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RP Chauhan

Department of Agricultural
Entomology, C. P. College of
Agriculture, Sardarkrushinagar
Dantiwada Agricultural
University, Sardarkrushinagar,
Dantiwada, Banaskantha
District, Satsan, Gujarat, India

MV Vekaria

Department of Agricultural
Entomology, C. P. College of
Agriculture, Sardarkrushinagar
Dantiwada Agricultural
University, Sardarkrushinagar,
Dantiwada, Banaskantha
District, Satsan, Gujarat, India

HK Chaudhary

Department Of Entomology B.
A. College of Agriculture Anand
Agricultural University Anand,
Gujarat, India

NJ Chaudhary

Department of Agricultural
Entomology, C. P. College of
Agriculture, Sardarkrushinagar
Dantiwada Agricultural
University, Sardarkrushinagar,
Dantiwada, Banaskantha
District, Satsan, Gujarat, India

Correspondence**RP Chauhan**

Department of Agricultural
Entomology, C. P. College of
Agriculture, Sardarkrushinagar
Dantiwada Agricultural
University, Sardarkrushinagar,
Dantiwada, Banaskantha
District, Satsan, Gujarat, India

Seasonal incidence of sucking pests and their natural enemies in *Bt* cotton

RP Chauhan, MV Vekaria, HK Chaudhary and NJ Chaudhary

Abstract

Field studies were undertaken on the Agronomy Instructional Farm, CPCA, SDAU, Sardarkrushinagar to study the seasonal incidence of sucking pests of *Bt* cotton. The pest sequence study was undertaken in the five different cultivars viz., Ajit-155, Dinkar-7, Vikram-5, Jackpot and GTHH 49 BG II of *Bt* cotton. It was observed that the *Bt* cotton was invaded first between the third week of July to second week of August by group of sucking pests viz., aphid, jassid, thrips, whitefly and their damage continued throughout the crop season. Later on two another sucking pests viz., mealybug and mite were infested in *Bt* cotton crop during the second and last week of September, the period of activity of these two pests were also remained till the harvesting of crop.

Keywords: Seasonal incidence, sucking pests, natural enemies and *Bt* cotton

1. Introduction

Cotton (*Gossypium hirsutum* L.) as “King of the Fibre” is one of the most ancient and important cash crop in India and plays a significant role in the Indian national economy. It is grown on a large scale almost in all the tropical and sub-tropical countries like India, U.S.A., Mexico, Iran, Egypt, Pakistan, Turkey, Brazil, Sudan, Uganda and China. *Bt* (*Bacillus thuringiensis*) cotton is a genetically modified cotton seeds which contain the *Bt* toxin. *Bt* cotton was first planted in India in 2002 and following its success, the area under this crop and the number of farmers who adopted this technology increased significantly from year to year. *Bt* cotton hybrids targeting at cotton bollworm substantially brought down the cost of cultivation and has been a boon as the technology is eco-friendly and acceptable to farmers. The *Bt* cotton hybrid based on Cry1 Ac is the moderately toxic to the *H. armigera*. Bollgard II hybrid which expresses the Cry1 Ac + Cry2 Ab toxin is more toxic to the bollworms and *Spodoptera litura* as compared to Bollgard [1]. After the introduction of transgenic *Bt* cotton, bollworms especially *H. armigera* is under controlled, but simultaneously sucking pests viz., aphid, jassid, white fly and thrips have been increased. Transgenic *Bt* cotton can effectively control specific lepidopterous species [2], but there is a lack of resistance against sucking insect pests [3, 4].

In India, 160 species of insect pests have been reported to attack the cotton crop right from germination till the final harvesting of the crop [5]. The pests have the potential to reduce yield by 20 to 80 per cent [6]. Few of them are considered as key pests causing huge damage to cotton crop all over the country. The major pests attacking on *Bt* cotton are aphid, jassid, thrips, whitefly, mealybug and mite [7].

2. Materials and Methods

Present investigations on “Seasonal incidence of sucking pests and their natural enemies in *Bt* cotton” was carried out at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *kharif* season 2015-16. It was laid in randomized block design with four replications. For recording the pest incidence total five *Bt* cotton cultivars viz., Ajit-155, Dinkar-7, Vikram-5, Jackpot and GTHH 49 BG II were sown at 6th July, 2015 with 120 cm X 60 cm spacing. All the recommended agronomical practices except plant protection were followed for raising the crop. Each variety was grown in separate plot measuring 6.0 m x 6.0 m. In each plot five plants were selected and tagged to record the population of pests.

The populations of sucking pests were recorded at standard week interval during morning hours, starting after germination till the maturity of the crop.

Whole plots were kept free from insecticidal application throughout the crop season. The number of aphids, Jassids, whiteflies and thrips were recorded. For the purpose, five plants were selected and tagged from each plot. Observations were recorded from three leaves, each from top, middle and lower portion of each selected plants from each plot at weekly interval. From this, the average population per leaf was worked out. For recording observation on the population of mealy bugs, 5 plants were selected randomly in each plot and tagged. The number of mealy bugs were counted on 3 twigs (each of 10 cm long) selected randomly on each tagged plant. Mite population was recorded from five plants selected randomly from each plot, tagged and numbered, and counted on the basis of 2 cm² leaf area from three leaves one each from top, middle and bottom region per plant. The population of ladybird beetles, green lacewings, spiders and syrphid flies were recorded from randomly selected plants. The population was recorded from whole plant at randomly selected and tagged five plants per plot at weekly intervals. From this, the average populations of natural enemies per plant were worked out.

3. Result and Discussion

The population of aphid commenced (Table 1 & Fig. 1) its activity at the third week of July (0.66 aphid/leaf). However, its population remained fluctuating at low level up to the 18th WAS *i.e.* the 2nd week of November. It increased steadily and reached the peak level (12.51 aphids/leaf) at the 21st WAS *i.e.* the last week of November. Thereafter, incidence of aphid declined and remained on the crop till harvest. Earlier to this [8] peak population of aphid was observed in the last week of November which is close conformity with present findings. However, peak population of aphid recorded in the second and third week of December [9, 10].

In case of jassid the data (Table 2 & Fig. 1) inferred that during the crop season population of jassid first appeared on the cotton during the 3rd WAS *i.e.* the last week of July. Initially, the population was quite low and recorded to be 0.38 jassid/leaf. It was further noted that the incidence of jassid increased slowly till the 10th WAS. Thereafter, the population increased rapidly and reached the peak level (10.17 jassids/leaf) at the 15th WAS *i.e.* the third week of October. The pest population declined slowly yet remained up to the harvesting of crop. Thus, the present findings are in conformity with which observed peak population of jassid in the second and the first week of October, respectively [9, 11]. Likewise, recorded maximum population of jassids in the months of September and October which is also similar with the present findings [12, 13].

Thrips started building up (Table 3 & Fig. 1) from the 2nd WAS *i.e.* the last week of July (0.15 thrips/leaf) and remained active throughout crop season. The population fluctuation was at lower level up to the 7th WAS. Thereafter, increased hurriedly and reached the peak at 15th WAS (15.04 thrips/leaf). The pest incidence remains higher till the 19th WAS later on it was decreased (1.30 thrips/leaf) up to the last week of the December. Earlier to this, the peak level of thrips was observed between the 10th to 21st weeks after sowing [14]. However, peak population of thrips was recorded in the first and second week of October which are in close conformity with the present findings [11, 15].

The mean over cultivars indicated (Table 4 & Fig. 1) that the incidence of whitefly was started from the 5th WAS *i.e.* the second week of August (0.38 whitefly/leaf). The pest population increased gradually up to the 14th WAS and thereafter, increased rapidly and showed peak activity at the

18th WAS *i.e.* the second week of November (12.60 whiteflies/leaf).

The whitefly population then decreased and remained until the crop harvest. Earlier to this peak of whitefly was reported between the 41st and 48th SMW by [11] which is supports the present research. However, higher population of whitefly between the months of August to October [16, 8, 17, 18] and [9]. The difference might be due to prevailing climate conditions as well as cropping period.

The mean over cultivars denoted (Table 5 & Fig. 2) that the influence of mealybug was started at the 10th WAS *i.e.* the second week of September (0.07 mealybug/10 cm twig). Thereafter the population increased up to the 14th WAS and subsequently reached the peak during the 18th WAS *i.e.* the second week of November (4.11 mealybugs/10 cm twig).

Later on, pest population gradually decreased and recorded till harvest of the crop (0.19 mealybug/10 cm twig). Earlier to this, mealybug population observed in the month of August while, higher population recorded between the months of September to October [19, 20, 21] and [22]. In the present findings the mealybug was observed from September to till harvest with low level. This might be due to the pest did not find congenial environment for the population build up during the crop period and could not cross ETL even once.

On the basis of the mean over cultivars, it was found (Table 6 & Fig. 2) that the incidence of mite started at the 12th WAS *i.e.* the last week of September (1.09 mites/2 cm² leaf area). It increased rapidly and reached the peak level at the 19th WAS *i.e.* the third week of November (10.44 mites/2 cm² leaf area). Thereafter, it gradually decreased and reached to lower level at the 25th WAS *i.e.* the last week of December (0.91 mite/2 cm² leaf area). Earlier to this, mite population appeared between the months of September to December [9, 23] which is collaborating to the present findings.

The population of ladybird beetle started (Table 7 & Fig. 3) its activity at the 5th WAS *i.e.* the second week of August (0.14 adult/plant). It increased gradually and reached the peak (2.94 adults/plant) during the 13th WAS *i.e.* the first week of October. Thereafter, the ladybird beetle population declined and remained up to the crop harvest. The highest number of ladybird beetles observed in the last week of September and the first week of October, respectively [11] and [12]. This is close conformity with the present findings. Likewise, activities of ladybird beetle recorded between the months of August to November/December [8, 16] and [24] which is also close conformity with the present findings.

The results on the mean over cultivars indicated that the population of green lacewing started (Table 8 & Fig. 3) at the 11th WAS *i.e.* the third week of September (0.20 adult/plant), increased gradually and reached the peak level (1.73 adults/plant) during the second fortnight of October (16th WAS). Thereafter, the population declined and was recorded up to the crop harvest. The present findings thus found close conformity with [24, 11] and [12] which observed the peak population of ladybird beetle in the second fortnight of October.

The data on mean over cultivars indicated (Table 9 & Fig. 3) that syrphid fly population started since the 3rd WAS *i.e.* the last week of July (0.25 adult/ plant). The population increased gradually and reached the peak level (1.68 adults/ plant) during the 8th WAS *i.e.* the last week of August. Later on, its population declined gradually and reached the lowest level. However, the population of the predator remained on the crop till harvest. The highest number of syrphid flies recorded in the second week of September [11]. However, the population

of syrphid flies observed throughout the crop season ^[25] which is close conformity with the present findings.

The mean over cultivars indicated (Table 10 & Fig. 3) that the appearance of spider started at the 5th WAS *i.e.* the second week of August (0.38 spider/ plant). It increased rapidly and reached the peak level (12.72 spiders/ plant) at the 18th WAS during the first fortnight of November. Later on, the population declined and remained active till the end of the

crop season (3.24 spiders/ plant) ^[11]. recorded occurrence of spider from the second week of August which is close conformity with the present findings. On the other hand, ^[10] the peak level of spider recorded in the second week of August which is different with the present findings due to different environmental conditions as well as host pests density.

Table 1: Seasonal abundance of aphids on different cultivars of *Bt* cotton (2015-16).

Sr. No.	WAS	SMW	Date	Mean number of aphids/leaf					Mean
				Ajit-155	Dinkar-7	Vikram-5	Jackpot	GTHH 49 BG II	
1	3	30	27/07/2015	1.58 (1.99)*	0.79 (0.12)	0.71 (0.00)	1.59 (2.02)	0.71 (0.00)	1.07 (0.66)
2	4	31	03/08/2015	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
3	5	32	10/08/2015	1.67 (2.29)	1.18 (0.89)	0.75 (0.06)	1.62 (2.11)	0.85 (0.23)	1.21 (0.97)
4	6	33	17/08/2015	1.35 (1.32)	1.24 (1.05)	1.14 (0.80)	1.31 (1.22)	1.15 (0.82)	1.24 (1.03)
5	7	34	24/08/2015	1.33 (1.28)	1.29 (1.16)	1.28 (1.15)	1.30 (1.19)	1.28 (1.14)	1.30 (1.18)
6	8	35	31/08/2015	1.90 (3.12)	1.72 (2.46)	1.56 (1.93)	1.85 (2.91)	1.60 (2.06)	1.73 (2.48)
7	9	36	07/09/2015	2.19 (4.30)	2.15 (4.12)	1.81 (2.77)	2.19 (4.30)	1.92 (3.17)	2.05 (3.71)
8	10	37	14/09/2015	2.35 (5.02)	2.17 (4.22)	1.82 (2.81)	2.31 (4.84)	1.85 (2.92)	2.10 (3.91)
9	11	38	21/09/2015	2.43 (5.39)	2.20 (4.33)	1.88 (3.02)	2.28 (4.70)	1.90 (3.09)	2.14 (4.06)
10	12	39	28/09/2015	2.46 (5.55)	2.23 (4.47)	1.91 (3.15)	2.29 (4.74)	1.93 (3.22)	2.16 (4.18)
11	13	40	05/10/2015	2.63 (6.41)	2.49 (5.70)	1.92 (3.19)	2.55 (6.00)	2.08 (3.81)	2.33 (4.94)
12	14	41	12/10/2015	2.63 (6.42)	2.51 (5.82)	2.22 (4.42)	2.55 (6.01)	2.37 (5.13)	2.46 (5.54)
13	15	42	19/10/2015	2.72 (6.89)	2.63 (6.42)	2.26 (4.60)	2.71 (6.83)	2.53 (5.89)	2.57 (6.10)
14	16	43	26/10/2015	2.67 (6.63)	2.36 (5.07)	2.04 (3.66)	2.42 (5.35)	2.10 (3.92)	2.32 (4.87)
15	17	44	02/11/2015	2.75 (7.09)	2.41 (5.32)	2.11 (3.97)	2.58 (6.18)	2.20 (4.34)	2.41 (5.32)
16	18	45	09/11/2015	2.79 (7.27)	2.51 (5.81)	2.17 (4.20)	2.64 (6.47)	2.28 (4.69)	2.48 (5.64)
17	19	46	16/11/2015	3.10 (9.11)	2.98 (8.38)	2.91 (7.98)	3.04 (8.75)	2.94 (8.14)	2.99 (8.47)
18	20	47	23/11/2015	3.60 (12.46)	3.55 (12.10)	3.47 (11.54)	3.59 (12.39)	3.50 (11.75)	3.54 (12.05)
19	21	48	30/11/2015	3.68 (13.02)	3.60 (12.46)	3.55 (12.10)	3.62 (12.60)	3.59 (12.39)	3.61 (12.51)
20	22	49	07/12/2015	3.27 (10.19)	3.19 (9.65)	3.12 (9.23)	3.25 (10.06)	3.16 (9.49)	3.20 (9.72)
21	23	50	14/12/2015	2.85 (7.63)	2.60 (6.26)	2.28 (4.70)	2.55 (5.98)	2.39 (5.21)	2.53 (5.92)
22	24	51	21/12/2015	2.04 (3.66)	1.70 (2.38)	1.49 (1.72)	1.80 (2.75)	1.60 (2.06)	1.73 (2.48)
23	25	52	28/12/2015	1.81 (2.77)	1.69 (2.36)	1.64 (2.20)	1.66 (2.26)	1.66 (2.26)	1.69 (1.22)
Mean				2.66 (6.57)	2.48 (5.66)	2.23 (4.48)	2.55 (6.00)	2.31 (4.84)	
S.Em. (±)				0.05					
C.D. at 5 %				0.16					
C.V. %				6.15					

*Figures outside parenthesis are $\sqrt{X + 0.5}$ transformed values while, those in parenthesis are retransformed value. WAS: Weeks After Sowing, SMW: Standard Meteorological Weeks.

Table 2: Seasonal abundance of jassids on different cultivars of *Bt* cotton (2015-16).

Sr. No.	WAS	SMW	Date	Mean number of jassids/leaf					Mean
				Ajit-155	Dinkar-7	Vikram-5	Jackpot	GTHH 49 BG II	
1	3	30	27/07/2015	1.09 (0.68)*	1.02 (0.53)	0.71 (0.00)	1.08 (0.67)	0.79 (0.12)	0.94 (0.38)
2	4	31	03/08/2015	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
3	5	32	10/08/2015	1.73 (2.50)	1.33 (1.27)	0.75 (0.06)	1.43 (1.55)	0.78 (0.11)	1.21 (0.95)
4	6	33	17/08/2015	1.65 (2.22)	1.35 (1.32)	0.83 (0.18)	1.41 (1.49)	1.05 (0.59)	1.26 (1.08)
5	7	34	24/08/2015	1.62 (2.12)	1.34 (1.30)	0.99 (0.49)	1.46 (1.64)	1.16 (0.84)	1.31 (1.23)
6	8	35	31/08/2015	1.70 (2.38)	1.55 (1.90)	1.14 (0.79)	1.59 (2.02)	1.38 (1.39)	1.47(1.66)
7	9	36	07/09/2015	1.94 (3.25)	1.61 (2.10)	1.23 (1.02)	1.64 (2.18)	1.57 (1.96)	1.60 (2.05)
8	10	37	14/09/2015	1.79 (2.70)	1.68 (2.32)	1.58 (1.99)	1.72 (2.46)	1.64 (2.19)	1.68 (2.33)
9	11	38	21/09/2015	2.46 (5.55)	2.40 (5.26)	2.37 (5.12)	2.44 (5.45)	2.38 (5.16)	2.41 (5.31)
10	12	39	28/09/2015	2.86 (7.68)	2.77 (7.17)	2.67 (6.64)	2.81 (7.40)	2.70 (6.79)	2.76 (7.13)
11	13	40	05/10/2015	3.02 (8.64)	2.97 (8.32)	2.90 (7.91)	3.01 (8.54)	2.93 (8.08)	2.97 (8.30)
12	14	41	12/10/2015	3.12 (9.23)	3.02 (8.62)	2.91 (7.97)	3.05 (8.80)	3.00 (8.52)	3.02 (8.62)
13	15	42	19/10/2015	3.38 (10.92)	3.25 (10.06)	3.19 (9.68)	3.29 (10.32)	3.22 (9.87)	3.27 (10.17)
14	16	43	26/10/2015	3.22 (9.87)	3.15 (9.41)	3.06 (8.86)	3.19 (9.68)	3.08 (8.99)	3.14 (9.36)
15	17	44	02/11/2015	3.13 (9.30)	2.97 (8.32)	2.71 (6.84)	3.07 (8.92)	2.94 (8.14)	2.96 (8.29)
16	18	45	09/11/2015	2.82 (7.45)	2.56 (6.05)	2.50 (5.75)	2.64 (6.47)	2.52 (5.85)	2.61 (6.30)
17	19	46	16/11/2015	2.51 (5.80)	2.45 (5.50)	2.34 (4.98)	2.48 (5.65)	2.42 (5.36)	2.44 (5.45)
18	20	47	23/11/2015	2.31 (4.84)	2.21 (4.38)	2.11 (3.95)	2.26 (4.61)	2.15 (4.12)	2.21 (4.38)
19	21	48	30/11/2015	2.12 (3.99)	1.84 (2.89)	1.75 (2.56)	1.89 (3.07)	1.77 (2.63)	1.87 (3.01)
20	22	49	07/12/2015	2.03 (3.62)	1.56 (1.94)	1.48 (1.69)	1.85 (2.92)	1.52 (1.81)	1.69 (2.35)
21	23	50	14/12/2015	1.62 (2.13)	1.40 (1.46)	1.33 (1.27)	1.58 (2.00)	1.38 (1.40)	1.46 (1.64)
22	24	51	21/12/2015	1.51 (1.78)	1.36 (1.34)	1.20 (0.94)	1.40 (1.46)	1.35 (1.32)	1.36 (1.36)
23	25	52	28/12/2015	1.44 (1.58)	1.23 (1.01)	1.16 (0.85)	1.26 (1.09)	1.19 (0.92)	1.26 (1.08)
Mean				2.16 (4.18)	1.99 (3.45)	1.81 (2.77)	2.05 (3.72)	1.90 (3.10)	
S.Em. (±)				0.04					
C.D. at 5 %				0.13					
C.V. %				5.50					

*Figures outside parenthesis are $\sqrt{X + 0.5}$ transformed values while, those in parenthesis are retransformed value. WAS: Weeks After Sowing, SMW: Standard Meteorological Weeks.

Table 3: Seasonal abundance of thrips on different cultivars of *Bt* cotton (2015-16).

Sr. No.	WAS	SMW	Date	Mean number of thrips/leaf					Mean
				Ajit-155	Dinkar-7	Vikram-5	Jackpot	GTHH 49 BG II	
1	2	29	20/07/2015	0.90 (0.31)*	0.78 (0.11)	0.73 (0.03)	0.81 (0.16)	0.75 (0.06)	0.79 (0.15)
2	3	30	27/07/2015	1.07 (0.65)	0.86 (0.24)	0.78 (0.11)	0.93 (0.36)	0.82 (0.17)	0.89 (0.33)
3	4	31	03/08/2015	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
4	5	32	10/08/2015	1.71 (2.42)	1.02 (0.54)	0.87 (0.26)	1.46 (1.63)	0.92 (0.35)	1.20 (1.16)
5	6	33	17/08/2015	2.36 (5.07)	1.19 (0.92)	1.01 (0.52)	2.04 (3.66)	1.08 (0.67)	1.54 (2.40)
6	7	34	24/08/2015	2.75 (7.06)	2.17 (4.21)	2.02 (3.58)	2.56 (6.06)	2.06 (3.74)	2.31 (5.15)
7	8	35	31/08/2015	3.16 (9.49)	2.95 (8.22)	2.87 (7.74)	3.10 (9.10)	2.92 (8.03)	3.00 (8.61)
8	9	36	07/09/2015	3.40 (11.06)	3.27 (10.19)	3.18 (9.61)	3.33 (10.60)	3.20 (9.74)	3.28 (10.34)
9	10	37	14/09/2015	3.49 (11.68)	3.39 (10.99)	3.32 (10.52)	3.45 (11.42)	3.35 (10.74)	3.20 (9.72)
10	11	38	21/09/2015	3.71 (13.26)	3.65 (12.82)	3.59 (12.39)	3.67 (12.97)	3.62 (12.57)	3.65 (12.85)
11	12	39	28/09/2015	3.78 (13.79)	3.69 (13.12)	3.62 (12.60)	3.73 (13.41)	3.64 (12.75)	3.69 (13.21)
12	13	40	05/10/2015	3.89 (14.63)	3.79 (13.86)	3.70 (13.19)	3.84 (14.25)	3.74 (13.49)	3.59 (12.33)
13	14	41	12/10/2015	3.95 (15.10)	3.87 (14.48)	3.77 (13.71)	3.92 (14.87)	3.83 (14.17)	3.87 (14.52)
14	15	42	19/10/2015	4.09 (16.25)	3.93 (14.94)	3.81 (14.02)	3.94 (15.02)	3.90 (14.71)	3.93 (15.04)
15	16	43	26/10/2015	4.05 (15.90)	3.90 (14.71)	3.79 (13.86)	3.91 (14.79)	3.87 (14.48)	3.90 (14.80)
16	17	44	02/11/2015	3.99 (15.42)	3.85 (14.32)	3.75 (13.56)	3.88 (14.55)	3.83 (14.17)	3.86 (14.45)
17	18	45	09/11/2015	3.98 (15.34)	3.84 (14.25)	3.74 (13.49)	3.86 (14.40)	3.81 (14.02)	3.85 (14.35)
18	19	46	16/11/2015	3.79 (13.86)	3.67 (12.97)	3.57 (12.24)	3.71 (13.26)	3.62 (12.60)	3.67 (13.07)
19	20	47	23/11/2015	3.31 (10.46)	3.12 (9.26)	2.97 (8.32)	3.20 (9.74)	3.02 (8.62)	3.12 (9.41)
20	21	48	30/11/2015	2.51 (5.79)	2.40 (5.26)	2.27 (4.65)	2.37 (5.12)	2.32 (4.88)	2.37 (5.19)
21	22	49	07/12/2015	2.12 (3.98)	2.02 (3.58)	1.83 (2.85)	2.09 (3.87)	1.90 (3.11)	1.99 (3.55)
22	23	50	14/12/2015	2.19 (4.31)	2.11 (3.95)	1.72 (2.45)	2.18 (4.25)	1.89 (3.07)	2.02 (3.71)
23	24	51	21/12/2015	1.96 (3.33)	1.73 (2.49)	1.34 (1.30)	1.87 (3.00)	1.50 (1.75)	1.68 (2.49)
24	25	52	28/12/2015	1.49 (1.72)	1.35 (1.32)	1.09 (0.69)	1.43 (1.54)	1.19 (0.92)	1.31 (1.30)
Mean				2.85 (7.61)	2.64 (6.47)	2.50 (5.76)	2.75 (7.06)	2.56 (6.06)	
S.Em. (±)				0.06					
C.D. at 5 %				0.17					
C.V. %				5.18					

*Figures outside parenthesis are $\sqrt{X + 0.5}$ transformed values while, those in parenthesis are retransformed value. WAS: Weeks After Sowing, SMW: Standard Meteorological Weeks.

Table 4: Seasonal abundance of whiteflies on different cultivars of *Bt* cotton (2015-16)

Sr. No.	WAS	SMW	Date	Mean number of whiteflies /leaf					Mean
				Ajit-155	Dinkar-7	Vikram-5	Jackpot	GTHH 49 BG II	
1	5	32	10/08/2015	1.25 (1.07)*	0.91 (0.33)	0.71 (0.00)	1.08 (0.67)	0.75 (0.06)	0.94 (0.38)
2	6	33	17/08/2015	1.28 (1.14)	0.95 (0.40)	0.78 (0.11)	1.11 (0.73)	0.82 (0.17)	0.99 (0.48)
3	7	34	24/08/2015	1.58 (2.00)	1.38 (1.39)	0.99 (0.49)	1.41 (1.48)	1.11 (0.73)	1.29 (1.17)
4	8	35	31/08/2015	1.62 (2.12)	1.40 (1.46)	1.20 (0.94)	1.50 (1.74)	1.28 (1.13)	1.40 (1.46)
5	9	36	07/09/2015	1.70 (2.39)	1.45 (1.60)	1.25 (1.06)	1.56 (1.93)	1.34 (1.30)	1.46 (1.63)
6	10	37	14/09/2015	1.82 (2.81)	1.54 (1.87)	1.37 (1.38)	1.66 (2.26)	1.44 (1.57)	1.57 (1.95)
7	11	38	21/09/2015	1.88 (3.03)	1.59 (2.03)	1.40 (1.46)	1.71 (2.42)	1.50 (1.75)	1.62 (2.11)
8	12	39	28/09/2015	1.90 (3.11)	1.70 (2.39)	1.50 (1.75)	1.80 (2.74)	1.62 (2.12)	1.70 (2.40)
9	13	40	05/10/2015	2.11 (3.95)	1.93 (3.22)	1.69 (2.36)	2.00 (3.50)	1.84 (2.89)	1.91 (3.16)
10	14	41	12/10/2015	2.51 (5.80)	2.34 (4.98)	2.10 (3.91)	2.40 (5.26)	2.26 (4.61)	2.32 (4.89)
11	15	42	19/10/2015	3.12 (9.23)	2.95 (8.20)	2.60 (6.26)	3.07 (8.92)	2.87 (7.74)	2.92 (8.04)
12	16	43	26/10/2015	3.47 (11.54)	3.39 (10.99)	3.25 (10.06)	3.42 (11.20)	3.31 (10.46)	3.37 (10.84)
13	17	44	02/11/2015	3.64 (12.75)	3.58 (12.32)	3.44 (11.33)	3.61 (12.53)	3.54 (12.03)	3.56 (12.19)
14	18	45	09/11/2015	3.69 (13.12)	3.63 (12.68)	3.51 (11.82)	3.66 (12.90)	3.61 (12.53)	3.62 (12.60)
15	19	46	16/11/2015	3.65 (12.82)	3.56 (12.17)	3.47 (11.54)	3.61 (12.53)	3.50 (11.75)	3.56 (12.16)
16	20	47	23/11/2015	3.63 (12.68)	3.53 (11.96)	3.45 (11.40)	3.56 (12.17)	3.48 (11.61)	3.53 (11.96)
17	21	48	30/11/2015	3.35 (10.72)	2.25 (4.56)	2.20 (4.34)	2.67 (6.63)	2.12 (3.99)	2.52 (5.84)
18	22	49	07/12/2015	2.62 (6.36)	2.79 (7.28)	2.70 (6.81)	2.65 (6.51)	2.69 (6.73)	2.69 (6.74)
19	23	50	14/12/2015	2.52 (5.85)	2.40 (5.26)	2.27 (4.65)	2.44 (5.45)	2.37 (5.12)	2.40 (5.26)
20	24	51	21/12/2015	2.33 (4.93)	2.21 (4.38)	2.12 (3.99)	2.24 (4.52)	2.22 (4.43)	2.22 (4.45)
21	25	52	28/12/2015	2.00 (3.52)	1.87 (3.01)	1.87 (3.00)	2.11 (3.96)	1.81 (2.76)	1.93 (3.24)
Mean				2.46 (5.56)	2.25 (4.58)	2.09 (3.87)	2.35 (5.00)	2.17 (4.19)	
S.Em. (±)				0.05					
C.D. at 5 %				0.14					
C.V. %				5.11					

*Figures outside parenthesis are $\sqrt{X + 0.5}$ transformed values while, those in parenthesis are retransformed value. WAS: Weeks After Sowing, SMW: Standard Meteorological Weeks.

Table 5: Seasonal abundance of mealybugs on different cultivars of *Bt* cotton (2015-16).

Sr. No.	WAS	SMW	Date	Mean number of mealybugs/10 cm twig					Mean
				Ajit-155	Dinkar-7	Vikram-5	Jackpot	GTHH 49 BG II	
1	10	37	14/09/2015	0.71 (0.00)*	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.95 (0.40)	0.76 (0.07)
2	11	38	21/09/2015	1.34 (1.29)	1.25 (1.06)	1.14 (0.80)	1.30 (1.19)	1.24 (1.04)	1.25 (1.07)
3	12	39	28/09/2015	1.53 (1.84)	1.50 (1.75)	1.37 (1.37)	1.52 (1.81)	1.39 (1.43)	1.46 (1.63)
4	13	40	05/10/2015	1.53 (1.85)	1.47 (1.66)	1.24 (1.03)	1.48 (1.69)	1.32 (1.25)	1.41 (1.48)
5	14	41	12/10/2015	1.58 (1.99)	1.50 (1.75)	1.43 (1.54)	1.53 (1.83)	1.46 (1.63)	1.50 (1.75)
6	15	42	19/10/2015	1.81 (2.78)	1.73 (2.49)	1.67 (2.29)	1.78(2.67)	1.70 (2.39)	1.74 (2.52)
7	16	43	26/10/2015	1.89 (3.07)	1.85 (2.92)	1.72 (2.46)	1.87 (3.00)	1.80 (2.74)	1.83 (2.83)
8	17	44	02/11/2015	2.15 (4.12)	2.07 (3.78)	1.80 (2.74)	2.10 (3.93)	1.87 (3.01)	2.00 (3.50)
9	18	45	09/11/2015	2.25 (4.56)	2.14 (4.08)	2.05 (3.70)	2.20 (4.34)	2.09 (3.87)	2.15 (4.11)
10	19	46	16/11/2015	2.21 (4.38)	2.12 (3.99)	2.04 (3.66)	2.17 (4.21)	2.07 (3.78)	2.12 (4.00)
11	20	47	23/11/2015	2.09 (3.87)	2.06 (3.74)	1.99 (3.46)	2.07 (3.78)	2.03 (3.62)	2.05 (3.69)
12	21	48	30/11/2015	1.73 (2.50)	1.67 (2.30)	1.46 (1.63)	1.72 (2.47)	1.52 (1.81)	1.62 (2.13)
13	22	49	07/12/2015	1.69 (2.36)	1.63 (2.16)	1.44 (1.57)	1.66 (2.26)	1.46 (1.63)	1.58 (1.98)
14	23	50	14/12/2015	1.60 (2.06)	1.55 (1.90)	1.33 (1.26)	1.57 (1.96)	1.35 (1.32)	1.48 (1.69)
15	24	51	21/12/2015	1.57 (1.96)	1.40 (1.46)	0.74 (0.05)	0.87 (0.26)	1.27 (1.11)	1.17 (0.87)
16	25	52	28/12/2015	0.96 (0.41)	0.80 (0.14)	0.75 (0.07)	0.86 (0.24)	0.77 (0.09)	0.83 (0.19)
Mean				1.66 (2.27)	1.59 (2.03)	1.43 (1.54)	1.59 (1.54)	1.52 (2.02)	
S.Em. (±)				0.04					
C.D. at 5 %				0.12					
C.V. %				6.14					

*Figures outside parenthesis are $\sqrt{x + 0.5}$ transformed values while, those in parenthesis are retransformed value. WAS: Weeks After Sowing, SMW: Standard Meteorological Weeks.

Table 6: Seasonal abundance of mites on different cultivars of *Bt* cotton (2015-16).

Sr. No.	WAS	SMW	Date	Mean number of mites/ 2 cm ² leaf area					Mean
				Ajit-155	Dinkar-7	Vikram-5	Jackpot	GTHH 49 BG II	
1	12	39	28/09/2015	1.49 (1.72)*	1.34 (1.30)	0.92 (0.35)	1.43 (1.55)	1.13 (0.78)	1.26 (1.09)
2	13	40	05/10/2015	2.01 (3.53)	1.74 (2.52)	1.68 (2.32)	1.80 (2.74)	1.73 (2.48)	1.79 (2.70)
3	14	41	12/10/2015	2.86 (6.68)	2.76 (7.12)	2.73 (6.95)	2.85 (7.62)	2.74 (7.01)	2.79 (7.27)
4	15	42	19/10/2015	3.15 (9.42)	2.89 (7.85)	2.85 (7.62)	3.00 (8.50)	2.88 (7.79)	2.95 (8.23)
5	16	43	26/10/2015	3.30 (10.39)	3.17 (9.55)	3.10 (9.11)	3.24 (10.00)	3.15 (9.42)	3.19 (9.69)
6	17	44	02/11/2015	3.32 (10.52)	3.19 (9.68)	3.16 (9.49)	3.20 (9.74)	3.17 (9.55)	3.21 (9.79)
7	18	45	09/11/2015	3.41 (11.13)	3.25 (10.07)	3.19 (9.68)	3.33 (10.59)	3.24 (10.00)	3.28 (10.29)
8	19	46	16/11/2015	3.43 (11.26)	3.28 (10.26)	3.21 (9.80)	3.35 (10.72)	3.27 (10.19)	3.31 (10.44)
9	20	47	23/11/2015	3.33 (10.59)	3.20 (9.74)	3.12 (9.23)	3.28 (10.26)	3.15 (9.42)	3.22 (9.84)
10	21	48	30/11/2015	3.20 (9.74)	3.06 (8.86)	3.00 (8.50)	3.10 (9.11)	3.03 (8.68)	3.08 (8.97)
11	22	49	07/12/2015	3.15 (9.42)	3.11 (9.17)	2.95 (8.20)	3.02 (8.62)	2.00 (3.50)	2.85 (7.62)
12	23	50	14/12/2015	1.74 (2.53)	1.69 (2.36)	1.66 (2.26)	1.74 (2.53)	1.67 (2.29)	1.70 (2.39)
13	24	51	21/12/2015	1.47 (1.65)	1.29(1.17)	1.18 (0.89)	1.34 (1.30)	1.21 (0.95)	1.30 (1.18)
14	25	52	28/12/2015	1.50 (1.76)	1.16 (0.85)	1.05 (0.60)	1.12 (0.75)	1.10 (0.71)	1.19 (0.91)
Mean				2.67 (6.62)	2.51 (5.80)	2.41 (5.33)	2.56 (6.04)	2.39 (5.21)	
S.Em. (±)				0.06					
C.D. at 5 %				0.18					
C.V. %				5.78					

*Figures outside parenthesis are $\sqrt{x + 0.5}$ transformed values while, those in parenthesis are retransformed value. WAS: Weeks After Sowing, SMW: Standard Meteorological Weeks.

Table 7: Seasonal abundance of ladybird beetles on different cultivars of *Bt* cotton (2015-16).

Sr. No.	WAS	SMW	Date	Mean number of ladybird beetles/plant					Mean
				Ajit-155	Dinkar-7	Vikram-5	Jackpot	GTHH 49 BG II	
1	5	32	10/08/2015	0.79 (0.12)*	0.81 (0.16)	0.77 (0.10)	0.83 (0.19)	0.81 (0.15)	0.80 (0.14)
2	6	33	17/08/2015	0.91 (0.32)	0.89 (0.30)	0.93 (0.36)	0.88 (0.28)	0.89 (0.29)	0.90 (0.31)
3	7	34	24/08/2015	1.13 (0.78)	1.11 (0.74)	1.15 (0.82)	1.13 (0.77)	1.14 (0.79)	1.13 (0.78)
4	8	35	31/08/2015	1.26 (1.08)	1.28 (1.13)	1.30 (1.19)	0.81 (0.15)	0.81 (0.16)	1.09 (0.69)
5	9	36	07/09/2015	1.41 (1.48)	1.44 (1.56)	1.46 (1.62)	1.02 (0.54)	1.02 (0.55)	1.27 (1.11)
6	10	37	14/09/2015	1.57 (1.98)	1.57 (1.95)	1.57 (1.98)	1.56 (1.92)	1.56 (1.93)	1.57 (1.95)
7	11	38	21/09/2015	1.72 (2.46)	1.71 (2.41)	1.72 (2.45)	1.70 (2.38)	1.70 (2.40)	1.71 (2.42)
8	12	39	28/09/2015	1.81 (2.79)	1.82 (2.83)	1.83 (2.86)	1.83 (2.84)	1.83 (2.84)	1.83 (2.83)
9	13	40	05/10/2015	1.86 (2.96)	1.84 (2.90)	1.87 (2.99)	1.85 (2.92)	1.85 (2.94)	1.86 (2.94)
10	14	41	12/10/2015	1.68 (2.32)	1.68 (2.31)	1.70 (2.39)	1.69 (2.35)	1.68 (2.33)	1.69 (2.34)
11	15	42	19/10/2015	1.60 (2.06)	1.58 (2.01)	1.61 (2.09)	1.61 (2.10)	1.58 (2.00)	1.60 (2.05)
12	16	43	26/10/2015	1.50 (1.74)	1.50 (1.74)	1.51 (1.79)	1.50 (1.96)	1.48 (1.70)	1.50 (1.75)
13	17	44	02/11/2015	1.26 (1.08)	1.24 (1.05)	1.26 (1.10)	1.26 (1.08)	1.23 (1.02)	1.25 (1.07)
14	18	45	09/11/2015	1.26 (1.09)	1.28 (1.14)	1.30 (1.20)	1.28 (1.15)	1.26 (1.10)	1.28 (1.14)
15	19	46	16/11/2015	1.27 (1.12)	1.28 (1.15)	1.52 (1.80)	1.30 (1.20)	1.30 (1.20)	1.34 (1.29)
16	20	47	23/11/2015	1.40 (1.45)	1.39 (1.42)	1.41 (1.49)	1.41 (1.50)	1.39 (1.44)	1.40 (1.46)
17	21	48	30/11/2015	1.35 (1.32)	1.36 (1.36)	1.35 (1.33)	1.34 (1.30)	1.36 (1.36)	1.35 (1.33)
18	22	49	07/12/2015	1.31 (1.21)	1.30 (1.20)	1.33 (1.26)	1.32 (1.25)	1.31 (1.21)	1.31 (1.23)
19	23	50	14/12/2015	1.11 (0.74)	1.12 (1.76)	1.10 (0.72)	1.13 (0.77)	1.11 (0.74)	1.12 (0.75)
20	24	51	21/12/2015	0.85 (0.23)	0.84 (0.20)	0.87 (0.25)	0.85 (0.23)	0.89 (0.29)	0.86 (0.24)
Mean				1.35 (1.33)	1.35 (1.33)	1.38 (1.40)	1.32 (1.23)	1.31 (1.22)	
S.Em. (\pm)				0.03					
C.D. at 5 %				0.09					
C.V. %				5.78					

*Figures outside parenthesis are $\sqrt{x+0.5}$ transformed values while, those in parenthesis are retransformed value. WAS: Weeks After Sowing, SMW: Standard Meteorological Weeks.

Table 8: Seasonal abundance of green lacewings on different cultivars of *Bt* cotton (2015-16).

Sr. No.	WAS	SMW	Date	Mean number of green lacewings/plant					Mean
				Ajit-155	Dinkar-7	Vikram-5	Jackpot	GTHH 49 BG II	
1	11	38	21/09/2015	0.86 (0.25)*	0.71 (0.00)	1.03 (0.56)	0.75 (0.06)	0.84 (0.21)	0.84 (0.20)
2	12	39	28/09/2015	0.87 (0.26)	0.84 (0.21)	0.99 (0.47)	0.90 (0.30)	0.85 (0.22)	0.89 (0.29)
3	13	40	05/10/2015	1.23 (1.01)	1.20 (0.94)	1.07 (0.65)	1.23 (1.02)	1.22 (0.98)	1.19 (0.92)
4	14	41	12/10/2015	1.23 (1.02)	1.29 (1.17)	1.29 (1.15)	1.24 (1.03)	1.19 (0.90)	1.25 (1.05)
5	15	42	19/10/2015	1.27 (1.11)	1.32 (1.25)	1.45 (1.60)	1.42 (1.51)	1.33 (1.26)	1.36 (1.34)
6	16	43	26/10/2015	1.39 (1.44)	1.54 (1.86)	1.50 (1.74)	1.51 (1.78)	1.53 (1.86)	1.49 (1.73)
7	17	44	02/11/2015	1.44 (1.58)	1.38 (1.41)	1.37 (1.38)	1.43 (1.53)	1.31 (1.21)	1.39 (1.42)
8	18	45	09/11/2015	1.32 (1.25)	1.26 (1.09)	1.14 (0.79)	1.17 (0.88)	1.27 (1.12)	1.23 (1.02)
9	19	46	16/11/2015	1.12 (0.75)	1.15 (0.83)	1.25 (1.07)	1.08 (0.67)	1.01 (0.52)	1.12 (0.76)
10	20	47	23/11/2015	1.05 (0.61)	1.06 (0.63)	0.88 (0.28)	0.93 (0.37)	1.02 (0.54)	0.99 (0.48)
11	21	48	30/11/2015	0.99 (0.47)	0.99 (0.48)	1.00 (0.50)	0.98 (0.46)	1.13 (0.78)	1.02 (0.54)
12	22	49	07/12/2015	0.78 (0.11)	0.88 (0.27)	0.77 (0.09)	0.80 (0.14)	1.06 (0.62)	0.86 (0.23)
Mean				1.13 (0.78)	1.14 (0.79)	1.14 (0.81)	1.12 (0.75)	1.15 (0.81)	
S.Em. (\pm)				0.04					
C.D. at 5 %				0.10					
C.V. %				7.22					

*Figures outside parenthesis are $\sqrt{x+0.5}$ transformed values while, those in parenthesis are retransformed value. WAS: Weeks After Sowing, SMW: Standard Meteorological Weeks.

Table 9: Seasonal abundance of syrphid flies on different cultivars of *Bt* cotton (2015-16).

Sr. No.	WAS	SMW	Date	Mean number of syrphid flies/plant					Mean
				Ajit-155	Dinkar-7	Vikram-5	Jackpot	GTHH 49 BG II	
1	3	30	27/07/2015	0.87 (0.26)*	0.90 (0.32)	1.05 (0.61)	0.71 (0.00)	0.80 (0.13)	0.87 (0.25)
2	4	31	03/08/2015	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
3	5	32	10/08/2015	1.03 (0.56)	1.10 (0.72)	0.98 (0.46)	0.93 (0.36)	1.09 (0.68)	1.03 (0.55)
4	6	33	17/08/2015	1.10 (0.71)	1.19 (0.91)	1.30 (1.18)	1.10 (0.72)	1.13 (0.77)	1.16 (0.84)
5	7	34	24/08/2015	1.22 (0.98)	1.39 (1.44)	1.25 (1.07)	1.35 (1.31)	1.09 (0.69)	1.26 (1.09)
6	8	35	31/08/2015	1.50 (1.76)	1.53 (1.83)	1.35 (1.32)	1.46 (1.62)	1.55 (1.89)	1.48 (1.68)
7	9	36	07/09/2015	1.41 (1.48)	1.24 (1.05)	1.34 (1.30)	1.26 (1.08)	1.37 (1.37)	1.32 (1.25)
8	10	37	14/09/2015	1.21 (0.97)	1.27 (1.11)	1.14 (0.81)	1.26 (1.09)	1.21 (0.97)	1.22 (0.99)
9	11	38	21/09/2015	1.21 (0.97)	1.12 (0.75)	1.00 (0.50)	1.26 (1.09)	1.17 (0.87)	1.15 (0.83)
10	12	39	28/09/2015	1.07 (0.64)	0.99 (0.48)	1.14 (0.79)	0.99 (0.49)	1.19 (0.92)	1.08 (0.66)
11	13	40	05/10/2015	0.97 (0.44)	1.07 (0.65)	0.87 (0.25)	1.10 (0.71)	1.13 (0.78)	1.03 (0.56)
12	14	41	12/10/2015	1.05 (0.60)	0.87 (0.25)	1.15 (0.81)	1.13 (0.77)	1.01 (0.51)	1.04 (0.58)
13	15	42	19/10/2015	0.92 (0.35)	1.03 (0.56)	1.00 (0.50)	0.95 (0.40)	0.96 (0.42)	0.97 (0.44)
14	16	43	26/10/2015	1.01 (0.52)	0.93 (0.36)	1.04 (0.58)	0.84 (0.21)	0.83 (0.19)	0.93 (0.36)
15	17	44	02/11/2015	0.88 (0.27)	0.95 (0.40)	0.97 (0.43)	0.99 (0.48)	1.03 (0.57)	0.96 (0.43)
16	18	45	09/11/2015	0.87 (0.26)	0.91 (0.32)	0.79 (0.12)	0.81 (0.15)	0.92 (0.35)	0.86 (0.24)
17	19	46	16/11/2015	0.76 (0.07)	0.82 (0.17)	0.97 (0.44)	0.91 (0.32)	0.84 (0.20)	0.86 (0.24)
18	20	47	23/11/2015	1.01 (0.52)	1.15 (0.83)	1.01 (0.51)	1.11 (0.73)	1.09 (0.68)	1.07 (0.65)
19	21	48	30/11/2015	1.20 (0.95)	1.11 (0.73)	1.06 (0.63)	1.19 (0.91)	1.21 (0.96)	1.15 (0.83)
20	22	49	07/12/2015	1.25 (1.06)	1.33 (1.26)	1.24 (1.04)	1.17 (0.87)	1.27 (1.11)	1.25 (1.07)
21	23	50	14/12/2015	1.20 (0.93)	1.24 (1.03)	1.15 (0.81)	1.06 (0.63)	1.06 (0.63)	1.14 (0.80)
22	24	51	21/12/2015	0.98 (0.47)	1.06 (0.62)	1.13 (0.77)	1.08 (0.67)	1.16 (0.84)	1.08 (0.67)
23	25	52	28/12/2015	1.09 (0.68)	1.01 (0.52)	0.98 (0.47)	1.09 (0.68)	0.86 (0.24)	1.01 (0.51)
Mean				1.09 (0.68)	1.09 (0.69)	1.07 (0.65)	1.09 (0.65)	1.10 (0.69)	
S.Em. (±)				0.03					
C.D. at 5 %				0.10					
C.V. %				7.73					

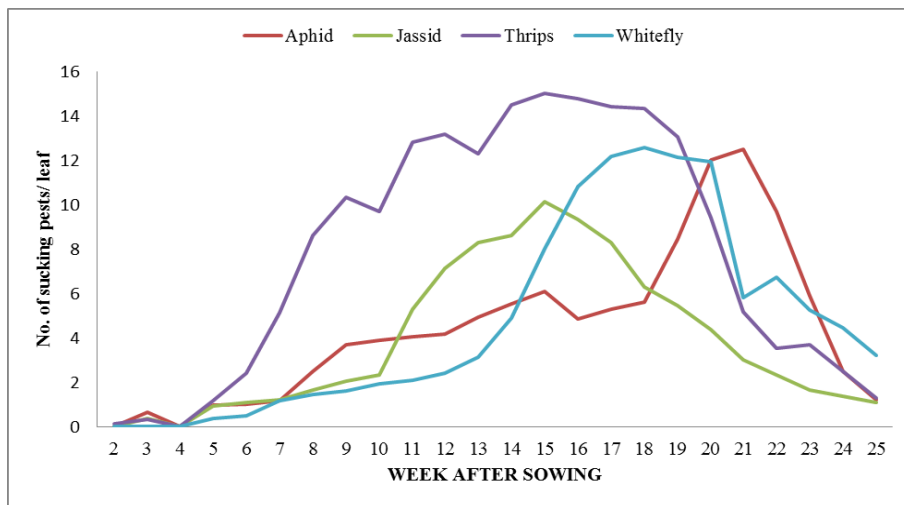


Fig 1: Periodic incidence of aphid, jassid, thrips and whitefly in bt cotton.

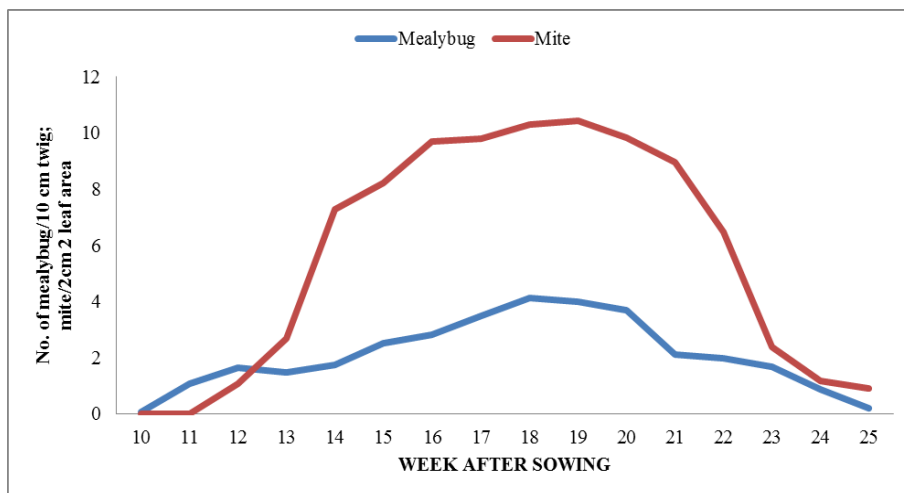


Fig 2: periodic incidence of mealybug and mite in bt cotton

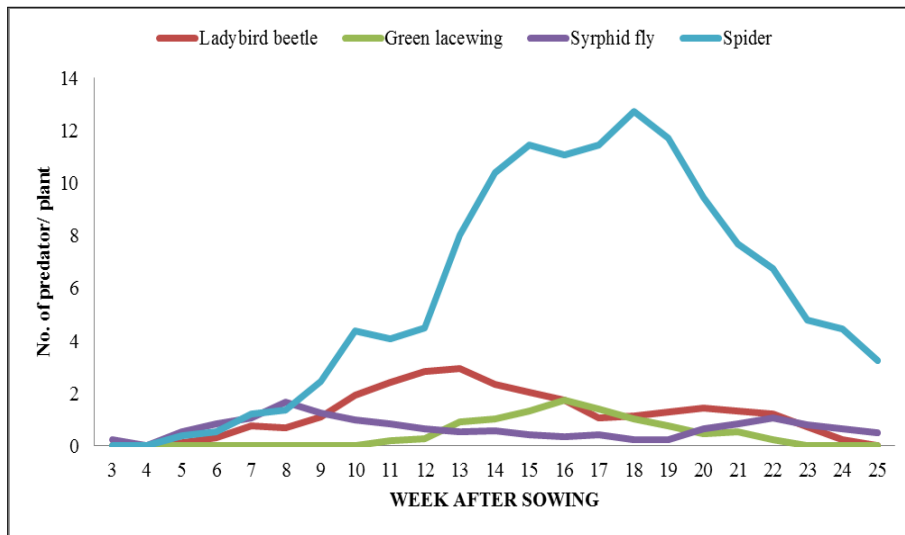


Fig 3: mean populations of natural enemies of sucking insect-pests in bt cotton

4. Conclusion

In the light of the results obtained through the present investigation, it can be concluded that the Bt cotton crop was initially invaded between the 2nd to 5th WAS by aphids, jassids, thrips and whiteflies and their damage continued throughout the crop season. Later on, two other sucking pests viz., mealybugs and mites were infested Bt cotton crop during the second and last week of September, respectively. The period of activity of these two pests was also remained active till the harvesting of crop. Among the natural enemies, syrphid fly appeared earlier at 3rd WAS (the last week of July) and remained throughout the crop season. Another two predators viz., ladybird beetle and spider were appeared at 5th WAS (the second week of August). However, green lacewing was started appearing at 12th WAS (the last week of November). The cultivars Vikram-5 and GTHH 49 BG II recorded lowest sucking insect-pests than the cultivars Ajit-155, Dinkar-7 and Jackpot.

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