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Influence of thermo-hygroclimatic parameters on sucking pest incidence and predator assemblages in high density planting (HDP) *Bt* cotton ecosystems

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Abstract
The investigation, entitled "Influence of thermo-hygroclimatic parameters on sucking pest incidence and predator assemblages in high density planting (HDP) *Bt* cotton ecosystems" was undertaken at the Agricultural Farm of Entomology Section, College of Agriculture, Dhule, Maharashtra, India (424004) during the *Kharif* season of 2023. The examination of the seasonal occurrence of various pests on *Bt* cotton and their natural adversaries revealed that aphid populations surged to a maximum in the final week of October, registering 43.6 aphids per three leaves per plant. The peak incidence of jassids was noted in the second week of October, with 16.9 jassids per three leaves per plant. Thrips populations reached their zenith in the second week of September, recording 53.1 thrips per three leaves per plant, whereas whitefly numbers culminated in the last week of September, with 41.9 whiteflies per three leaves per plant. Among natural predators, the ladybird beetle exhibited its greatest activity in the second week of September, with 3.98 beetles per plant, Exhibiting a pronounced and statistically significant concordance with the heightened incidence and spatial distribution of phloem-feeding arthropod infestations across agronomic landscapes.

Keywords: Aphid, Jassids, Whitefly, Thrips, Ladybird beetle, *Bt* cotton, Seasonal incidence

Introduction
Cotton (*Gossypium* spp.), ubiquitously exalted as India's "White Gold," is taxonomically situated within the *Malvaceae* family and the genus *Gossypium*. Of the approximately forty extant species, only four *G. arboreum*, *G. herbaceum*, *G. hirsutum*, and *G. barbadense* have undergone extensive domestication for agronomic exploitation. As a quintessential fibre and remunerative crop, cotton exerts a profound influence on both the industrial and agricultural macroeconomies at a global scale. It constitutes the primary lignocellulosic substrate for the textile manufacturing sector and underpins the livelihoods of over 250 million individuals worldwide, engaging nearly 7% of the labour force in economically emergent nations. Approximately half of all textile commodities are derived from cotton, underscoring its irreplaceable role in global sartorial production. In the Indian context, cotton contributes over 60% of the fibrous input utilized in textile fabrication and serves as a pivotal source of ancillary agro-industrial derivatives namely, 1.15 million tonnes of oil, 9 million tonnes of livestock fodder, and approximately 20 million tonnes of lignified stalks, which are valorised for biofuel and engineered wood composites such as particle boards. The spatial expanse and volumetric yield of cotton in India during the 2024-2025 cropping cycle are estimated at 113.6 lakh hectares and 299.26 lakh bales, respectively, with Maharashtra contributing 40.84 lakh hectares and 84.80 lakh bales (Anonymous, 2025) [1]. Entomological perturbations remain a formidable constraint to cotton productivity. In India, 162 insect and acarine taxa have been catalogued as phytophagous antagonists of cotton, precipitating yield attrition ranging from 50% to 60% (Jayaswal and Sundaramurthy, 1992) [4]. Maharashtra alone has documented 25 pestiferous species inflicting damage across various phenological stages (Manjunath, 2004) [6]. Among the most pernicious are sap-sucking arthropods such as *Aphis gossypii* (Glover), *Amrasca biguttula biguttula* (Ishida), *Thrips tabaci* (Lindeman), *Bemisia tabaci* (Gennadius), and *Dysdercus cingulatus* (Fabricius).

Quantified losses attributed to these pests are substantial 11.60% due to sucking pests, 44.50% from bollworms, and a compounded 52.10% when both infestations co-occur (Dhawan and Sindhu, 1986) [3].

The widespread adoption of *Bt* cotton has engendered a paradigmatic shift in cultivation practices and pest ecology. While the prevalence of lepidopteran bollworms has markedly declined, hemipteran and thysanopteran saprophagous insects have ascended as dominant phytosanitary threats. Their early-season incursions compromise seedling Vigor and crop establishment, while late-season infestations particularly by aphids and whiteflies deteriorate fibre quality through the deposition of saccharine honeydew, which facilitates sooty mold colonization and impairs lint purity. Moreover, *Bemisia tabaci* functions as a vector for cotton leaf curl disease, compounding its Phyto pathological impact. The present study was undertaken to elucidate the incidence and population dynamics of *A. gossypii*, *A. biguttula biguttula*, *T. tabaci*, *B. tabaci*, and *D. cingulatus*, along with their natural antagonists, in *Bt* cotton, and to analysed their correlative interactions with prevailing meteorological parameters.

Material and Methods

This study was conducted at Agricultural Farm of Entomology Section, College of Agriculture, Dhule, Maharashtra, India (424004) during the *Kharif* season of 2023 to examine the seasonal dynamics of insect pests and their natural enemies in *Bt* cotton (*Gossypium hirsutum* L., RCH-659 BG **II**), and their correlation with weather parameters. The crop was sown using manual dibbling at 120cm × 30cm spacing and managed per recommended agronomic practices. The populations of aphids, jassids, thrips, and whiteflies were recorded weekly from three leaves, one each from the top, middle, and bottom canopy on five randomly selected and tagged plants. Observations on the population of natural enemies, such as the ladybird beetle per plant, were recorded weekly on five randomly selected and tagged plants. Meteorological data were sourced from the College of Agriculture, Dhule, and analysed to assess pest-weather relationships.

Result and Discussion

The temporal prevalence of phytophagous insect taxa and their entomophagous antagonists, alongside the modulatory effects of thermo-hygrometric variables namely, pluviometry input, diurnal thermal maxima and minima, relative atmospheric moisture (both ante-meridian and post-meridian), and photoperiodic exposure on their respective population dynamics was systematically evaluated and encapsulated in Table 1.

Seasonal incidence of various pests of *Bt* cotton along with natural enemies

Aphids, *Aphis gossypii* (Glover)

The Table 1 illustrates the population change in the aphid throughout *Kharif*-2023 and found that aphid populations in *Bt* cotton ranged from 0.90 to 43.66 aphids 3 leaves^{-1} plant^{-1}. Aphid infestation started on the 28th SMW (0.09 aphids 3 leaves^{-1} plant^{-1}). The 35th SMW witnessed the initial peak in aphid incidence (40 aphids 3 leaves^{-1} plant^{-1}). The second highest incidence was observed in the 43rd SMW (43.60 aphids 3 leaves^{-1} plant^{-1}). The aphid population has decreased (13.40 aphids 3 leaves^{-1} plant^{-1}) within the 52nd SMW. These findings are similar with Khedkar and Kabre (2020) [5] they noticed that emergence of aphid populations on the 27th Standard Meteorological Week (SMW), which continued until the 47th SMW. During this time, aphid densities varied from 2.03 to 8.82 per three leaves of the plant^{-1}. Interestingly, the maximum peak activity (8.82 aphid 3 leaves-1 plant-1) occurred precisely during the 42nd SMW, which corresponded to the third week of October.

Jassids, *Amrasca bigutulla bigutulla* (Ishida)

The data on population fluctuation of jassid during *Kharif*-2023 presented in Table 1 and Fig. 1. revealed that the jassid population in *Bt* cotton ranged between (2.00 to 16.90 jassids 3 leaves^{-1} plant^{-1}). The incidence was started from 29th SMW and continued till the crop harvest. The initial peak of jassids incidence occurred in 33rd SMW (15.01 jassids 3 leaves^{-1} plant^{-1}). The second peak incidence was reported in the 35th SMW. and third peak incidence was on 41st SMW. After 41st SMW the population of jassid decreased and reached to 0.1 jassids 3 leaves^{-1} plant^{-1} in 52nd SMW. During *Kharif*-2023. Present findings were supported by Sarode *et al.* (2020) [8] noticed that the population fluctuations of jassids 3 leaves^{-1} plant^{-1} in cotton during *Kharif*-2018 ranged between 2.0 to 21.6 jassids 3 leaves^{-1} plant^{-1}. The incidence of jassids 3 leaves^{-1} plant^{-1} started from 29th SMW (3.9) with its first peak in 31st SMW (10.2) and second peak in 37th SMW (21.60).

Thrips, *Thrips tabaci* (Lindeman)

The data on population dynamics of thrips in *Bt* cotton during *Kharif*-2023 are presented in Table 1. The population of thrips during *Kharif*-2023 ranged from 5.1 to 53.1 thrips 3 leaves^{-1} plant^{-1}. The incidence was started from 29th SMW and reached at its first peak (48.4 thrips 3 leaves^{-1} plant^{-1}) during 34th SMW. Second peak incidence was recorded during 37th SMW (thrips 3 leaves^{-1} plant^{-1}) and third peak incidence was recorded during 44th SMW (41.90 thrips 3 leaves^{-1} plant^{-1}). Thereafter, population showed declining trend till 50th SMW (0.80 thrips 3 leaves^{-1} plant^{-1}). The present finding was corroborated with Deshmukh and patil (2024) [2] reported that thrips population was ranged between 0.26 to 13.78 thrips 3 leaves^{-1} plant^{-1}. The incidence was first observed during the 29th MW (4.12 thrips 3 leaves^{-1} plant^{-1}) and reached its peak during 30th MW (13.78 thrips 3 leaves^{-1} plant^{-1}). Subsequently, the population showed a decreasing trend with lowest count of 0.26 thrips 3 leaves^{-1} during the 42nd MW.

Whitefly, *Bemisia tabaci* (Gennadius)

The data on the population dynamics of whitefly in *Bt* cotton during *Kharif*-2023 are presented in Table 1. which was ranged from 0.70 to 41.90 whitefly 3 leaves^{-1} plant^{-1}. The incidence was started from 29th SMW (0.70 whitefly 3 leaves^{-1} plant^{-1}) and reached at its first peak (29.80 whitefly 3 leaves^{-1} plant^{-1}) during 35th SMW. Second peak incidence was recorded during 44th SMW (41.90 whitefly 3 leaves^{-1} plant^{-1}) and third peak incidence was recorded during 44th SMW (41.90 whitefly 3 leaves^{-1} plant^{-1}). Thereafter, population showed declining trend till 52th SMW (3.10 whitefly 3 leaves^{-1} plant^{-1}). Above findings are similar with Ratnakar (2019) [7] reported that whiteflies population ranged from 0.7 to 18.9 whitefly 3 leaves^{-1} plant^{-1} in *Bt* cotton. Which reached its peak during 44th SMW (18.9

whitefly 3 leaves^{-1} plant^{-1}). Thereafter incidence started declining up to 54th SM.W. (0.7 whitefly 3 leaves^{-1} plant^{-1}).

Lady bird beetle, *Coccinella transversalis* (*Fabricius*)

The data pertaining to population fluctuation of *Coccinellids* beetle during *Kharif*-2023 are presented in Table 1 More or less ladybird beetle population was observed throughout cropping period from 29th SMW to 52nd SMW. The population of *Coccinellids* beetle ranged between 0.58 to 3.91 *Coccinellids* beetle plant^{-1} during *Kharif*-2023. The occurrence of *Coccinellids* beetle initiated from 29th MW (0.58 *Coccinellids* beetle plant^{-1}) and the highest population (3.91 *Coccinellids* beetle plant^{-1}) was recorded in 39th SMW during *Kharif*-2023. Similar results were found by Deshmukh and Patil (2024) [2] beetle population was observed throughout cropping period from 29th SMW to 52nd SMW. The population beetle was ranged between 0.30 to 3.74 bettle plant^{-1}. The occurrence of ladybird beetle initiated from 29th SMW (0.30 beetle plant^{-1}). The highest population (3.74 beetle plant^{-1}) was recorded in 48th SMW.

Correlation of weather parameters with various insect pests on *Bt* cotton

The data on average population of aphids, jassids, thrips, whiteflies, red cotton bug and lady bird beetle was recorded under field conditions and correlated with meteorological parameters such as rainfall, maximum temperature, minimum temperature, relative humidity, rainfall and sunshine hours. The Pearson's correlation coefficient values (r) were computed and are presented in Table 2.

Aphids

The data presented in Table 2 of correlation coefficient between *A. gossypii* population and weather parameters revealed that sunshine hour (r= 0.576), max temperature (r= 0.400), were found positive and having significant correlation. Whereas, Min. temperature (r= 0.311) shows negatively non-significant. The population of *A. gossypii* showed negative significant correlation with rainfall (r= -0.580) and morning (r= -0.810) & evening (r= -0.551) relative humidity at 5 per cent level of significance and 1 per cent level of significance. The current findings are consistent with Waman *et al*. (2023) [9] revealed that a significant positive correlation was observed between maximum temperature and aphid populations. Whereas minimum temperature and evening relative humidity shows negative significant correlation, while morning relative humidity and rainfall shows negative non-significant corelation with aphid population.

Jassids

The data on correlation between weather parameters and jassid population during *Kharif*-2023 are presented in Table 2. During *Kharif*-2023, population of jassid in relation to maximum temperature (r = 0.557) showed positively significant effect while, Sunshine hour (r = 0.329) and minimum temperature (r = 0.280) showed positively non-significant effect whereas, Rainfall (r = -0.298), morning relative humidity (r = -0.367) and evening relative humidity (r = -0.113) showed negatively non-significant effect with jassid population at 5 per cent level of significance and 1 per cent level of significance. Deshmukh and Patil (2024) [2] in year 2021 found that jassid population shows positive significant correlations with morning relative humidity and negative significant correlation with evening relative humidity, conversely negative significant correlations were observed with rainfall and minimum temperature.

Thrips

The data on correlation between weather parameters and thrips population during *Kharif*-2023, presented in Table 2. The population of thrips in relation to maximum temperature (r = 0.409) and minimum temperature (r =0.498) was found positively significant effect whereas, evening relative humidity (r = 0.196) and sunshine hour (r = 0.097) had a positive non-significant effect while, rainfall (r = -0.047) and morning relative humidity (r = -0.036) effect negatively non-significant on thrips population at 5 per cent level of significance and 1 per cent level of significance. The thrips population was negatively non-significant with maximum temperature whereas, it showed positively non-significant effect with minimum temperature, morning relative humidity, evening relative humidity and rainfall. (Deshmukh & Patil, 2024) [2].

Whitefly

The data on correlation between weather parameters and whitefly population during *Kharif*-2023 present on Table 2 shows that the data regarding the correlation between whitefly population with weather parameters in *Bt* cotton showed that maximum temperature (r = 0.538) and sunshine hour (r = 0.708) showed positive significant correlation whereas, rainfall (r = -0.443), morning relative humidity (r = -0.850), and evening relative humidity (r = -0.671) showed negatively significant effect and minimum temperature (r = -0.298) showed negatively non-significant effect with whitefly population at 5 per cent level of significance and 1 per cent level of significance. These finding are similar with Khedkar and Kabre (2020) [5] who, found that whitefly shows positive non-significant correlation with maximum temperature and minimum temperature showed negative significant correlation, while morning relative humidity showed negative significant correlation, evening humidity showed negative non-significant correlation and rainfall had negative non-significant effect on occurrence of whitefly population.

Table 1: Population dynamics of major sucking pest complex and their natural enemy in *Bt* cotton.

Months	S.M.W.	Aphid/ 3leaves/ plant	Jassid/ 3leaves/ plant	Thrip/ 3leaves/ plant	Whitefly/3leaves plant	LLB/ plant	Rainfall (mm)	Temp. (ºC)		Relative humidity (%)		SSH (Hour)
								Max.	Min.	Morn.	Eve.	
July	27	0.0	0.0	0.0	0.0	0.00	93.2	33.8	21.8	92.0	49.0	3.2
	28	0.9	0.0	0.0	0.0	0.00	29.4	31.2	21.1	91.0	57.0	0.9
	29	5.3	2.0	5.1	0.7	0.58	31.8	30.7	21.1	93.0	54.0	0.8
	30	12.4	4.1	13.5	3.8	1.11	16.6	30.9	21.5	89.0	61.0	1.4
	31	21.3	7.3	21.1	8.1	1.89	8.8	30.6	21.2	89.0	60.0	1.4
August	32	28.1	13.4	29.5	13.4	2.11	5.2	31.9	20.3	88.0	59.0	1.9

	33	34.8	15.1	36.1	18.3	2.24	2.2	32.6	20.3	88.0	53.0	2.4
	34	36.5	13.7	48.4	21.7	2.96	14.4	29.8	20.6	88.0	59.0	1.5
	35	40.3	15.9	45.3	29.8	0.68	0.0	34.1	19.7	80.0	46.0	7.9
September	36	28.6	10.5	31.1	22.7	1.80	61.5	33.2	20.7	82.0	48.0	3.2
	37	27.9	13.6	53.1	23.4	3.98	23.0	30.5	19.4	89.0	55.0	3.4
	38	12.7	7.1	29.3	10.4	2.78	106.8	31.4	20.0	91.0	60.0	3.7
	39	15.4	11.2	38.8	15.1	3.91	33.4	32.4	20.0	90.0	57.0	5.2
October	40	22.4	13.1	41.5	24.6	3.45	0.0	33.9	19.7	87.0	43.0	8.2
	41	29.8	16.9	40.7	28.8	1.95	0.0	34.9	18.1	84.0	38.0	7.8
	42	37.1	15.1	37.3	33.4	1.65	0.0	34.8	18.5	83.0	38.0	6.3
	43	43.6	12.1	22.1	37.5	1.10	0.0	34.4	14.9	75.0	28.0	8.0
	44	41.9	11.3	16.6	41.9	0.98	0.0	33.1	13.0	75.0	28.0	8.1
November	45	39.7	10.1	11.9	38.4	0.75	0.0	33.6	12.6	76.0	32.0	7.5
	46	36.5	8.3	7.1	33.1	0.55	0.0	32.6	12.7	76.0	31.0	7.3
	47	34.6	5.1	8.4	28.4	0.89	0.0	32.2	13.6	80.0	38.0	5.9
	48	11.3	2.1	3.1	10.8	1.33	42.4	27.9	16.2	90.0	50.0	1.6
December	49	18.3	4.9	3.0	12.7	1.21	0.0	27.4	15.4	90.0	56.0	4.2
	50	26.8	2.2	0.8	15.2	1.10	0.0	29.4	11.6	87.0	46.0	6.8
	51	20.3	0.9	0.0	7.7	1.00	0.0	27.8	9.2	83.0	36.0	5.2
	52	13.4	0.1	0.0	3.1	1.00	0.0	31.9	10.1	87.0	38.0	6.7

Table 2: Correlation between weather parameters and sucking pest complex of *Bt* cotton.

Correlation coefficient values (r)						
Pests	**Temperature (°C)**		**Relative humidity**		**Rainfall (mm)**	**SSH**
	Maximum	**Minimum**	**Morning**	**Evening**		
Aphid	0.400^{*}	-0.311^{NS}	-0.810^{**}	-0.551^{**}	-0.580^{**}	0.576^{**}
Jassid	0.557^{**}	0.280^{NS}	-0.367^{NS}	-0.113^{NS}	-0.298^{NS}	0.329^{NS}
Thrips	0.409^{*}	0.498^{**}	-0.036^{NS}	0.196^{NS}	-0.047^{NS}	0.097^{NS}
Whitefly	0.538^{**}	-0.298^{NS}	-0.850^{**}	-0.671^{**}	-0.443^{*}	0.708^{**}

** significant at 1%, *significant at 5%.

Conclusion

The present studies concluded that aphids, jassids, thrips, and whiteflies persist on *Bt* cotton throughout the cropping period. Despite variations in population trends, aphids consistently remained the most prevalent pest. As the crop matured, cooler temperature favoured aphids, jassids and thrips resulting their peak population during later stage. In the mid -stages of the crop, the weather was favourable for whiteflies also the incidence of red cotton bug was observed during boll opening stage. The study highlights the intricate connection between pest populations and their natural predators, revealing that predator numbers align with pest activity levels. These results enhance our knowledge of pest ecology in *Bt* cotton farming and emphasize the importance of integrated pest management strategies to effectively reduce crop damage.

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