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Population Dynamics of Thrips and Bud Necrosis Virus Disease on Tomato

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A B S T R A C T

Studies on population dynamics of thrips on tomato crop were carried out during two consecutive kharif seasons (2016 and 2017). The observations viz., number of adult thrips and associated GBNV disease and natural enemies were recorded at weekly intervals. The results revealed that, thrips activity found throughout the cropping period. The population of thrips was increased gradually from first week after transplanting to flowering and fruit development stage and later it was decreased as crop matures. During 2015-16 kharif crop, maximum thrips population (8.40 thrips/three leaves) was observed during the last week of November and first week of December. Similarly during 2016-17 kharif crop, maximum thrips population (10.30 thrips/three leaves) was observed during third and last week of December. The population of zoopytophagous miridbug, *Nesidiocoris tenuis* Reuter was found linear with the population of thrips during both the seasons. The percent disease incidence of GBNV on tomato crop was linier with the thrips population during both the seasons. The cumulative disease incidence was 42.50 % and 45.10 % during first and second seasons respectively. Correlation studies indicated that, minimum temperature, rainfall, rainy days and evening relative humidity were found significant negative correlation with the thrips population, while sunshine hours and morning relative humidity found significant positive correlation with the thrips population.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the major and widely grown staple vegetable crop in both tropics and sub-tropics of the world. Though, the area under tomato cultivation is high but the productivity is low due to various biotic and abiotic stress factors. Among the biotic factors, Sucking pests *viz*., Whitefly (*Bemisia tabaci* Genn), thrips, aphids (*Myzus persicae* or *Aphis gossypii*), mite (*Tetranychus* spp.) are major threat for tomato cultivation under rainfed area. Of these, recently thrips become emerging pest and viral vector of *Groundnut Bud Necrosis Virus* (GBNV) disease and causes significant economic damage to the tomato crop.

Three thrips vectors species viz., *Thrips palmi* Karny *Scirtothrips dorsalis* Hood and *Thrips* *tabaci* Lindman transmitting different tospoviruses *viz*., *Groundnut bud necrosis virus* (GBNV), *Watermelon bud necrosis virus* (WBNV), *Iris yellow spot virus* (IYSV) in various vegetable and field crops in different agro ecosystems in India (Vijayalakshmi, 1994; Mandal *et al.*, 2012; Latha and Hanumantharaya, 2017).

Thrips-tospovirus relationship is very unique because, thrips are the sole insect vectors of tospoviruses. Tospoviruses are not known to be exist in crops or in nature in the absence of thrips vector, the spread of a tospoviruses to large extent depends on the dispersal activity and virus vectoring capacity of local thrips and prevailed weather conditions (Mound, 2002).

GBNV disease causes 60-100% yield losses in groundnut, chilli and other pulse crops, these are transmitted by *T. palmi* and *S. dorsalis* (Reddy *et al.*, 1983, Rayapati *et al.*, 2012). WBNV disease causes severe yield losses (80-100%) in cucurbit crops (Singh and Krishnareddy, 1996). IYSV infects on onion and garlic growing region of Maharashtra, Haryana and Punjab and it was vectored by *T. tabaci* Lindmen (Ravi *et al.*, 2006; Pavan *et al.*, 2012).

Field symptoms of GBNV disease are unique, initially yellow faint chlorotic spots appear on young leaves, subsequently necrosis and development of chlorotic rings. In rainy and postrainy seasons, necrosis of terminal bud is the main characteristic symptom, whereas stunting and malformation of leaflets are secondary symptoms.

When the disease occurs at early stage of the crop (before 1 month of transplanting) plants become bushy, stunted and die prematurely, whereas plants tolerate the disease and infection restrict to few branches (after month of transplanting) during later stage of the crop (Hemalatha, 1999; Anjaneya Reddy *et al.*, 2008; Manjunath, 2008).

Thrips are tiny (0.5-2mm), active insect with cryptic living habit, feeds and resides in protective closed areas (unopened shoot buds, flower buds and flowers and fruit calyx) where insecticides difficult to penetrate, hence most of the insecticides are failed to eliminate thrips population (Mandal *et al.*, 2012).

Weather factors *viz*., temperature, relative humidity and prolonged sunshine hours favours the thrips activity and multiplication and population build-up. Resistant(R) genes require optimum temperature for enzyme expressions, which involve in transcriptional and translational processes. Failing to express R genes of a resistant variety, it may become susceptible to pathogens (Van der Plank, 1963). Weather factors play crucial role in vector-virus interactions and disease epidemics. Meagre research efforts were made on thrips and GBNV epidemiology in groundnut and chilli but there were no reports on thrips and GBNV disease of tomato crop. In this context the present research plan was formulated to generate the information on thrips population and GBNV disease dynamics and their relation with weather factors on tomato crop.

Materials and Methods

Experiments on population dynamics of thrips on tomato crop were carried out during two consecutive growing seasons of *kharif*, 2016 and 2017 at the fields of Department of Agricultural Entomology, Main Agriculture Research Station, UAS, Raichur, Karnataka.

Raichur is situated at North Eastern Dry Zone (Zone-2) of Karnataka between 16° 15’ N latitude, 77° 20’ E longitude and 398.37 m above mean sea level. The average rainfall is

660 mm confined to monsoon period between June and October with occasional showers during pre-monsoon months of April and May. Mean maximum temperature is more than 30° C throughout the year except during December, the Relative humidity (RH) is high during summer months from April to May.

Studies on population dynamics of thrips were conducted on susceptible tomato variety (cv. Arka vikas) which was grown in experimental plot with $200m^2$ area. All the recommended package of practices of UAS, Raichur was followed (except plant protection measures) for the crop cultivation.

The seeds of tomato variety (cv Arka Vikas) were sown on raised seed bed under insect free greenhouse. Healthy seedlings were transplanted to the main field after 25 days after sowing.

Observations were made on 30 randomly selected tomato plants at weekly intervals after the first week of transplanting to crop maturity. Mean number of adult thrips on terminal three leaves and associated natural enemies were recorded by tapping the leaves on A4 size white paper. The fallen thrips on paper were counted and collected with fine and moist camel hair brush in 2ml centrifuge tubes with 95% alcohol for taxonomic study. The per cent disease incidence of GBNV was also observed and recorded and it was calculated by using the formula

$$\text{Disease incidence (\%)} = \frac{\text{Number of diseased plants}}{\text{Total number of plants examined}} \times 100$$

The data obtained was subjected to statistical analysis and correlated with weather parameters (minimum and maximum temperature, morning and evening RH, rainfall, rainy day and sunshine hours) during the period of observations. Weather data was obtained from the Meteorology section, MARS, UAS, Raichur campus

Results and Discussion

Population dynamics of thrips and GBNV disease during *kharif*, 2015-16

During *kharif* season, 2015-16, transplanting of tomato seedlings was done at 39^{th} Standard Meteorological Week (SMW) and observations were started after the first week of transplanting (40^{th} SMW).

Observations revealed that, activity of thrips and miridbug found throughout the cropping period. Maximum thrips population (8.40 thrips/three leaves) was observed during last week of December (48^{th} SMW), followed by third week of November (8.00 thrips/three leaves) (47^{th} SMW). Overall population mean of thrips was 4.86±2.46 per three terminal leaves.

Miridbug population

The miridbug, *Nesidiocoris tenuis* Reuter which was known as zoophytopagous predator (Hinomoto *et al.*, 2015; Bouagga *et al.*, 2018) was found throughout the cropping period. The mean number of miridbug was 4.56±2.49 per plant, population increasing trend was linear with the thrips population, but reached peak during the later stage of the crop (8.40 miridbug/ plant), whereas thrips population was gradually decreased as crop matures (Table 1).

GBNV disease incidence

The mean disease incidence of GBNV disease was ranged from 4.90 to 42.50 % during cropping period (42^{nd} SMW to 7^{th} SMW). The cumulative disease incidence 42.50 % was observed at later stage of the crop (7^{th} SMW) (Table 1).

Influence of weather parameters on thrips population, GBNV disease and miridbug

The data in the Table 2 revealed that, all the meteorological weather parameters influenced the thrips population, disease incidence and miridbug population.

The weather parameters *viz*., rainfall (r=-0.588) and rainy days (r=-0.603) minimum temperature (r=-0.475) were found highly significant negative correlation with thrips population. Whereas maximum temperature (r=-0.305) and evening relative humidity (r=-0.051) shown non significant negative correlation. While morning relative humidity (r=0.259) and sunshine hours (r=0.076) shown non significant positive correlation with thrips population.

When the data subjected to Multiple Linear Regression (MLR) analysis, results revealed that, 80.30 per cent of the thrips population was influenced by weather parameters (R^2= 0.803) (Table 3). The MLR model was

$$Y=2.673-0.024\ X_1-0.132\ X_2+0.059\ X_3-1.980\ X_4+0.013\ X_5+0.035\ X_6+0.110\ X_7$$

The miridbug, *N. tenuis* population was also influenced by all the weather parameters. Minimum temperature (r= -0.643), rainfall (r= -0.570), rainy days (r= -0.565), and evening relative humidity (r= -0.710) shown highly significant negative correlation with the thrips population, whereas maximum temperature (r= 0.068) and sunshine hours (r= 0.106) shown non significant positive correlation (Table 2) with the thrips population.

When the data subjected to MLR analysis, the results revealed that 71.20 per cent of miridbug was influenced by weather parameters (R^2= 0.712) (Table 3).

The MLR model was

$$Y=5.618+0.056X_1-0.134X_2+0.097X_3-2.324X_4-0.022X_5-0.008X_6-0.072X_7$$

The GBNV disease incidence was influenced by all the weather parameters under the study. The minimum temperature (r=-0.717) and evening relative humidity (r=-0.600) were shown highly significant negative correlation with the disease incidence, followed by rainfall (r=0.573) and rainy days (r=-0.568). Maximum temperature (r= -0.029) and morning relative humidity (r= -0.325) shown non significant negative correlation, but sunshine hours (r=0.600) shown non significant positive correlation with the disease incidence (Table 2).

When the data subjected to MLR (Multiple Linear Regression) analysis, the results revealed that 60.90 per cent of the thrips population was influenced by weather parameters (R^2= 0.609) (Table 3). The MLR model was,

$$Y=86.791+1.540X_1-4.316X_2+3.744X_3-83.920X_4-0.176X_5-0.168X_6-0.570X_7.$$

Population dynamics of thrips and GBNV disease during *kharif*, 2016-17

During *kharif* 2016-17 season, transplanting of tomato seedlings was done at 41^{st} SMW and observations were started from the first week after transplanting (42^{nd} SMW)**.**

Observations revealed that, thrips and miridbug activity found throughout the cropping period. Maximum thrips population (10.30thrips/three leaves) was observed during 49^{th} SMW. Overall population mean of thrips was 5.83±17.10 per three terminal leaves.

Miridbug populations

Miridbug activity was found throughout the cropping period and population followed the similar increasing trend like thrips but the population reached its peak at later stages of the crop. The mean number of miridbug population was 7.32±3.18 per plant, peak incidence was noticed during last week of February (12.30/ plant).

GBNV disease incidence

The GBNV disease incidence was increased gradually from 4.90 per cent to 45.10 per cent (42^{nd} SMW to 9^{th} SMW) during the cropping period, cumulative disease incidence was 45.10 % at later stage of the crop.

Correlation between thrips, GBNV disease and *N. tenius* with weather parameters

Population of thrips had significant negative correlation with maximum temperature (r=-0.485), minimum temperature (r=-0.605), but sunshine hours (r=-0.301) and evening relative humidity (r=-0.099) exhibited non significant negative impact. Rainfall (r=0.215) and morning relative humidity (r=0.230) shown non significant positive correlation (Table 2).

When the data subjected to MLR analysis, the results revealed that 60.49 per cent of the thrips population was influenced by weather parameters (R^2= 0.649) (Table 3). The MLR model was

$$Y=16.296-0.298X_1+0.007X_2-0.013X_3+0.00X_4-0.002X_5-0.073X_6-0.025X_7$$

The miridbug, *N. tenuis* population was also influenced by all the weather parameters under the study. Evening relative humidity (r= -0.617) shown highly significant negative correlation followed by morning relative humidity (r= -0.512). Minimum temperature (r= 0.291), maximum temperature (r= 0.056), rainfall (r= -0.033), and sunshine hours (r= 0.333) were shown non significant and positive correlation with mirid population (Table 2).

When the data subjected to MLR analysis, the results revealed that 61.70 per cent of the mirid population was influenced by weather parameters (R^2= 0.617) (Table 3). The MLR model was

$$Y=14.153-0.250X_1+0.137X_2-0.009X_3+0.00X_4-0.013X_5-0.096X_6-0.224X_7.$$

GBNV disease incidence was affected by all the weather parameters under the study. The parameters *viz.*, evening relative humidity (r= -0.689) shown highly significant negative correlation followed by morning relative humidity (r= -0.480), but minimum temperature (r= -0.031) and rainfall (r= -0.004) were shown non significant negative impact. Maximum temperature (r= 0.188), and sunshine hours (r=0.387) were shown non significant positive correlation with disease incidence (Table 2).

When the data subjected to MLR analysis, the results revealed that 75.00 per cent of the disease incidence was influenced by weather parameters (R^2= 0.750) (Table 3).

The MLR model was

$$Y=358.983-8.516X_1+2.868X_2+0.476X_3+0.00X_4-0.493X_5-2.092X_6-0.778X_7.$$

Weather conditions play an important role in pest and disease epidemics in different crops, favours the thrips multiplication. Rainfall usually eliminates thrips population and has negative influence on thrips population in different crop plants (Funderburk, 2012). Activity, mobility and multiplication of thrips population were more during favourable weather conditions (i.e., 15-30 °C temperature range, 70±10% RH and bright sunshine hours) (Vijayalakshmi, 1994). Minimum temperature and rainfall were negatively correlated with thrips population in groundnut (Krishnaveni, 1998).

Results of the present findings revealed that, during 2015-16 *kharif* season, the maximum population of thrips (8.4 thrips/ three leaves) was observed during first and second week of December (48th and 49th SMW respectively), thereafter population started declining (Figure 1). Similarly during 2016-17, the highest population (10.30 thrips/ three leaves) was observed at third week of December (51st SMW) and first week of January (1st SMW), thereafter the population started declining (Figure 2). This may be due to peak flowering during December months and minimum rainy days which might have favoured the multiplication of thrips, yellow colour flowers with pollen and nector attracts the thrips towards tomato crop and thereafter, when the crop starts fruiting, thrips population starts declining. The zoophytophagous miridbug, *N. tenuis* presence was suspected to be another reason for thrips decline. Activity of miridbug, *N. tenuis* was linear with the thrips population, it was started from the third week after transplanting and it was increased gradually, reached peak (8.40/ plant) at later stage of the crop (7th SMW) during 2015-16. Similarly peak activity (12.30/plant) of miridbug was observed during last week of February (9th SMW) in 2016-17.

Table.1 Population dynamics of thrips and GBNV disease on tomato

Observation at Standard Meteorological weeks	Mean number of thrips per three terminal leaves		GBNV disease incidence (%)		*Nesideocoris tenuis* Reuter	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
40	0.00	0.00	0.00	0.00	0.00	0.00
41	1.70	1.90	0.00	0.00	1.30	1.30
42	2.70	3.10	4.90	4.90	1.70	3.30
43	4.00	4.50	9.05	9.05	2.60	5.20
44	4.60	4.80	12.20	11.25	2.30	5.30
45	5.40	5.30	12.50	18.90	2.90	6.20
46	6.90	6.20	18.25	20.00	3.10	6.70
47	8.00	8.50	23.90	22.30	3.10	7.20
48	8.40	8.70	28.70	25.80	3.90	7.40
49	8.40	10.30	32.80	38.50	3.70	7.70
50	7.90	10.20	36.80	40.80	4.30	7.40
51	7.20	9.80	36.80	43.00	5.20	7.70
52	6.00	8.70	37.00	43.75	5.60	8.60
1	5.90	7.60	37.50	44.10	5.60	9.60
2	5.00	6.60	37.80	44.30	6.90	9.80
3	4.60	5.80	38.40	44.50	7.50	9.00
4	3.30	4.30	39.20	44.60	7.30	9.00
5	2.60	3.90	42.10	44.80	7.90	11.30
6	2.50	3.20	42.30	45.00	7.90	11.40
7	2.20	3.20	42.50	45.10	8.40	12.30
Mean±SD	4.86±2.46	5.83±17.10	26.64±15.07	29.53±17.10	4.56±2.49	7.32 ±3.18

Table.2 Correlation between thrips, GBNV disease and *Nesidiocoris* with different weather parameters

Particulars	Temperature		Rainfall (X_3)	Rainy day (X_4)	Relative humidity		Sunshine hours (X_7)
	Maximum (X_1)	Minimum (X_2)			Morning (X_5)	Evening (X_6)	
***Kharif season*, 2015-16**							
Thrips	-0.305	**-0.475***	**-0.588****	**-0.603****	0.259	-0.051	0.076
***Nesidiocoris tenuis* Reuter**	0.060	**-0.654****	**-0.573****	**-0.568****	**-0.550***	**-0.707****	0.106
Disease incidence (%)	-0.029	**-0.717****	**-0.521***	**-0.523***	-0.325	**-0.600****	0.098
***Kharif* season, 2016-17**							
Thrips	**-0.485***	**-0.605****	0.215	0.00	0.230	-0.099	-0.301
***Nesidiocoris tenuis* Reuter**	0.291	0.056	0.033	0.00	**-0.512***	**-0.671****	0.333
GBNV disease disease (%)	0.188	-0.031	-0.004	0.00	**-0.480***	**-0.689****	0.387

N=20

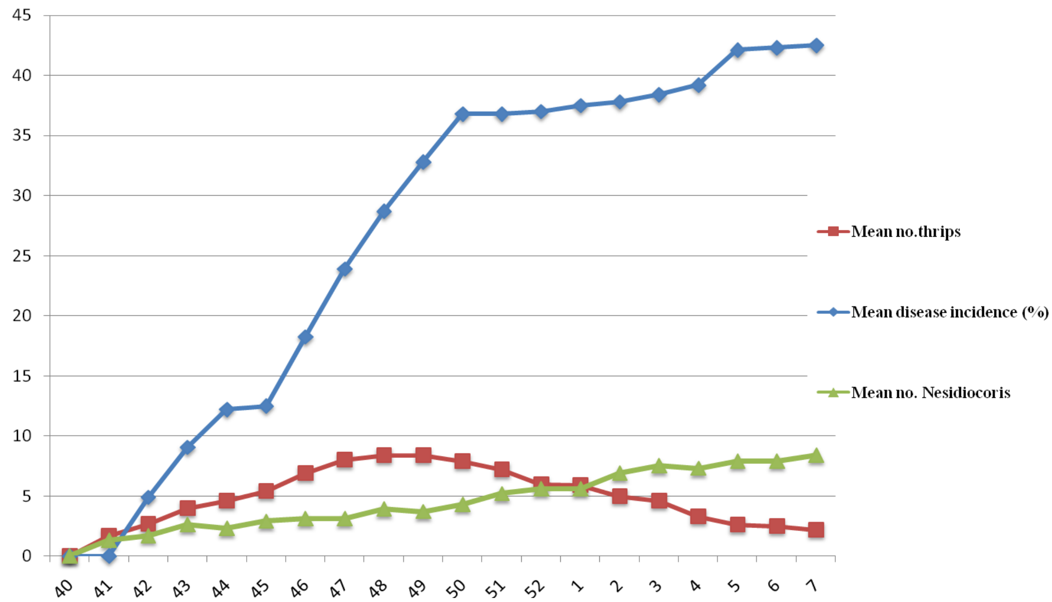
*Significance at p = 0.05; ** significance at p = 0.01

Table.3 Multiple regression equations for thrips, GBNV disease and *Nesidiocoris* with different weather parameters

Particulars	Regression equation	R^2 Value
***Kharif*, 2015-16**		
Total thrips	$Y=2.673-0.024 X_1-0.132 X_2+0.059 X_3-1.980 X_4+0.013 X_5+0.035 X_6+0.110 X_7$	0.803
***Nesideocoris tenuis* Reuter**	$Y=5.618+0.056X_1-0.134X_2+0.097X_3-2.324X_4-0.022X_5-0.008X_6-0.072X_7$	0.712
Disease incidence (%)	$Y=86.791+1.540X_1-4.316X_2+3.744X_3-83.920X_4-0.176X_5-0.168X_6-0.570X_7$	0.609
***Kharif*, 2016-17**		
Total thrips	$Y=16.296-0.298X_1+0.007X_2-0.013X_3+0.00X_4-0.002X_5-0.073X_6-0.025X_7$	0.649
***Nesideocoris tenuis* Reuter**	$Y=14.153-0.250X_1+0.137X_2-0.009X_3+0.00X_4-0.013X_5-0.096X_6-0.224X_7$	0.617
GBNV disease incidence (%)	$Y=358.983-8.516X_1+2.868X_2+0.476X_3+0.00X_4-0.493X_5-2.092X_6-0.778X_7$	0.750

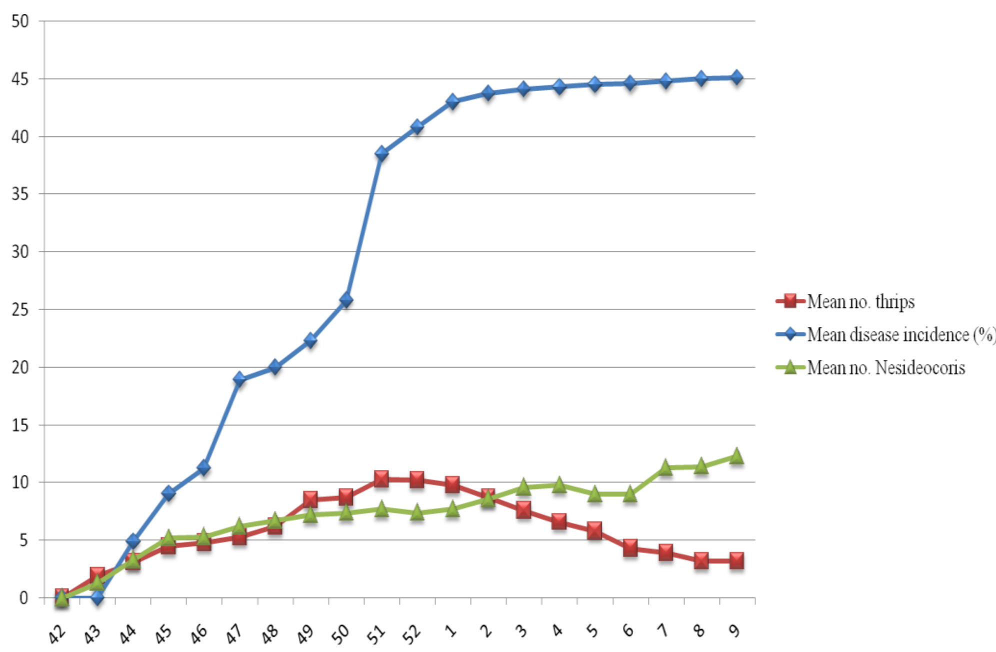
X_1=Maximum Temperature; X_2=Minimum Temperature; X_3=Rainfall X_4=Rainy days; X5=RH I (Morning relative humidity), X_6 =RH II (Evening relative humidity),
X_7 = Sunshine hours

Fig.1 Population dynamics of thrips on tomato Kharif (2015-16)



Observation at different standard weeks

Fig.2 Population dynamics of thrips on tomato Kharif (2016-17)



Observation at different standard weeks

The minimum temperature (r= -0.717) and evening relative humidity (r= -0.600) shown highly significant negative correlation with thrips population. The maximum temperature and sunshine hours found non significant negative and positive correlation respectively. Similarly during 2016-17, evening relative humidity (r= -0.689) was highly significant and negatively correlated, but minimum temperature and rainfall were non significant and negatively correlated.

These findings are in agreement with the earlier reports which reveals, the higher thrips population in chilli was noticed during post rainy season (December to March) (Borah, 1987; Hosamani *et al.,* 2007) and significant negative correlation was observed between tomato thrips with minimum temperature (r=-0.524), evening relative humidity (r=-0.566) and rainfall (r=-0.453) Subba and Ghosh (2016). Minimum temperature, morning and evening relative humidity and sunshine hours were negatively correlated with thrips in onion (Vijayalakhsmi *et al.,* 2017). In contrary to this minimum temperature, morning relative humidity were positively correlated with thrips population in tomato (Ruth, 2010), deviation might be due to the different planting time and prevailed weather conditions during the study period.

Increased *N. tenuis* population could be the other reason for thrips decline, the miridbug population shown significant positive correlation with thrips population. These findings were in conformity with the findings of Hinomoto *et al.,* (2015) who reported that, *N. tenuis* significantly reduced the *T. tabaci* population on onion under protected greenhouse in Japan. *N. tenuis* significantly reduced the thrips, *F. occidentalis* population in sweet pepper (Sarra *et al.,* 2018).

The cumulative mean disease incidence of GBNV was 42.50 % and 45.10 % during 2015-16 and 2016-17 respectively (Figure 1 and 2), it may be due to gradual decrease in rainfall and evening temperature (21.8 to 18.90 C° and 16.70 to 13.80 C°) during later stage of the crop. These findings are on par with the earlier reports, where the higher incidence of GBNV disease in chilli and groundnut were more during post rainy season (Hosamani, 2007; Vijayalakshmi, 1994)

Summary and conclusions are as follows:

The studies on population dynamics of thrips and bud necrosis disease on tomato crop, indicated that, the thrips activity found throughout the cropping period. The population of thrips was more during flowering and fruiting stage later it was decreased as crop matures. During 2015-16 *kharif* crop, maximum thrips population (8.40 thrips/three leaves) was observed during the last week of November and first week of December. Similarly during 2016-2017 *kharif* crop, maximum thrips population (10.30 thrips/three leaves) was observed during third and last week of December.

The population of zoopytophagous miridbug, *Nesidiocoris tenuis* Reuter was found linear with the population of thrips during both the seasons.

The mean disease incidence of GBNV was directly proportional to the mean number of thrips. The cumulative disease incidence 42.50 % and 45.10 % was observed during 2015-16 and 2016-17 *kharif* crops respectively.

Correlation studies indicated that, the minimum temperature, rainfall and evening relative humidity were found significant negative correlation, whereas the sunshine hours and morning relative humidity found significant positive correlation with the thrips population and GBNV disease incidence.

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