Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(6): 696-701
Received: 25-09-2020
Accepted: 29-10-2020

M Sivarama Krishna
Regional Agricultural Research Station, Nandyal, Andhra Pradesh, India

Dr. Y Rama Reddy
Regional Agricultural Research Station, Nandyal, Andhra Pradesh, India

Dr. E Chandrayudu
Regional Agricultural Research Station, Nandyal, Andhra Pradesh, India

Corresponding Author:
M Sivarama Krishna
Regional Agricultural Research Station, Nandyal, Andhra Pradesh, India

Impact of weather parameters on seasonal incidence of insect pests in Bt and non Bt cotton

M Sivarama Krishna, Dr. Y Rama Reddy and Dr. E Chandrayudu

DOI: https://dx.doi.org/10.22271/phyto.2020.v9.i6j.13023

Abstract
A field trial was conducted to study the impact of weather parameters on seasonal dynamics of insect pests in Bt and non Bt cotton during the years 2018 and 2019 at Regional Agricultural Research station, Nandyal. During the year 2018 results indicated that in both the test hybrids leafhoppers crossed Economic threshold level during 39th to 45th standard weeks and attained peak during 40th and 41st standard weeks. With regard to pink bollworm population and fruiting body damage both the test hybrids attained peak during 52nd standard week. During the year 2019 Peak population of leafhoppers were recorded during 43rd to 46th standard weeks in both the test hybrids (6.02 to 11.8/3 leaves), with regard to fruiting body damage both the test hybrids attained peak during 51st standard week (56 to 68%). Correlation of abiotic factors with sucking pests in cotton during the both seasons revealed that leafhopper population had shown significant positive relation with temperature maxium (0.678) whereas minimum temperature had shown positively non-significant relation (0.512), rainfall and relative humidity had shown negatively non sigficant relation with leafhopper population.

Keywords: Leaf hoppers, economic threshold level, abiotic factors, fruiting body damage

Introduction
Cotton *Gossypium hirsutum* L. (Family: Malvaceae) is the most important commercial crop of India, which is subjected to the ravages of a number of insect pests. Sucking pests have become quite serious from seedling stage their heavy infestation at times reduces the crop yield to a great extent. The estimated loss due to sucking pests is up to 21.20% [1]. In India More than 90 per cent area is under Bt cotton which is susceptible to sucking pests [2, 3, 4]. Among the vast array of insect pests, major sucking pests are, white fly, *Bemisia tabaci* (Gennadius), leafhopper, *Amrasca biguttula biguttula* (Ishida), mealy bug, *Pnenacoccus solenopsis* Tinsley, thrips, *Thrips tabaci* Lindeman and aphid, *Aphis gossypii* Glover. Krishnaiah *et al.* described the method of jassid population estimation by counting on second, third and fourth leaves from top on okra plant [5]. The sucking pest population increased with advancement of vegetative growth and attained peak value at maximum leaf area stage Bishnoi *et al*, and Prasad and Rao reported that there were not much differences between *Bt* and non-*Bt* version of the same hybrid though there were difference among the hybrids regarding the incidence of sucking pests [6]. Sharma and Dhawan reported that the sucking pests population was significantly less in RCH-134 *Bt* and RCH-317 *Bt* as compared to other *Bt* hybrid [7]. Furthermore other weather parameters like rainfall, humidity and temperature play a remarkable part in the expansion, occurrence and population alteration of sucking insect pests throughout the cotton season [8, 9, 10]. The weather parameters like temperature and humidity also fluctuate leafhopper population [11]. For control of insect pest on Bt cotton farmers frequently rely on the chemical control [12], Use of chemical control is not only creating health hazards and ecological contamination but also growing the resistance in the insects and disturbing the balance between the forces of destruction i.e. predators, parasitoids and pathogens in agro-ecosystem [13, 14]. The occurrence and progress of all the insect pests are much dependent upon the customary environmental factors such as temperature, relative humidity and precipitation [15]. The knowledge about incidence of pest during the cropping season and its possible dynamics help in designing pest management strategies [16]. Information on seasonal activity of sucking pests on Bt cotton helps to take up effective management, hence the present study was taken up to correlate the abundance of insect pest population with weather parameters.

Materials and Methods
A Field trial was conducted to study the seasonal dynamics of insect pests in Bt and non Bt cotton and their correlation with weather parameters for two consecutive years of 2018 and 2019. Bollgard II (Jadoo) and DCH-32 were used as test hybrids.

The experiment was laid out in one acre of field i.e. 4000 sq. feet at Regional Agricultural Research station, Nandyal during the kharif season of 2018 and 2019 under unsprayed condition. Jadoo B.G II cotton and DCH-32 were sown during last week of July in both the years, spacing of 90x45cm was adopted between rows and plants respectively. All the standard agronomic practices were adopted as prescribed by Agricultural University except plant protection practices for sucking pests and bollworms. Observations on sucking pests were recorded on ten randomly selected plants from each plot of Bt hybrid and non Bt hybrid from upper, middle and lower leaves of the plant during every meteorological standard week and corresponding weather parameters were also recorded for each standard week. Similarly observations on cotton bollworms were also collected by destructive sampling of green bolls at 90,110 and 140 DAS. Data on sucking pests and bollworms were averaged and correlation studies were done to study the impact of weather parameters on pest dynamics.

Results: During 2018

Sucking pest population dynamics

Leafhoppers: Among the sucking pests the leafhoppers were recorded as below ETL in all the standard weeks except in 41st std week (6.80/3 leaves) regarding thrips except 40th std week (30.70/3 leaves) all the std weeks had recorded below ETL population. The activity of whiteflies were noticed during 38th std week and attained a peak of 13.40 per 3 leaves during 40th and 43rd std weeks, whereas the population of aphids were negligible in RCH-2 BGII.

In DCH 32 the peak population of leafhoppers was observed during 40th std. week (12.30 leafhoppers/ 3 leaves) jassids crossed ETL during 39, 40,42,43,44 and 45th std weeks. Population had declined steadily thereafter. The activity of thrips started during 40th std week and attained a peak during 44th std week, activity of thrips remained up to 48th std week and sudden decline was noticed thereafter. The peak population of whiteflies was noticed during 41st, 42nd and 43 and 45th std weeks 21.54, 20.40.20.56, 21.20 per three leaves respectively thereafter there was a steady decline in population was noticed. (Table no.1)

Table 1: Seasonal dynamics of sucking pests and natural enemies during 2018-19

Std. week	Leafhoppers / 3 leaves		Moth catches/trap/week					Temperature		Relative Humidity (%)		Rainfall (mm)
	RCH 2 BG II	DCH 32	SL	HA	EV	SE	PBW	Max (^{0}C)	Min. (^{0}C)	Mor	Eve	
38	3.30	5.80	15.71	0.43	0.00	0.00	0.54	32.20	23.40	85.00	55.00	11.50
39	3.80	6.20	17.29	1.14	0.43	0.00	0.79	34.80	25.10	77.60	45.90	1.10
40	4.70	12.30	3.29	0.57	0.86	0.00	1.71	35.20	25.10	77.40	48.00	0.00
41	6.80	13.20	14.86	0.43	0.00	0.00	2.46	35.90	23.80	80.40	35.90	0.00
42	4.00	9.00	6.57	0.00	0.00	0.43	1.32	34.40	24.20	81.00	56.70	0.60
43	3.10	10.90	7.57	0.00	0.14	3.43	2.96	35.10	21.70	80.60	37.10	0.00
44	4.70	9.10	6.43	2.00	0.71	6.43	3.29	33.70	21.90	69.00	45.60	0.10
45	4.40	8.70	6.57	1.00	0.00	1.43	2.57	34.30	21.40	81.10	45.30	0.00
46	3.00	5.00	9.71	0.00	0.29	1.57	12.33	33.70	21.10	81.90	51.00	1.20
47	2.40	4.20	6.86	0.86	0.14	1.14	9.68	32.50	22.60	78.40	54.60	0.00
48	4.20	5.40	0.40	1.80	0.00	3.40	20.27	31.50	18.50	83.10	45.90	0.00
49	1.80	3.60	8.43	0.00	0.14	0.29	4.38	31.10	21.20	89.60	59.60	0.40
50	3.30	1.60	5.86	0.14	0.57	0.57	9.21	31.00	19.90	87.30	50.70	0.00
51	2.00	2.40	4.57	0.86	0.86	1.29	5.81	29.90	19.50	84.00	51.70	0.00
52	0.80	1.50	1.50	0.13	0.63	4.25	10.27	31.90	18.80	82.30	44.10	0.00

Thrips, Aphids and whiteflies

The population of aphids has not crossed ETLs during the season.

Natural enemies

Natural enemy population was observed to be very low during the season in both the test hybrids (Table: 2).

Table 2: Seasonal dynamics of bollworms and predators during 2018-19

Std. week	H.armigera		Earias spp. larvae/ 5 plants	PBW Larvae/ 20 green bolls (RCH 2 BG II)	PBW Larvae/ 20 green bolls (DCH 32)	*S. litura* larvae / 5 plants	% prasitism on bollworms	Fruiting Body damage % (RCH2 BG II)	Fruiting Body damage % (DCH-32)	Temperature		Relative Humidity (%)		Rainfall (mm)
	Eggs/ 5 plants	Larvae/ 5 plants								Max (^{0}C)	Min. (^{0}C)	Mor	Eve	
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.20	23.40	85.00	55.00	11.50
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.80	25.10	77.60	45.90	1.10
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.20	25.10	77.40	48.00	0.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.90	23.80	80.40	35.90	0.00
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.40	24.20	81.00	56.70	0.60
43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.10	21.70	80.60	37.10	0.00
44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.70	21.90	69.00	45.60	0.10
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.30	21.40	81.10	45.30	0.00
46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.70	21.10	81.90	51.00	1.20
47	0.00	0.00	0.00	1.00	1.00	0.00	0.00	10.00	5.00	32.50	22.60	78.40	54.60	0.00
48	0.00	0.00	0.00	1.00	4.00	0.00	0.00	5.00	25.00	31.50	18.50	83.10	45.90	0.00
49	0.00	0.00	0.00	1.00	3.00	0.00	0.00	20.00	25.00	31.10	21.20	89.60	59.60	0.40

50	0.00	0.00	0.00	2.00	4.00	0.00	0.00	10.00	20.00	31.00	19.90	87.30	50.70	0.00
51	0.00	0.00	0.00	2.00	2.00	0.00	0.00	15.00	20.00	29.90	19.50	84.00	51.70	0.00
52	0.00	0.00	0.00	10.00	8.00	0.00	0.00	50.00	45.00	31.90	18.80	82.30	44.10	0.00

Bollworms

The field incidence as well as the trap catches of *H. armigera* and *Earias* spp. was low during the season. Though there were trap catches of *S. litura*, the larval incidence in the field was almost negligible (Table:2).

With regard to incidence of Pink bollworm in RCH 2 BG II the pink bollworm larvae in green bolls crossed ETL from 50th to 52nd std weeks (2 larvae in 20 green bolls), whereas the 52nd std week had recorded highest of 10 larvae in 20 green bolls. With regard to fruiting body damage from 47th std week onwards it has crossed ETL, highest fruiting body damage of 50% was recorded during 52nd std week.

With regard to DCH-32 test hybrid pink bollworm larvae had crossed ETL from 48th std week and attained a peak of 8 larvae per 20 green bolls during 52nd std week. Regarding fruiting body damage it has crossed ETL from 48th std week and recorded highest damage during 52nd std week (45%).

The moth catches of *Spodoptera* were noticed from 38th std week and attained a peak during 39th std. week (17.29 moths/ trap / week).The incidence of pink bollworm has started during beginning of the season, they attained ETL from 49th to 52nd std. week and reached peak during 52nd std. week (54.27 moths/trap/week). (Table no: 3)

During 2019: Sucking pest population dynamics:

Table 3: Seasonal dynamics of bollworms (trap catches) during 2018-19

Standard week	Trap catches / week					Abiotic factors				
	SL	HA	EV	SE	PBW	Temp. (^{0}C)		RH %		Rainfall (mm)
						Max.	Min.	Mor.	Eve.	
36	15.71	0.43	0.00	0.00	0.54	33.2	25.1	85.6	65.6	16.2
37	17.29	1.14	0.43	0.00	0.79	33.7	24.7	81.4	63.1	58.4
38	3.29	0.57	0.86	0.00	1.71	31.8	24.0	83.6	61.1	18.2
39	14.86	0.43	0.00	0.00	2.46	32.4	24.8	88.7	72.6	8.0
40	6.57	0.00	0.00	0.43	1.32	31.5	24.5	90.0	69.09	52.6
41	7.57	0.00	0.14	3.43	2.96	30.9	23.9	91.7	70.7	46.6
42	6.43	2.00	0.71	6.43	3.29	32.9	23.6	88.4	61.7	25.6
43	6.57	1.00	0.00	1.43	2.57	33.6	23.5	79.9	50.6	0.0
44	9.71	0.00	0.29	1.57	12.33	32.3	22.7	74.4	44.3	0.0
45	6.86	0.86	0.14	1.14	9.68	32.1	21.9	86.1	53.1	3.2
46	0.40	1.80	0.00	3.40	20.27	32.7	23.3	77.3	47.3	0.0
47	8.43	0.00	0.14	0.29	4.38	33.3	22.9	85.7	51.0	0.0
48	5.86	0.14	0.57	0.57	9.21	31.5	20.6	82.7	48.1	0.0
49	4.57	0.86	0.86	1.29	5.81	31.3	19.4	86.6	47.3	0.0
50	1.50	0.13	0.63	4.25	10.27	33.0	19.0	83.4	41.1	0.0
51	0.14	22.99	2.86	0.00	6.21	30.8	17.0	85.0	40.9	0.0
52	0.19	23.78	1.56	0.81	8.56	30.9	16.4	86.8	39.5	0.0

H.a- *Helicoverpa armigera* PBW- pink bollworm EI- *Earias insulana* EV- *Earias vittella* S. l- *Spodoptera litura*

Leafhoppers: In the test hybrid jadoo (BG-II) leafhoppers were recorded as above ETL in all the standard weeks except 35th and 36th std week and from 49th to 52 std weeks. Peak population of leafhoppers were recorded in 46th std week (8.90/3 leaves). Thrips and whiteflies population was negligible and recorded as below ETL.

In DCH 32 leafhoppers crossed ETL in all the std weeks, the peak population of leafhoppers was observed during 43rd and 45th std. week (11.80 and 11.0 leafhoppers/ 3 leaves) respectively. Thrips and whiteflies population was negligible and recorded as below ETL. (Table:4)

Table 4: Seasonal dynamics of sucking pests and natural enemies during 2019-2020

0	Leafhoppers / 3 leaves		Moth catches/trap/week					Temperature		Relative Humidity (%)		Rainfall (mm)
	Jadoo	DCH 32	SL	HA	EI	SE	PBW	Max (^{0}C)	Min. (^{0}C)	Mor	Eve	
35	4.20	6.78	8.2	0.00	0.00	0.00	0.00	32.50	25.20	86.90	68.70	34.20
36	5.35	7.78	5.6	0.00	0.00	0.00	0.00	32.00	24.30	89.40	64.10	5.00
37	6.02	8.76	10.1	0.00	0.00	0.00	0.00	34.80	24.90	82.30	56.70	140.8
38	6.87	7.02	15.4	0.00	0.00	0.00	0.00	30.00	24.10	90.90	77.00	222.2
39	6.50	7.63	30.57	0.43	0.00	0.00	0.00	32.50	25.00	87.60	67.90	5.60
40	5.50	8.80	27.14	0.57	0.71	0.00	0.00	33.80	24.40	82.90	72.40	0.00
41	6.30	9.10	22.24	0.43	0.00	0.00	0.55	33.40	24.10	86.90	66.70	18.20
42	7.50	8.30	19.56	0.57	0.00	0.00	1.26	32.10	24.50	87.90	74.00	20.60
43	6.20	11.80	20.43	1.00	0.00	0.00	0.96	31.10	23.70	91.60	70.60	21.80
44	6.30	9.20	27.34	0.71	0.00	0.00	0.60	31.60	23.50	84.70	68.00	25.60
45	7.50	11.00	22.12	0.29	0.00	0.00	14.56	33.00	23.00	87.60	61.40	6.80
46	8.90	8.60	16.54	0.00	0.00	0.00	12.10	35.60	22.90	86.90	66.60	0.00
47	6.50	6.10	9.12	0.00	0.00	0.00	14.30	31.60	21.20	85.70	64.30	0.00
48	6.70	7.20	5.23	0.14	0.14	0.00	15.10	30.80	21.40	87.40	63.40	0.00
49	3.60	6.80	0.00	0.00	0.00	0.00	12.2	29.10	20.40	89.70	65.40	6.00
50	4.20	7.80	3.14	0.00	0.00	0.00	10.30	30.90	18.90	91.90	59.00	0.00
51	5.20	6.40	12.29	0.00	0.00	0.00	11.43	30.90	19.50	90.40	62.00	0.00
52	4.00	6.00	2.71	0.00	0.00	0.00	11.20	29.80	19.20	89.40	57.80	0.00

Natural enemies

Natural enemy population was observed to be very low during the season in both the test hybrids.

Bollworms

Although *spodoptera litura* trap catches were noticed from 35th std week and remained active upto 51st std week no corresponding field damage was recorded. Two peaks of spodoptera trap catches were recorded during 39th and 44th std weeks (30.57 and 27.34/trap/week) The field incidence as well as the trap catches of *H. armigera* and *Earias* spp. was low during the season. (Table:7). With regard to pink bollworm trap catches, crossed ETL from 45th std week and attained peak during 51st to 52nd std weeks (31.20/trap/week) With regard to larval population, Earias and Helicoverpa were negligible in both test hybrids. Pink bollworm larvae in green bolls crossed ETL (2 larvae in 20 green bolls), from 46th std week in both the test hybrids, peak larval recovery of 14 per 20 green bolls was recorded in 51st std week in jadoo hybrid whereas the 52nd std week had recorded highest of 11 larvae in 20 green bolls in DCH-32 test hybrid. With regard to fruiting body damage both the test hybrids crossed ETL from 46th std week, highest fruiting body damage of 56% was recorded during 51st std week in jadoo hybrid whereas DCH-32 recorded a fruiting damage of 68% in the same std week. (Table: 5)

Table 5: Seasonal dynamics of bollworms and predators during 2019-2020

Std. week	*H. armigera*		Earias spp. larvae/ 5 plants	PBW Larvae/ 20 green bolls (Jadoo BG II)	PBW Larvae/ 20 green bolls (DCH 32)	*S. litura* larvae / 5plants	% prasitism on bollworms	Fruiting Body damage % (Jadoo BG II)	Fruiting Body damage % (DCH-32)	Temperature		Relative Humidity (%)		Rainfall (mm)
	Eggs/5 plants	Larvae/5 plants								Max (^{0}C)	Min. (^{0}C)	Mor	Eve	
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.50	25.00	87.60	67.90	5.60
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.80	24.40	82.90	72.40	0.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.40	24.10	86.90	66.70	18.20
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.10	24.50	87.90	74.00	20.60
43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.10	23.70	91.60	70.60	21.80
44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.60	23.50	84.70	68.00	25.60
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.00	23.00	87.60	61.40	6.80
46	0.00	0.00	0.00	2.00	3.00	0.00	0.00	8.00	12.00	31.60	22.90	86.90	66.60	0.00
47	0.00	0.00	0.00	3.00	4.00	0.00	0.00	12.00	16.00	31.60	21.20	85.70	64.30	0.00
48	0.00	0.00	0.00	4.00	6.00	0.00	0.00	16.00	24.00	30.80	21.40	87.40	63.40	0.00
49	0.00	0.00	0.00	10.00	8.00	0.00	0.00	32.00	32.00	29.10	20.40	89.70	65.40	6.00
50	0.00	0.00	0.00	5.00	9.00	0.00	0.00	20.00	36.00	30.90	18.90	91.90	59.00	0.00
51	0.00	0.00	0.00	14.00	7.00	0.00	0.00	56.00	68.00	30.90	19.50	90.40	62.00	0.00
52	0.00	0.00	0.00	9.00	11.00	0.00	0.00	40.00	44.00	29.80	19.20	89.40	57.80	0.00

Table 6: Seasonal dynamics of bollworms (trap catches) during 2019-2020

Std. week	Moth catches/trap/week					Temperature		Relative Humidity (%)		Rainfall (mm)
	SL	HA	EI	SE	PBW	Max (^{0}C)	Min. (^{0}C)	Mor	Eve	
39	30.57	0.43	0.00	0.00	0.00	32.50	25.00	87.60	67.90	5.60
40	27.14	0.57	0.71	0.00	0.00	33.80	24.40	82.90	72.40	0.00
41	5.29	0.43	0.00	0.00	0.55	33.40	24.10	86.90	66.70	18.20
42	2.71	0.57	0.00	0.00	1.26	32.10	24.50	87.90	74.00	20.60
43	20.43	1.00	0.00	0.00	0.96	31.10	23.70	91.60	70.60	21.80
44	4.43	0.71	0.00	0.00	0.60	31.60	23.50	84.70	68.00	25.60
45	4.71	0.29	0.00	0.00	1.33	33.00	23.00	87.60	61.40	6.80
46	0.00	0.00	0.00	0.00	12.10	31.60	22.90	86.90	66.60	0.00
47	0.00	0.00	0.00	0.00	14.30	31.60	21.20	85.70	64.30	0.00
48	0.00	0.14	0.14	0.00	15.10	30.80	21.40	87.40	63.40	0.00
49	0.00	0.00	0.00	0.00	12.2	29.10	20.40	89.70	65.40	6.00
50	3.14	0.00	0.00	0.00	10.30	30.90	18.90	91.90	59.00	0.00
51	12.29	0.00	0.00	0.00	11.43	30.90	19.50	90.40	62.00	0.00
52	2.71	0.00	0.00	0.00	11.20	29.80	19.20	89.40	57.80	0.00

H.a- *Helicoverpa armigera* PBW- *pink bollworm* EI- *Earias insulana* EV- *Earias vittella* S. l- *Spodoptera litur*

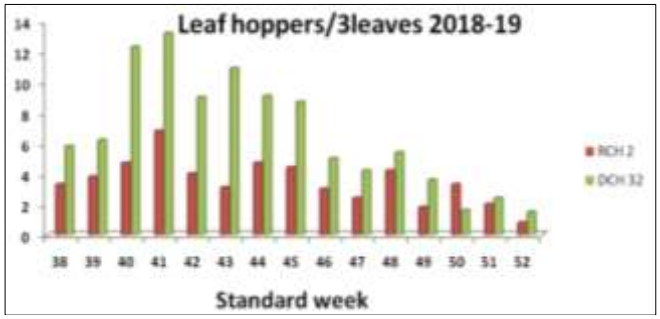

Fig 1: Seasonal dynamics of leafhopper population

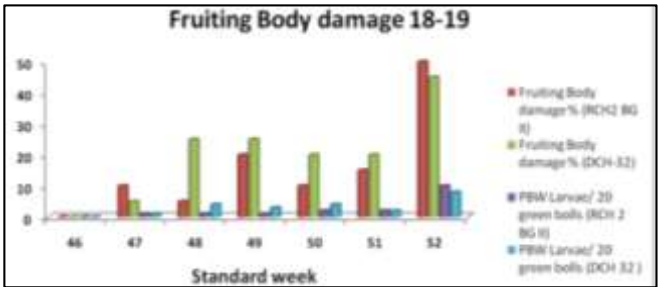

Fig 2: Seasonal dynamics of pink bollworm population and fruiting body damage

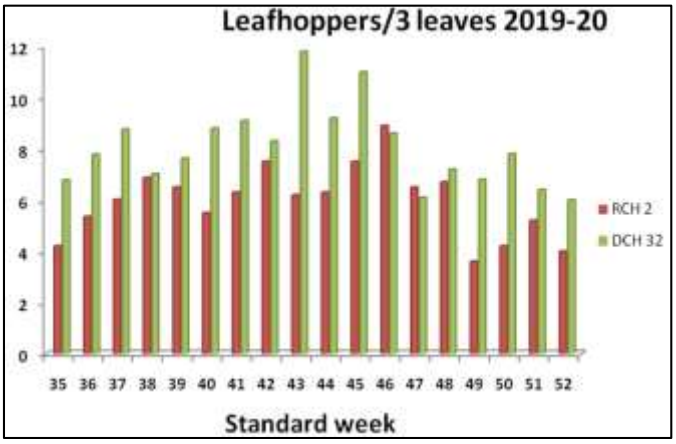

Fig 3: Seasonal dynamics of Leaf hopper population

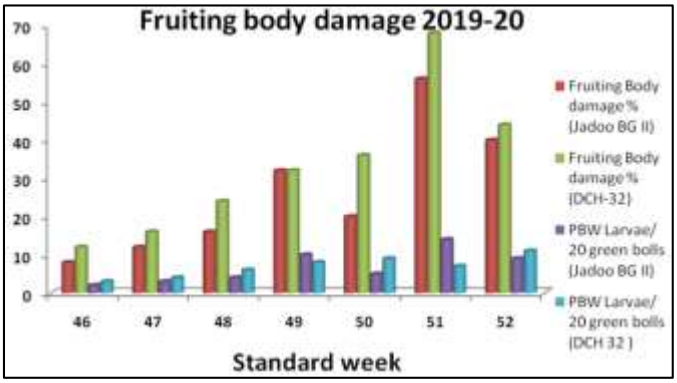

Fig 4: Seasonal dynamics of pink bollworm population and fruiting body damage

Discussion

The above results were in corroboration with the results of Bhute *et al*. [17] who reported maximum temperature showed significant positive correlation with thrips populations. Phulse and Udikeri [18] reported the peak thrips incidence was recorded in September 2nd fortnight to October first fortnight due to low rainfall and low humidity. The present findings are in agreement with Singh *et al.* [19] who reported significant positive influence of temperature on population of the leafhopper. Leafhopper population was positively correlated with temperature, relative humidity and wind speed while negative correlation with rainfall, which corroborates the finding of Parsad *et al*. [20] who reported positive correlation between jassid population and relative humidity.

Conclusion

The present studies concluded that weather factor determines the seasonal activity and population buildup of insect pest in cotton crop. The correlation studies clearly shows the importance of weather parameters in predicting the sucking pest incidence and this studies will be definitely helpful to farmers and extension workers for developing efficient pest management strategies for increased cotton production.

References

1. Dhawan AK, Sidhu AS, Simwat GS. Assessment of avoidable loss in cotton (*Gossypium hirsutum and G.arboreum*) due to sucking pests and bollworms. Indian Journal of Agricultural Sciences 1988;58:290-292.
2. Hofs JL, Schoeman A, Vaissayre M. Effect of Bt cotton on arthropod biodiversity in South African cotton fields. Communications in Agricultural and Applied Biological Sciences 2004;69:191-194.
3. Sharma HC, Pampapathy G. Influence of transgenic cotton on the relative abundance and damage by target and non-target insect pests under different protection regimes in India. Crop Protection 2006;25:800-813.
4. Kranthi KR. Bt cotton Q & A. CICR Nagpur 2012;27:46-47.
5. Krishnaiah K, Ramachander PR, Jagmohan N, Wahi SD. Sampling technique for estimation of jassid population on okra. Indian Journal of Entomology 1979;41**:**200-202.
6. Bishnoi OP, Singh M, Rao VUM, Ram Niwas, Sharma PD. Population dynamics of cotton pests in relation to weather parameters. Indian Journal of Entomology 1996;58:103-107.
7. Sharma M, Dhawan AK. Field evaluation of *Bt* transgenic hybrid against sucking pests and natural enemies. Congress on Insect Science PAU, Ludhiana 2005, 69-71.
8. Mohapatra LN. Population dynamics of sucking pests in hirsutum cotton and influence of weather parameters on its incidence in western Orissa. Journal of Cotton Research and Development 2008;22(2):192-194.
9. Akram Muhammad *et al*. A case to study population dynamics of *Bemisia tabaci* and *Thrips tabaci* on Bt and non-Bt cotton genotypes. Pakistan Journal of Agricultural Sciences 2013;50:4.
10. Inee Gogoi, Dutta BC. Seasonal abundance of cotton jassid, *Amrasca biguttula biguttula* (Ishida) on okra. Journal of the Agricultural Science Society of North-East India 2000;13(1):22-26.
11. Sharma GN, Sharma PD. Population dynamics of cotton leaf hopper, *Amrasca biguttula biguttula* (Ishida) on cotton and okra in relation to the physical factors of environment in Haryana. Annals of Biology 1997;13:189-184.
12. Arif MJ, Abbas G, Saeed S. Cotton in danger, Dawn, The Internet Edition (http://DAWN.com) 2007,4.
13. Hamburg HV, Guest PJ. The impact of insecticide arthropods in cotton agro-ecosystem in South Africa. Archives of Environmental Contamination and Toxicology 1997;32(1):63-68.

14. Sorejani M. Current trend in pesticide usage in some Asian countries. Review of Applied Entomology 1998;77:219-234.
15. Aheer GM, Ahmed KJ, Ali A. Role of weather in fluctuating aphid density in wheat crop. Journal of Agricultural Research 1994;32:295–301.
16. Santhosh BM, Patil SB, Udikeri SS, Awaknavar JS, Katageri IS. Impact of Bt cotton on pink bollworm, *Pectinophora gossypiella* (Saunders) infestation. Karnataka Journal of Agricultural Sciences 2009;22(2):322-326.
17. Bhute NK, Bhosle BB, Bhede BV, More DG. Population dynamics of major sucking pests of Bt cotton. Indian Journal of Entomology 2012;74(3):246-252.
18. Phulse VB, Udikeri SS. Sucking pests and predator dynamics in Bt and non Bt cottons grown in traditional and non-traditional locations. Journal of Cotton Research Development 2017;31(2):309-316.
19. Singh S, Niwas R, Saina RK, Khichar ML. Relationship of micro climatic parameters with population dynamics of leafhopper and whitefly in cotton. Abstracts of National Symposium on I Changing World Order-Cotton Research, Development and Policy in Context ANGRAU, Rajendra Nagar, Hyderabad 2004,104.
20. Parsad NVVSD, Rao NHP, Mahalakshmi MS. Population dynamics of major sucking pests infesting cotton and their relation to weather parameters. Journal of Cotton Research Deveopment 2008;22**:**85-90.