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Seasonal Incidence of Thrips a Potential Insect Vector of GBNV in Black Gram

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ABSTRACT

Background: Present experiment was aimed to know the influence of weather on the incidence of thrips, a major sucking pest and potential vector of GBNV in blackgram.

Methods: The incidence of thrips complex for consecutive three seasons (spring 2019-20, *autumn* 2020-21, *spring* 2020-21) have been recorded from 7 DAS, till to crop maturity and correlated with weather parameters.

Result: The thrips population was observed in the field approximately after 14 DAS. Overall view of thrips incidence in blackgram was more during *autumn* 2020-2021 (17.35 mean no of thrips per plant) compared to *spring* 2019-2020 (10.6) and 2020-2021 (10.10). Thrips population has showed a highly significant positive correlation with maximum temperature (0.74), minimum temperature (0.75), as well as with mean temperature (0.819) during *rabi* 2019. During *spring* 2020-21 only maximum temperature has shown significant positive correlation, but minimum and mean temperatures have shown positive correlation without any significance. Whereas during *autumn* 2020-21 temperature has shown positive correlation without any significance. Across the three seasons relative humidity has shown insignificant negative correlation.

Key words: *Autumn*, *Incidence, Spring,* Thrips.

INTRODUCTION

Globally India is the largest producer of black gram, accounting for more than 70% of production followed by Myanmar and Pakistan (Bharathi *et al*., 2025). Blackgram is referred as the “king of the pulses” due to its delicious taste and numerous other nutritional qualities (Vadivel *et al*., 2023). It is rich in nutritional quality with 24-27% protein, 1% fat, 57% carbohydrate, 3.8% fibre and 4.8 % ash. It is grown in both summer and winter seasons (Mohanlal *et al*., 2023). Furthermore, it is fed to milch cows in particular as nutrient-rich fodder. Thirty per cent yield loss of this major rabi pulse is due to the sucking insect pests as they act as vectors of deadly viral diseases. From the last decade, thrips transmitted bud necrosis disease and its menace had been reported by the various researchers in India. GBNV, a Tospovirus is not seed-transmitted and thrips play critical role in the survival and spread of it. However, *the* studies on blackgram infecting thrips are scanty in the line of their incidence, survival and spread in the changing climates. Keeping in view of the problems caused by thrips directly as pest and indirectly as vector, the present study was aimed to know the “Impact of changing climate on incidence of thrips in blackgram”.

MATERIALS AND METHODS

The present investigation was conducted in the Northern block of Agricultural College farm, Bapatla, Guntur district, Andhra Pradesh for three seasons *viz*., *spring* 2019-20, *autumn* and *spring* of 2020-2021. The meteorological data was obtained from the meteorological observatory, Bapatla, Guntur Dist. A bulk plot of blackgram, LBG 752 was maintained under unprotected conditions. Three crops were taken up during *spring* 2019-20, *autumn* and *spring* of 2020-21. Twenty plants were selected randomly and tagged for recording the observations on thrips population. The pest population was recorded at weekly intervals from 7 DAS and up to the crop maturity. Data was recorded from top, middle and bottom leaves randomly during early morning hours. On tagged plants leaves were gently turned over to observe the infestation of thrips and magnifying lens was used to count the number. The weather parameters such as maximum, minimum temperature (°C), morning and evening relative humidity (RH) (%), wind speed

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(kmph), rainfall (mm) were correlated with the thrips population. The influence of weather parameters on incidence of thrips was worked out by simple correlation and multiple regression analysis (MLR) by using SPSS (Version 20) software. As thrips acts as vector for the bud necrosis disease, incidence of disease was also recorded simultaneously and this data was correlated with the incidence of thrips population for three seasons.

RESULTS AND DISCUSSION

Incidence of Thrips in blackgram during *Rabi* 2019-2020

From the Table 1 it was revealed that thrips population was observed initially at 14 DAS during 3rd SMW (Standard meteorological week) and mean number of thrips per plant was 1.00. The maximum and minimum temperatures during that period were 30.79, 19.83°C, respectively. Mean temperature was 25.31°C while the average morning, evening relative humidities (RH) were 84.14, 64.43 per cent respectively with 74.29 per cent mean RH. No rainfall was recorded and wind speed of 1.71 kmph. The peak of thrips population was observed at 63 DAS during 10th SMW with 10.6 mean number of thrips. The maximum, minimum temperatures during that period were 32.33, 21.96°C, respectively. Mean temperature was 27.14°C while the average morning, evening RH were 81.86, 66.29 per cent respectively with 74.07 per cent mean RH. No rainfall was recorded and wind speed of 4.86 kmph. The thrips population remained static up to 70 DAS and then started declining during first 12th SMW with 7.8 mean number of thrips. The maximum, minimum temperatures were 34.76, 23.21°C respectively. Mean temperature was 28.99°C while the average morning, evening RH were 83.71, 52.00 per cent respectively with mean RH 67.86 per cent and 4.71 kmph wind speed. No rainfall was recorded. The present findings are in agreement with Vinuthan (2018) who has reported that during *rabi* season minimum thrips population of 1.8 thrips per plant was noticed in early stages of crop growth and maximum thrips population of 61.04 thrips/plant was noticed. He has also reported that the onion crop transplanted during *rabi* recorded the maximum population of thrips (31.81 thrips/plant) when compared to *kharif* transplanted onion crop. When correlation coefficient (*r*) values were assessed (Table 2) thrips population has showed a highly significant positive correlation with maximum temperature (0.74), minimum temperature (0.75), as well as with mean temperature (0.819) while the morning RH (-0.43), showed non-significant negative correlation. Whereas evening RH (0.015) showed positive correlation without any significance. Further, mean RH showed non-significant negative correlation (-0.206). Rainfall (-0.256) and number of rainy days (-0.156) showed non-significant negative correlation. Wind speed (0.802) showed highly significant positive correlation. Results pertaining to maximum and minimum temperature correlation with thrips population were in accordance with Saritha *et al*. (2020) who reported that during r*abi* season, the mean

Table 1: Incidence of thrips in blackgram during *spring* 2019 -2020.

Standard meteorological week (SMW)	Date	Crop Stage	Mean No. of thrips per plant	Mean PDI of bud necrosis disease	Max Temp. (°C)	Min Temp. (°C)	Mean Temp. (°C)	Morning RH (%)	Evening RH (%)	Mean RH (%)	Rainfall (in mm)	No. of rainy days	Avg. wind speed in (KMPH)
2	17.01.2020	7 DAS	0	0	29.36	19.64	24.50	87.14	63.57	75.36	0	0	1.86
3	24.01.2020	14 DAS	1	0.00	30.79	19.83	25.31	84.14	64.43	74.29	0.00	0.00	1.71
4	31.01.2020	21 DAS	4.2	0.00	30.60	21.41	26.01	81.00	61.86	71.43	0.00	0.00	2.43
5	07.02.2020	28 DAS	1	0.00	29.61	21.39	25.50	79.43	62.57	71.00	10.00	0.00	3.00
6	14.02.2020	35 DAS	1	1.50	31.19	19.74	25.46	81.00	57.86	69.43	0.00	2.00	1.86
7	22.02.2020	42 DAS	0.9	3.73	30.93	19.93	25.43	82.29	61.86	72.07	0.00	0.00	2.29
8	02.03.2020	49 DAS	0.35	5.30	31.74	21.55	26.64	85.63	66.50	76.06	0.70	0.00	3.25
9	10.03.2020	56 DAS	5.5	6.98	31.64	24.04	27.84	83.57	68.29	75.93	0.00	1.00	6.29
10	18.03.2020	63 DAS	10.6	21.08	32.33	21.96	27.14	81.86	66.29	74.07	0.00	0.00	4.86
11	26.03.2020	70 DAS	10	25.90	33.31	23.71	28.51	77.71	65.43	71.57	0.00	0.00	5.57

temperature (r = 0.815), maximum temperature (r = 0.708), minimum temperature (r = 0.797) had positive insignificant positive correlation with thrips population. Similarly, Aishwarya *et al*. (2019) who has conducted a study in water melon during summer 2019 in Tamil Nadu reported that the temperature (r = 0.2) was positively correlated with the incidence of *T. palmi*. Vinuthan *et al*. (2018) in their study in *rabi* onion during 2018 found that temperature showed significant positive correlation with thrips population and also during second season (*rabi*-summer) temperature showed significant positive correlation with thrips population. Vijayalakshmi *et al*. (2017) reported that thrips incidence on groundnut in Tamil Nadu showed positive correlation with maximum temperature (0.082), minimum temperature (0.052) and sunshine hours (0.085) in *rabi* 2017.

The present findings about correlation between RH and thrips population were in agreement with Saritha *et al*. (2020) who reported non-significant negative correlation with mean RH (r = 0.314) and it was evident that the mean temperature favored the pest population in groundnut during r*abi* season. Aishwarya *et al*. (2019) also reported that in water melon during summer 2019 in Tamil Nadu, RH (r = -0.5) and rainfall (r = -0.5) were negatively correlated with population of thrips. Vinuthan *et al*. (2018) reported that the thrips population showed non-significant negative correlation with rainfall in *rabi* onion during 2018 and rabi summer 2018. Vijayalakshmi *et al*. (2017) reported that thrips population in groundnut showed negative correlation with morning (-0.322) and evening relative humidity (-0.162) in *rabi* 2017. Multiple linear regression analysis (MLR) (Table 3) results showed that all the weather variables together could influence the incidence of thrips by 77.0 (R^2= 0.77) per cent. It was also evident that among various factors studied, the partial regression coefficient (b) for maximum temperature (-0.106) rainfall (-0.48), minimum temperature (-1.47) morning RH (-0.642) showed negative influence on thrips population. Rainfall (-0.48) and average wind speed (-3.18) were also showed negative influence on thrips population. Evening RH (0.226) showed positive influence on thrips population. The above findings were in agreement with Naresh *et al*. (2018) whose regression analysis on foliar damage caused by the thrips indicated that all the weather parameters together resulted in 94 per cent (R^2 = 0.94) and 95 per cent (R^2 = 0.95) in groundnut cultivars Dharani and K-6 sown during November second fortnight. Harish *et al*. (2015) also reported that the coefficient of multiple determinations (R^2) was 36, 54 and 80 per cent during *autumn*, *spring* and summer seasons during 2015 on groundnut in Gujarat, respectively.

Incidence of thrips during *autumn* 2020-2021

Data presented in the Table 4, revealed that during *autumn* 2020-2021 thrips population was observed initially at 21 DAS during third week of August *i.e*. 33rd SMW with 4.2 mean number of thrips per plant. The maximum and minimum temperatures were 30.50, 24.49^{o}C, respectively. Mean temperature was 27.5^{o}C while the average morning, evening RH were 84.43 , 71.71 per cent respectively with mean RH 78.1 per cent. About 3.14 mm rainfall was recorded with five rainy days and wind speed was 9.14 kmph. Highly fluctuating thrips incidence was noticed during the *autumn* season. Thrips population has increased gradually and reached peak at 35 DAS with 17.35 mean number of thrips per plant. The maximum and minimum temperatures were 33.94, 26.40^{o}C respectively. Mean temperature was 30.2^{o}C while the average morning, evening RH were 78.71, 51.14 per cent respectively with mean RH 64.9 per cent. There was no rainfall and wind speed was 6.43 kmph. After 35 days, population started declining to 5.2, 4.6, 4.55 and 3.33 (thrips per plant) at 42, 49, 56, 63 DAS respectively. At 70 DAS slight increase in thrips population was noticed *i.e.* 7.1 thrips per plant during first week of October (40th SMW). The maximum and minimum temperatures were 32.64, 25.50^{o}C respectively. Mean temperature was 29.1^{o}C. While the average morning, evening RH were 81.14, 71.86 per cent respectively with mean RH 76.5 per cent. Less rainfall (0.24 mm) and wind speed was 4.86 kmph. Again a slight decline of thrips population was noticed towards the crop maturity at 77 DAS during 41st SMW. Similarly, Meena *et al*. (2013) reported that the infestation of thrips, *S. dorsalis* in chili crop was

Table 2: Simple correlation between thrips population with weather parameters during *spring* 2019-20.

Season		Temperature (°C)			Relative Humidity (%)			Rainfall (in mm)	No. of rainy days	AWS
		Max temp.	Min temp.	Mean	Morning	Evening	Mean			
Spring 2019-20	Thrips Per Plant	0.744**	0.756**	0.819**	-0.435	0.015	-0.206	-0.256	-0.156	0.802**

*Significant, **highly significant.

Table 3: Multiple linear regression between thrips population in blackgram with weather parameters during *spring* 2019-20.

Year and Season	Dependent variable	R^2	Regression equation
Spring 2019-20	Mean no. of thrips per plant	0.77	Y = 96.12 - 0.106 (Max Tm) -1.47 (Min Tm) - 0.642 (Mng RH) +0.226 (Eve RH) - 0.48 (RF) - 1.94 (RD) - 3.18 (AWS)

initiated in the fourth week of July (30th meteorological week) and continued up to fourth week of November (48th MW) during 2006-07, 2007-08 at Allahabad, Uttar Pradesh. The population increased gradually and touched its peak with a mean of 14.5 and 14.7 thrips/3 leaves /plant during 2006-07 and 2007-08, respectively. Yadav *et al*. (2012) also reported that *S. dorsalis* in groundnut at Udaipur, first appeared during 32nd standard meteorological week (SMW) *i.e*. 6th - 12th August, 2010 (2nd week) with a mean population of 1.20 thrips/3leaves/plant. The population increased gradually and attained the peak in the fourth week of September with a mean population of 4.16 thrips/ 3 leaves/ plant. Later on, the population declined and reached a minimum level of 0.9/ 3 leaves/plant during 42nd SMW *i.e.* 14th - 21st October (3rd week). Correlation coefficient (*r*) values from the Table 5 revealed that the number of thrips per plant showed positive correlation with maximum temperature (0.151), minimum temperature (0.158) as well as with mean temperature (0.172) but insignificant. The morning RH (-0.079), evening RH (-0.566) showed non- significant, negative correlation with thrips population. Further, mean RH showed non-significant negative correlation (-0.475). Rainfall (-0.289) and wind speed (-0.346) showed non-significant negative correlation while number of rainy days (-0.657) showed significant negative correlation. These findings are in agreement with Nayak *et al*. (2019) who reported that thrips showed significant positive correlation with minimum temperature and regression equation revealed a positive influence of temperature on thrips population. The thrips population also showed significant positive correlation with mean atmospheric temperature. Moanaro and Choudhary (2018) reported the similar findings of non-significant positive correlation of thrips population with minimum, maximum and mean temperatures in capsicum. Vijayalakshmi *et al*. (2017) also reported that thrips population showed positive correlation with maximum and minimum temperature, respectively in groundnut crop during *kharif* in Tamil Nadu. Mahipal *et al*. (2017) reported that population of flower thrips *Megalurothrips sjoestdi* (Trybom) in cowpea was positive and highly significant with maximum temperature, minimum temperature during *kharif* season. Findings by Akashe *et al*. (2016) in sunflower crop during *kharif* season are in line with the present findings, *i.e.* the thrips population showed non-significant positive correlation with maximum temperature. Pramod *et al*. (2011) reported significant and positive correlation of thrips with maximum temperature in sunflower hybrid KBSH-1 in *kharif* season. Findings of Kandakoor *et al*. (2012) are in line with our present findings that thrips population showed non-significant positive correlation to maximum and minimum temperature in groundnut during *kharif*. Nandagopal *et al*. (2008) reported positive correlation of thrips population with the maximum temperature during *kharif* seasons in groundnut. Present findings pertaining to RH influence on thrips population are in agreement with Jamuna *et al*. (2019) reported non-significant negative correlation of thrips population with

Table 4: Incidence of thrips in black gram during *autumn* 2020 -2021.

Standard meteorological week (SMW)	Date	Crop stage	Mean no. of thrips per plant	Mean PDI of BND	Max temp. (°C)	Min temp. (°C)	Mean temp. (°C)	Morning RH (%)	Evening RH (%)	Mean RH (%)	Rainfall (in mm)	No. of rainy days	Avg. wind speed in (KMPH)
31	04.08.2020	7 DAS	0	0.00	33.9	26.2	30.0	84.1	72.3	78.2	3.5	5	8.6
32	11.08.2020	14 DAS	0	0.00	32.91	25.86	29.4	78.00	67.29	72.6	4.86	4	8.86
33	18.08.2020	21 DAS	4.2	0.00	30.50	24.49	27.5	84.43	71.71	78.1	3.14	5	9.14
34	25.08.2020	28 DAS	8.9	11.23	31.87	24.76	28.3	85.29	79.71	82.5	9.20	5	8.14
35	01.09.2020	35 DAS	17.35	14.94	33.94	26.40	30.2	78.71	51.14	64.9	0.00	0	6.43
36	08.09.2020	42 DAS	5.2	21.10	33.34	26.10	29.7	81.29	68.14	74.7	4.34	3	5.86
37	15.09.2020	49 DAS	4.6	22.19	31.49	25.03	28.3	83.00	75.71	79.4	10.11	6	5.86
38	22.09.2020	56 DAS	4.55	24.76	31.97	25.53	28.8	77.00	72.14	74.6	10.33	5	7.29
39	29.09.2020	63 DAS	3.3	26.05	32.90	25.17	29.0	78.86	72.57	75.7	23.61	4	7.29
40	05.10.2020	70 DAS	7.1	26.05	32.64	25.50	29.1	81.14	71.86	76.5	0.24	1	4.86

evening relative humidity in tomato during *kharif* season. Vijayalakshmi *et al.* (2017) reported that thrips population showed negative correlation with morning and evening RH in groundnut crop during *kharif*. Subba and Ghosh (2016) has reported that RH (minimum, maximum, mean RH showed non-significant negative influence on thrips population in tomato during *kharif* season. Findings of Akashe *et al*. (2016) are in line with our findings, *i.e.* the thrips population showed highly significant negative correlation with RH-I, non-significant negative correlation with RH-II in sunflower crop during *autumn* season. Findings of Kandakoor *et al*. (2012) reported that population of thrips showed significant negative correlation with morning RH whereas evening RH showed non-significant negative correlation in groundnut during *kharif*. Thrips population was negatively correlated with average RH in groundnut reported by Nandagopal *et al*. (2008). Pramod (2007) has reported that population of Thrips were in non-significant negative correlation with morning, evening RH, respectively in sunflower. The results of present study pertaining to rainfall influence on thrips population during *kharif* season are in agreement with Jamuna *et al*. (2019) reported that rainfall, rainy days showed significant negative correlation with thrips population in tomato. Vinaykumar *et al*. (2019) has also reported negative correlation between the thrips and rainfall. Negative correlation between thrips population and rainfall was reported by Moanaro and Choudhary (2018) in capsicum. Subba and Ghosh (2016) also reported that weekly total rainfall showed non-significant negative influence on thrips in tomato during *kharif*. Mahipal *et al*. (2017) reported that thrips population showed non-significant negative correlation with rainfall during *kharif* in cowpea. Findings of Akashe *et al*. (2016) are in line with our findings, *i.e.* the thrips population showed non-significant negative correlation with rainfall in sunflower crop during *kharif*. Kandakoor *et al*. (2012) reported non-significant negative correlation of thrips with rainfall in groundnut during *kharif* season. Nandagopal *et al*. (2008) reported the negative correlation of thrips population with rainy days in groundnut. Similarly, Pramod (2007) has reported that thrips during *autumn* seasons showed non-significant negative correlation with rainfall.

The data (Table 6) MLR analysis results showed that all the weather variables together contributed to the incidence of thrips by 70.0 (R^2= 0.70) per cent. It was also evident that the partial regression coefficient (b) for maximum temperature (2.53) morning RH (0.299) showed positive influence on thrips population. Minimum temperature (-8.52) evening RH (-0.64) rainfall (-0.09) and average wind speed (-1.44) showed negative influence on thrips population.

These findings are in accordance with Timmanna *et al*. (2020) who has analyzed stepwise regression analysis and revealed that the thrips population was influenced by all the weather parameters during current week (R^2 = 0.810), one lag week (R^2 = 0.739) and two lag week (R^2 = 0.879). Jamuna *et al.* (2019) also reported that 80.30 per cent of the thrips population was influenced by weather parameters (R^2 = 0.803) while Harish *et al.* (2015) reported that the coefficient of multiple determinations (R^2) was only 36 per cent during *kharif* season in groundnut. Similarly, Moanaro and Choudhary (2018) also reported weather parameters as independent variable, thrips population fluctuation as dependent variable, explained to 42 per cent thrips population fluctuation.

Incidence of thrips in blackgram during *Rabi* 2020-2021

From the Table 7, it was evident that thrips population was observed initially at 21 DAS during fourth week of December *i.e.* 52nd SMW with 2.15 mean number of thrips per plant. The maximum and minimum temperatures during that period were 29.26,17.99°C respectively. Mean temperature was 23.63°C while the average morning, evening RH were 84.13 and 53.75 per cent, respectively with mean RH 68.94 per cent. No rainfall was recorded and wind speed was 3.63 kmph. Thrips population has increased gradually and reached peak at 63 DAS during 6th SMW with 10.10 mean number of thrips. The maximum and minimum temperatures during that period were 30.87,17.46°C respectively. Mean temperature recorded 24.16°C while the average morning, evening RH were 85.14, 8.14 per cent respectively with mean RH 66.64 per cent. No rainfall was recorded; wind

Table 5: Simple correlation between thrips population in blackgram with weather parameters during *autumn* 2020-21.

Season		Temperature (°C)			Relative humidity (%)			Rainfall (in mm) Days	No. of rainy	AWS
		Max temp.	Min temp.	Mean	Morning	Evening	Mean			
Autumn 2020-21	Thrips Per Plant	0.151	0.158	0.172	-0.079	-0.566	-0.475	-0.289	-0.657*	-0.346

*Significant, **highly significant.

Table 6: Multiple linear regression between thrips population in blackgram with weather parameters during *kharif* 2020-21.

Year and season	Dependent variable	R^2	Regression equation
Autumn 2020-21	Mean no. of Thrips per plant	0.70	Y = 712.76 + 2.53 (Max Tm) - 8.52 (Min Tm) + 0.299 (Mng RH) - 0.64 (Eve RH) - 0.09 (RF) - 0.014 (RD) - 1.44 (AWS)

speed was 1.86 kmph. Thrips population started declining towards maturity and lowest incidence was recorded at 77 DAS during 8th SMW with 1.10 mean number of thrips per plant. The maximum and minimum temperatures were 30.36, 20.34°C respectively. Mean temperature was 25.35°C while the average morning, evening RH were 83.14, 59.00 per cent respectively with mean RH 71.07 per cent, 3.29 mm rainfall and a wind speed of 3.57 kmph was recorded. Correlation coefficient (*r*) data (Table 8) revealed that the number of thrips per plant showed a significant positive correlation with maximum temperature (0.726). Minimum temperature (0.55), mean temperature (0.435) showed non-significant positive correlation while the morning RH (-0.43), evening RH (-0.188), mean RH (-0.266) showed non-significant negative correlation with thrips population. Further, rainfall (-0.319), number of rainy days (-0.319) and wind speed (-0.463) also showed non-significant negative correlation.

Rahul *et al*. (2020) who has reported similar findings that maximum, minimum temperatures showed significant positive correlation with thrips population in blackgram during late *rabi* 2019, *rabi* 2020. Further, mean temperature also showed positive correlation with thrips population. Finding by Naresh *et al*. (2018) are also in agreement with the present results that thrips population was in positive correlation with maximum temperature in two cultivars of groundnut (Dharani and K6) in second fortnight of November and first fortnight of December sown groundnut. Vijayalakshmi *et al.* (2017) reported that in *rabi* 2017, thrips incidence showed positive correlation with maximum temperature, minimum temperature and sunshine hours in groundnut. Rahul *et al*. (2020) also reported that morning RH showed significant negative correlation. Evening RH, mean RH has shown non-significant negative correlation with thrips population in blackgram during late *rabi* 2019 and 2020. Naresh *et al.* (2018) also reported that the evening RH showed significant negative correlation with thrips population in all these dates of sowing *i.e.* 1st, 2nd fortnight of November and first fortnight of December. Similarly, Vijayalakshmi *et al.* (2017) reported that thrips incidence showed negative correlation with morning and evening RH in *rabi* 2017. Harish *et al.* (2015) also found that during summer, evening relative humidity and rainfall showed highly significant negative correlation with thrips population in groundnut.

MLR analysis data (Table 9) revealed that all the weather variables together contributed to the incidence of thrips by 83.0 (R^2 = 0.83) per cent. It was also evident that the partial regression coefficient (b) for maximum temperature (0.736) minimum temperature (4.26) showed positive influence whereas morning RH (-1.23), evening RH (-0.69) showed negative influence on thrips population. Rainfall (-2.76), average wind speed (-2.15) have also shown negative influence on thrips population. These findings are in agreement with Harish *et al.* (2015) who reported that the coefficient of multiple determinations (R^2) was 54 and 80 per cent during *rabi* and summer seasons respectively on groundnut in Gujarat.

Table 7: Incidence of thrips in blackgram during *spring* 2020 -2021.

Standard meteorological week (SMW)	Date	Crop Stage	Mean no. of thrips per plant	Mean PDI of BND	Max temp. (°C)	Min temp. (°C)	Mean temp. (°C)	Morning RH (%)	Evening RH (%)	Mean RH (%)	Rainfall (in mm)	No. of rainy days	Avg. wind speed in (KMPH)
50	17.12.2020	7 DAS	0.00	0.00	29.86	18.21	24.04	87.57	55.43	71.50	0.00	0.00	2.14
51	24.12.2020	14 DAS	0.00	0.00	29.54	18.53	24.04	85.43	56.43	70.93	0.00	0.00	3.71
52	31.12.2020	21 DAS	2.15	2.61	29.26	17.99	23.63	84.13	53.75	68.94	0.00	0.00	3.63
1	07.01.2021	28 DAS	3.85	3.59	29.36	19.66	24.51	86.14	53.57	69.86	0.00	0.00	4.57
2	14.01.2021	35 DAS	6.30	4.52	30.89	20.57	25.73	85.29	65.43	75.36	0.00	0.00	3.29
3	21.01.2021	42 DAS	8.00	4.92	30.80	19.54	25.17	85.29	56.71	71.00	0.00	0.00	2.57
4	28.01.2021	49 DAS	8.50	6.01	31.56	19.04	25.30	84.00	54.43	69.21	0.00	0.00	2.00
5	04.02.2021	56 DAS	9.75	6.96	30.81	19.10	24.96	85.14	53.86	69.50	0.00	0.00	2.71
6	11.02.2021	63 DAS	10.10	6.96	30.87	17.46	24.16	85.14	48.14	66.64	0.00	0.00	1.86
7	18.02.2021	70 DAS	3.20	6.96	30.77	17.40	24.09	85.00	49.57	67.29	0.00	0.00	2.29
8	25.02.2021	77 DAS	1.10	10.22	30.36	20.34	25.35	83.14	59.00	71.07	3.29	1.00	3.57

Table 8: Simple correlation between thrips population, bud necrosis disease incidence in blackgram with weather parameters during *spring* 2020-21.

Season		Temperature (°C)			Relative humidity (%)			Rainfall	No. of	AWS
		Max temp.	Min temp.	Mean	Morning	Evening	Mean	(in mm)	rainy days	
Spring 2020-21	Thrips per plant	0.726*	0.55	0.435	-0.162	-0.188	-0.266	-0.319	-0.319	-0.463

*Significant, **highly significant.

Table 9: Multiple linear regression between thrips population and bud necrosis disease incidence in blackgram with weather parameters during *spring* 2020-21.

Year and Season	Dependent variable	R^2	Regression equation
Spring 2020-21	Mean no. of Thrips per plant	0.83	Y = 52.06 + 0.736 (Max Tm) + 4.26 (Min Tm) - 1.23 (Mng RH) - 0.69 (Eve RH) - 2.76 (RF) - 0 (RD) - 2.15 (AWS)

Table 10: Simple correlation between thrips population and bud necrosis disease incidence in blackgram across three seasons.

Season		Mean number of thrips per plant
Spring 2019-20	PDI of BND	0.889**
Autumn 2020-21	PDI of BND	0.279
Spring 2020-21	PDI of BND	0.466

*Significant, **highly significant.

Correlation studies between thrips and bud necrosis disease

When correlation coefficient (*r*) values were assessed (Table 10), mean number of thrips showed highly significant positive correlation with disease incidence (0.889) during *rabi* 2019-20, similarly they had shown non-significant positive correlation with disease incidence during *autumn* (0.279) and *spring* (0.466) 2020-21. These findings are in agreement with Timmanna *et al.* (2020) who have reported that the percent bud necrosis disease was (23.87%) was in linear with the thrips population during *autumn* 2016. Jamuna *et al*. (2019) also quoted the similar findings that the mean disease incidence of GBNV was directly proportional to the mean number of thrips in *kharif* tomato crop during 2015 to 2017. Vinaykumar *et al*. (2019) reported that a high positive correlation between the bud necrosis disease incidence and the thrips population in tomato during *kharif* season.

CONCLUSION

Overall view of present study exposed that the density of thrips population and per cent disease incidence was more during *kharif* 2020-2021 compared to *rabi* 2019-2020 and *rabi* 2020-2021. Compared to *rabi*, *kharif* weather has shown profound influence which led to insect vector (thrips) population fluctuation and might be reason for their resurgence. The thrips population was observed in the field approximately after 14 DAS and showed significant proportional increase with increasing temperature. Relative humidity negatively influenced the thrips outbreak. The clear weather conditions with no rainfall during the crop growth period have favored the thrips population in turn disease development. Positive correlation between vector and vector borne disease incidence may be useful in designing vector control management tactics to prevent dual loss by sucking pest and viral disease. This study may also be helpful in designing the future climate-based prediction models.

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Disclaimers

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Informed consent

Not applicable.

Conflict of interest

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