recorded as pests of cotton (Balakrishnan *et al*., 2010) [5]. India contributed about 12% of the total cotton production, mainly due to low yield potentials of Indian cottons and heavy damage by insect pests.
Cotton insect pests primarily are divided into sucking pests and bollworms. About 1326 insect pests have been reported to cause damage to the cotton crop. among them, only a dozen insect pests are major and half of them are key pests which cause losses to the extent of 30-80 %. Cotton is an excellent reproductive host for many sucking insects such as leafhopper; *Amrasca* sp, *Chlorotettix* sp and *Empoasca* sp. The estimated loss due to sucking pests is up to 21.20 % (Dhawan *et al*., 1998) [8]. In India, more than 90 % area is under Bt cotton which is susceptible to sucking pests (Hofs JL *et al*., 2004; Sharma HC *et al*., 2006; Kranthi KR 2012) [12, 19, 15]. Among serious pests, sucking pests like leafhoppers are important and cause significant yield loss. Insect-leafhoppers are serious pest among the sucking group and its heavy infestation may cause pre-mature shedding of leaves, flower buds and bolls (Mahmood *et al*., 1988; Khan *et al*., 1993) [18, 13] found highly significant Correlation in between hair density and jassid infestation to cotton. These are major sucking pests throughout the crop growth (Kumar and Singh, 2002) [16], the nymphs and adults suck the sap from leaves and cause phytotoxic symptoms know as hopper burn occurs in all the cotton growing tracts of India (Shivanna *et al*., 2009) [21] and are an important sporadic pest. nInsect-Leafhoppers can transmit diseases such as viruses and mycoplasma.
The main objective of this study was to investigate 'Seasonal diversity and abundance of insect-leafhoppers in Bt and non-Bt cotton fields of Nalgonda district of Telangana state, India.'

Materials and methods
The study was conducted at Palem village, Nakrekal Mandal, Nalgonda District, Telangana State of Bt cotton (SRCH-639 BG II) and non-Bt cotton fields during 2018-2019 and 2019-2020 cotton cropping seasons. It is located around 17˚ 13' 49''N and 79˚ 28' 04'' E. Sample was collected, every month from July 2018 to January

2019 and July 2019 to January 2020 in the morning because most of insects become active when temperature is about 25˚c - 30˚c (Garcia *et al*., 1982) [10]. Sweep net and hand-picking method was used for the collection of insect-leafhoppers on Bt and non-Bt cotton plants (Van den Berg *et al*., 1990) [22]. For leafhopper investigation 5-plots each having area 5m x 5 m was selected on both Bt and non-Bt cotton fields. Whole plants were observed visually for insect-leafhoppers. The whole plant was observed from top to bottom and both sides (Lower and upper sides) of the plant leaves. The insect leafhopper population was carefully counted with help of 5x magnifier lens. Insect-leafhoppers were preserved in 70 percent ethyl alcohol in glass vials of size 10 cm x 2.5 cm and labeled. Insect-leafhopper species were identified with the help of Guide on cotton pests and predators (Dileep Kumar *et al*., 2008) [9] by Regional Agricultural Research Station, PJTSAU Warangal and Literature.
We calculated Diversity indices of insect-leafhopper species i.e.,

- Species diversity (Shannon-Wiener Index),
- Species richness (Margalefs Index) &
- Species evenness (Pielou Evenness Index).

Species diversity [Shannon-Wiener index (H]

$$H= -\sum P_i \log P_i$$

Where, H = Shannon – Weiner index; ∑= Sum; Pi = ni /N; ni = Number of individuals of each species in the sample; N = Total number of individuals of all species in the sample.
Species evenness [Pielou Evenness Index (J)]

$$J=H/H_{max}$$

Where, J = Evenness index; H= Shannon – Weiner index; $H_{max} = \log S$; S = number of species.
Species richness [Margalef' s Index(D)]

$$D=\frac{S-1}{\log N}$$

Where, D= Species richness; S= total number of species; N= total number of individuals.

Results and Discussion
We collected 1724 individuals from Bt cotton field and 1935 individuals from non-Bt cotton field during 2018-19 cotton cropping season and 2250 individuals from Bt cotton and 2670 individuals from non-Bt cotton field during 2019-20 cotton cropping season. Out of them, we observed two species of insect-leafhoppers in Bt cotton and four species insect-leafhoppers in non-Bt cotton fields during 2018-2019 cotton season and three species insect-leafhoppers in Bt cotton and five species insect-leafhoppers in non-Bt cotton fields during 2019-2020 cotton season (Table 1-2).
The species *Amrasca biguttula biguttula* (Indian cotton jassid) and *Chlorotettix* sp (Deltocephaline leafhopper) were observed in both Bt and non-Bt cotton fields during both 2018-2019 and 2019-2020 cotton seasons. The species *Dalbulus maidis* (Maize leafhopper) was observed in non-Bt cotton fields during 2019-2020 cotton cropping season only. The species *Empoasca* sp (Smaller green leafhopper) was recorded in non-Bt cotton fields only during 2018-2019 cotton season and in both Bt and non-Bt cotton fields during 2019-2020 cotton seasons. The species *Jikradia olitoria* (Brown leafhopper/Coppery leafhopper) was observed in non Bt cotton fields only during both 2018-2019 and 2019-2020 cotton seasons (Table 1-2).

Table 1: List of insect-leafhoppers on Bt and non-Bt cotton fields during 2018-2019 cotton season

Order	Family	Species		
		Bt	**Non-Bt**	**Common Name**
Hemiptera	Cicadellidae	*Amrasca biguttula biguttula* (Ishida)	*Amrasca biguttula biguttula* (Ishida)	Indian cotton jassid
		Chlorotettix sp	*Chlorotettix* sp	Deltocephaline leafhopper
		-	*Empoasca* sp	Smaller green leafhopper
		-	*Jikradia olitoria* (Say)	Brown leafhopper/Coppery leafhopper

Table 2: List of insect-leafhoppers on Bt and non-Bt cotton fields during 2019-2020 cotton season

Order	Family	Species		Common Name
		Bt	Non-Bt	
Hemiptera	Cicadellidae	*Amrasca biguttula biguttula* (Ishida)	*Amrasca biguttula biguttula* (Ishida)	Indian cotton jassid

		Chlorotettix sp	*Chlorotettix* sp	Deltocephaline leafhopper
		-	*Dalbulus maidis* (DeLong)	Maize leafhopper
		Empoasca sp	*Empoasca* sp	Smaller green leafhopper
		-	*Jikradia olitoria* (Say)	Brown leafhopper/Coppery leafhopper

Seasonal Diversity & Abundance

We did not find insect-leafhoppers in July, 1-species of insect-leafhoppers in August, 1- species in September, 1-species in October, 2-species in November, 1-species in December and 1-species in January on Bt cotton and we did not find insect-leafhoppers in July, 1-species in August, 1- species in September, 1-species in October, 3-species in November, 2-species in December and 1-species in January on non-Bt cotton fields during 2018-2019 cotton cropping season (Figure 1) and We did not find insect-leafhoppers in July, 1-species in August, 1- species in September, 3-species in October, 3-species in November, 3-species in December and 1-species in January on Bt cotton and We did not find insect-leafhoppers in July, 1-species in August, 1- species in September, 5-species in October, 5-species in November, 3-species in December and 1-species in January on non-Bt cotton fields during 2019-2020 cotton cropping season (Figure 2). Seasonal diversity and abundance of insect-leafhoppers showed lower differences between Bt and non-Bt cotton fields (Figure 1, 2)

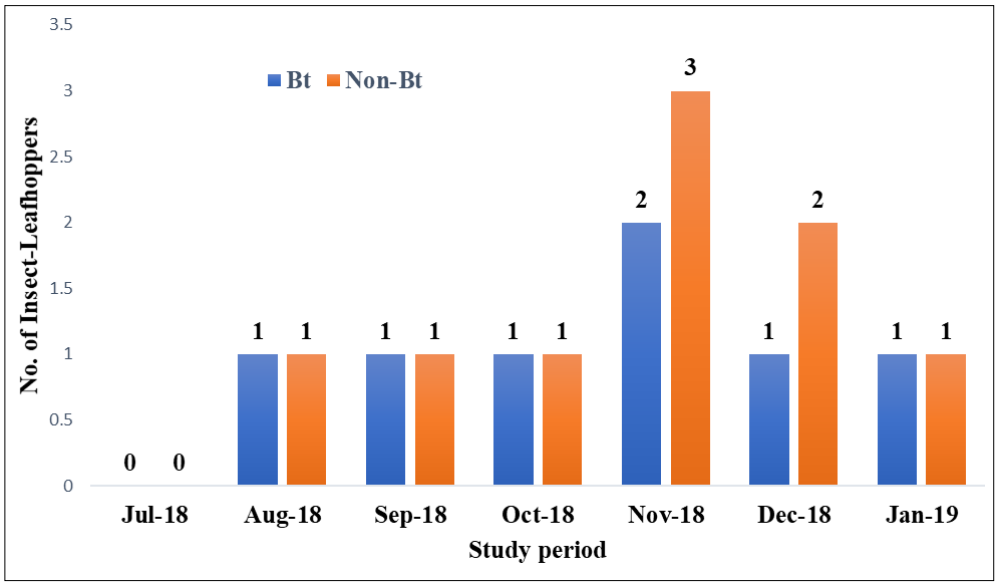

Fig 1: Seasonal diversity & abundance of total insect-leafhoppers in Bt and non-Bt cotton fields during 2018-2019 cotton season.

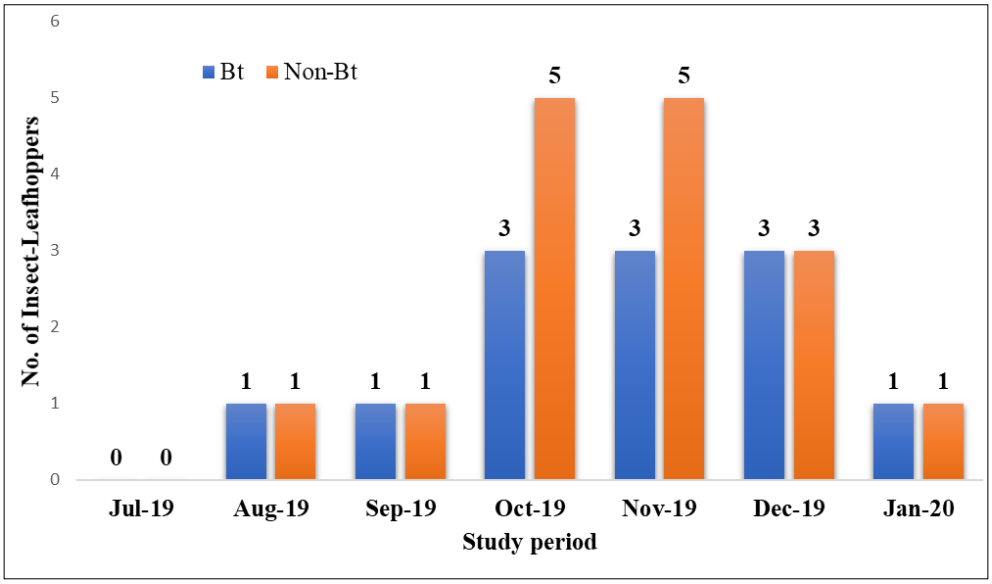

Fig 2: Seasonal diversity & abundance of total insect-leafhoppers in Bt and non –Bt cotton fields during 2019-2020 cotton season.

The species *A. biguttula biguttula* was noticed in both Bt and non-Bt cotton fields from August to December, the species *Chlorotettix* sp was noticed in both Bt and non-Bt cotton fields in November, the species *J. olitoria* was

noticed in November on non-Bt cotton fields only and the species *Empoasca* sp was noticed in December on non-Bt cotton fields during 2018-19 cotton season and The species *A. biguttula biguttula* was noticed in both Bt and non-Bt cotton fields from August to December, the species *Chlorotettix* sp was noticed in both Bt and non-Bt cotton fields from October to December, The species *D. maidis* was noticed from October to December in non-Bt cotton fields only, The species *Empoasca* sp was noticed from October to December in both Bt and non-Bt cotton fields only and The species *J. olitoria* was noticed from October to November in non-Bt cotton fields during 2019-20 cotton season.

Cotton jassid (*Amrasca biguttula biguttula*)

The incidence of Cotton jassid was noticed from 33rd SMW (Standard Meteorological Week) (August-2018) to till end of the season in both Bt and non-Bt cotton fields and peak (102 ± 6.188 in Bt cotton, 98 ± 4.110 in non-Bt cotton) was noticed from 36th SMW to 39th SMW (September-2018) during 2018-2019 cotton season. The incidence of Cotton jassid was noticed from 33rd SMW(August-2019) to till end of the season in both Bt and non-Bt cotton fields and peak with 78.6 ± 6.071 from 40th SMW to 44th SMW(October-2019) in Bt cotton, 71.2 ± 6.077 from 36th SMW to 39th SMW (September-2019) in non-Bt cotton was noticed during 2019-2020 cotton season (Table 3).

Table 3: Seasonal diversity and Mean abundance of Cotton jassid (*Amrasca biguttula biguttula*) in Bt and non-Bt cotton fields during 2018-2020

SI. No	Month of observation	Mean ± SE of *Amrasca biguttula biguttula*			
		2018-2019		2019-2020	
		Bt cotton	Non-Bt cotton	Bt cotton	Non-Bt cotton
1	July	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
2	August	22.4 ± 1.208	23.4 ± 1.208	20 ± 1.612	22 ± 1.612
3	September	102 ± 6.188	98 ± 4.110	65 ± 4.538	71.2 ± 6.077
4	October	77.4 ± 6.249	84.6 ± 4.308	78.6 ± 6.071	50.2 ± 9.478
5	November	56 ± 3.162	55.4 ± 5.564	39.4 ± 5.353	38 ± 1.483
6	December	37.4 ± 3.668	39.6 ± 6.500	38.2 ± 0.663	39.6 ± 1.435
7	January	19.6 ± 2.561	21.8 ± 1.019	19.4 ± 0.678	21 ± 0.707

Deltocephaline leafhopper (*Chlorotettix* sp): The Deltocephaline leafhopper infestation was noticed from 45th SMW to 48th SMW (November-2018) with 30 ± 1.843 in Bt and 32.4 ± 2.315 in non-Bt cotton fields during 2018-2019 cotton season. The Deltocephaline leafhopper infestation was noticed from 45th SMW (November-2018) to 51st SMW (December-2019) in both Bt and non-Bt cotton fields and peak with 30.8 ± 0.663 in Bt, 34.4 ± 2.441 in non-Bt was noticed from 49th SMW to 51st SMW during 2019-2020 cotton season (Table. 4).

Table 4: Seasonal diversity and Mean abundance of Deltocephaline leafhopper (*Chlorotettix* sp) in Bt and non-Bt cotton fields during 2018-2020

SI. No	Month of observation	Mean ± SE of *Chlorotettix* sp			
		2018-2019		2019-2020	
		Bt cotton	Non-Bt cotton	Bt cotton	Non-Bt cotton
1	July	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
2	August	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
3	September	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
4	October	0.00 ± 0.00	0.00 ± 0.00	30.4 ± 3.487	33 ± 2.983
5	November	30 ± 1.843	32.4 ± 2.315	29.4 ± 1.363	32.2 ± 1.772
6	December	0.00 ± 0.00	0.00 ± 0.00	30.8 ± 0.663	34.4 ± 2.441
7	January	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

Maize leafhopper (*Dalbulus maidis*)

Maize leafhopper incidence was noticed from 41st SMW (October-2019) to 48th SMW (November-2019) in non-Bt cotton field and peak with 31.6 ± 1.661 was noticed from 45th SMW to 48th SMW during 2019-2020 cotton season only (Table 5).

Table 5: Seasonal diversity and Mean abundance of Maize leafhopper (*Dalbulus maidis*) in Bt and non-Bt cotton fields during 2018-2020

SI. No	Month of observation	Mean ± SE of *Dalbulus maidis*			
		2018-2019		2019-2020	
		Bt cotton	Non-Bt cotton	Bt cotton	Non-Bt cotton
1	July	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
2	August	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

3	September	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
4	October	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	26.4 ± 1.886
5	November	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	31.6 ± 1.661
6	December	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
7	January	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

Smaller green leafhopper (*Empoasca* sp)

The Smaller green leafhopper infestation was initiated with 21.6 ± 3.185 from 49th SMW to 52nd SMW (December-2018) in non-Bt cotton field only during 2018-19 cotton season. The Smaller green leafhopper infestation was initiated from 42nd SMW (October-2019) to 52nd SMW (December-2019) in both Bt and non-Bt cotton fields and peak with 41.2 ± 1.240 in Bt, 49.4 ± 2.088 in non-Bt cotton was recorded during 2019-2020 cotton season (Table. 6).

Table 6: Seasonal diversity and Mean abundance of Smaller green leafhopper (*Empoasca* sp) in Bt and non-Bt cotton fields during 2018-2020

SI. No	Month of observation	Mean ± SE of *Empoasca* sp			
		2018-2019		2019-2020	
		Bt cotton	Non-Bt cotton	Bt cotton	Non-Bt cotton
1	July	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
2	August	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
3	September	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
4	October	0.00 ± 0.00	0.00 ± 0.00	41.2 ± 1.240	49.4 ± 2.088
5	November	0.00 ± 0.00	0.00 ± 0.00	25.8 ± 1.907	30.6 ± 1.913
6	December	0.00 ± 0.00	21.6 ± 3.185	31.8 ± 1.685	32.4 ± 1.029
7	January	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

Brown leafhopper/Coppery leafhopper (*Jikradia olitoria*)

The Brown leafhopper/Coppery leafhopper infestation was noticed from 45th SMW to 48th SMW (November-2018) with 10.2 ± 1.428 on non-Bt cotton field only during 2018-2019 cotton season. The Brown leafhopper/Coppery leafhopper infestation was noticed from 42nd SMW (October-2019) to 48th SMW (November-2019) and peak infestation was noticed from 45th SMW to 48th SMW (November) on non-Bt cotton field only during 2019-2020 cotton season (Table. 9).

Table 7: Seasonal diversity and Mean abundance of Brown leafhopper/Coppery leafhopper (*Jikradia olitoria*) in Bt and non-Bt cotton fields during 2018-2020

SI. No	Month of observation	Mean ± SE of *Jikradia olitoria*			
		2018-2019		2019-2020	
		Bt cotton	Non-Bt cotton	Bt cotton	Non-Bt cotton
1	July	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
2	August	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
3	September	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
4	October	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	10.8 ± 0.663
5	November	0.00 ± 0.00	10.2 ± 1.428	0.00 ± 0.00	11 ± 1.581
6	December	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
7	January	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

Ecological Indexes: 3 characteristics were calculated for analysis of community structure of insect-leafhoppers (Table 10, 11). i.e.,

- Species diversity (Shannon –Wiener Index),
- Species evenness (Pielou Evenness Index) &
- Species richness (Margalef's Index).

Table 8: Ecological Indexes for Insect-Leafhoppers in Bt & Non-Bt cotton fields during 2018-19 cotton season

	H-Values		J-Values		D-Values	
	Bt	non-Bt	Bt	non-Bt	Bt	non-Bt
July	-	-	-	-	-	-
August	0	0	-	0	0	0
September	0	0	-	-	0	0
October	0	0	-	-	0	0
November	0.647	0.924	0.933	0.841	0.165	0.323
December	0	0.649	-	0.937	0	0.175
January	0	0	-	-	0	0

Table 9: Ecological Indexes for Insect-Leafhoppers in Bt & Non-Bt cotton fields during 2019-20 cotton season

	H-Values		J-Values		D-Values	
	Bt	**non-Bt**	**Bt**	**non-Bt**	**Bt**	**non-Bt**
July	-	-	-	-	-	-
August	0	0	-	-	0	0
September	0	0	-	-	0	0
October	1.017	1.502	0.926	0.934	0.302	0.5930.608
November	1.082	1.549	0.985	0.962	0.325	0.608
December	1.094	1.095	0.996	0.997	0.321	0.319
January	0	0	-	-	0	0

Species diversity (Shannon-Weiner Index) values (H-Values) of insect-leafhoppers ranged between 0 and 0.647 in Bt, 0 to 0.924 in non-Bt were calculated during 2018-2019 cotton season and during 2019-2020 cotton cropping season, ranged between 0 and 1.094 in Bt, 0 to 1.549 in non-Bt were calculated. Over all H-Values of insect-leafhoppers ranged between 0 and 1.094 in Bt, 0 to 1.549 in non-Bt were calculated during 2018-2020 cotton cropping season.

Species richness (Margalef´s Index) values (D-Values) of insect-leafhoppers ranged between 0 and 0.165 in Bt, 0 to 0.323 in non-Bt were calculated during 2018-2019 cotton season and during 2019-2020 cotton cropping season, ranged between 0 and 0.325 in Bt, 0 to 0.608 in non-Bt were calculated. Over all D-Values of insect-leafhoppers ranged between 0 and 0.325 in Bt, 0 to 0.608 in non-Bt were calculated during 2018-2020 cotton cropping seasons.

Species evenness (Pielou Evenness Index) values (J-Values) of insect-leafhoppers ranged between 0 and 0.933 in Bt, 0 to 0.937 in non-Bt were calculated during 2018-2019 cotton season and during 2019-2020 cotton season, ranged between 0 and 0.996 in Bt, 0 to 0.997 in non-Bt were calculated. Over all J-Values of insect-leafhoppers ranged between 0 and 0.996 in Bt, 0 to 0.997 in non-Bt were calculated during 2018-2020 cotton cropping seasons.

The H-values of insect-leafhoppers under 1.0 indicate that the habitat structure not suitable. In case H-values above 1.0 indicate that Bt and non-Bt cotton fields are stable for them. In case H-values are between 1.5 and 2.0 indicate that the structure of habitat is stable and suitable balanced for them. Evenness values are in Bt and non-Bt cotton are closer to 1.0 indicate that the individuals are distributed equally. Richness values are in Bt and non-Bt cotton are under 0.5 it indicates that the individuals are low, closer to 1.0 indicate that the individuals are more.

The incidence of insect-leafhoppers were noticed from 32nd SMW (August-2018) to till end of the season in both Bt and non-Bt cotton fields and peak was noticed 45th SMW (September-2018) to 52nd SMW (December) in both Bt and non-Bt cotton fields during 2018-2019 cotton season and during 2019-2020 cotton cropping season, the incidence of insect-leafhoppers were noticed from 33rd SMW (August-2019) to till end of the season in both Bt and non-Bt cotton fields and the peak from 40th SMW to 49th SMW (October-2019) in Bt cotton, from 36th SMW to 49th SMW (September-2019) in non-Bt cotton was noticed. It is partially associated with the results of Dhaka and Pareek, (2007) [7], Sharma *et al*., (2004) [19] who reported the peak in the last week of August. The reports of Anitha and Nandihalli, (2008) [2] and Arif *et al*., (2006) [4] support the present findings that insect-leafhoppers incidence was found August to till end of the season. The present investigation similar finding of Laxman P *et al*., (2013) [17] and Kiranmai and Sammaiah, (2019) [14] who reported that incidence of insect leafhoppers were found during 2017-2018 cotton season. Hegde *et al*., (2004) [11] reported that population of cotton insect-leafhoppers were higher in non-Bt-cotton compared to Bt-cotton.

Conclusion

As a result of this study, we observed two species of insect-leafhoppers in Bt cotton and four species insect-leafhoppers in non-Bt cotton fields during 2018-2019 cotton season and three species insect-leafhoppers in Bt cotton and five species insect-leafhoppers in non-Bt cotton fields during 2019-2020 cotton season. In conclusion, Seasonal diversity and abundance of insect-leafhoppers showed lower differences between Bt and non-Bt cotton fields. seasonal diversity and abundance of insect-leafhoppers were lower in Bt cotton than non-Bt cotton fields. Bt insecticidal proteins may be influenced on seasonal diversity and abundance of insect-leafhoppers in Bt cotton fields. The ecological indexes showed that species composition in each agro ecosystems show contrasting patterns between Bt and non-Bt cotton fields.

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