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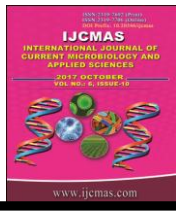

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Surveillance of Mungbean Yellow Mosaic Virus (MYMV) Incidence and its Vector Population for Development of Yellow Mosaic Disease Forewarning

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A B S T R A C T

Surveillance of Mungbean Yellow Mosaic Virus (MYMV) on mungbean was undertaken to know the effect of weather factors on whitefly population (*Bemisia tabaci* Genn.) and MYMV incidence at three fixed locations *viz*., Kavalur, Raichur (UASR, Campus) and Wadagnal during *kharif* 2016. The results revealed that, the highest whitefly population observed during 26th SMW at Kavalur and 29th SMW at Raichur and Wadagnal locations during crop growth. The influence of weather parameters was studied by correlation and regression statistical analysis. The correlation analysis revealed that, maximum temperature was positively significantly correlated with whitefly population at Kavalur and Wadagnal villages (0.079 and 0.721 respectively) whereas minimum temperature was negatively correlated with whitefly population at Kavalur and Raichur (0.889 and 0.684 respectively). The per cent disease incidence showed negatively significant correlation with maximum temperature at Kavalur and Raichur (0.737 and 0.707 respectively). The rainfall was negatively correlated but non-significant with both whitefly population and per cent disease incidence at all the three locations. Correlation between whitefly population and disease incidence showed positive non-significant relation with each other in all the locations. The regression analysis revealed that, per cent contribution of weather factors on whitefly population and disease incidence at Kavalur, Raichur and Wadagnal was 98.3 percent (R^2=0.983), 97.8 per cent (R^2=0.978) and 97 per cent (R^2=0.970)

Introduction

Mungbean (*Vigna radiata* (L.) Wilczek) is one of the thirteenth food legumes grown in India and third most important pulse crop after chickpea and pigeonpea. Mungbean is grown principally for its protein rich edible seeds which are used for consumption by cooking, fermenting, milling or sprouting. The crop is mainly cultivated during *kharif* season under rainfed conditions. Its cultivation has been hampered by many biotic and abiotic stresses. Among yellow mosaic virus disease of mungbean is considered as serious threat, limiting the production and productivity. Mungbean yellow mosaic virus belongs to the family Geminiviridae (Geminate means twin particles) consisting of viruses with circular (20 x 30 nm), single-stranded (ss) DNA genome (Hull, 2004). These viruses are transmitted from one plant to other plant through arthropod vectors with twin particles. Geminiviridae is taxonomically divided into four genera *viz*., *Mastrevirus*, *Curtovirus*, *Topocuvirus* and *Begomovirus* based on host range, genome organization and

insect vector. The genus Begomovirus contains viruses that are transmitted by whitefly (*Bemisia tabaci* Genn.) infecting dicotyledonous plants like urdbean, mungbean and soybean (Haq *et al.,* 2011).

The weather parameters play a vital role in survival and multiplication of white fly (*B. tabaci*) and influence the outbreak of MYMV in mungbean during crop season. Therefore, understanding of weather factors and their role in MYMV incidence is a prerequisite to provide base line information for developing disease forewarning system. However, studies in this regard and epidemiological aspects of MYMV are scanty in the North Eastern Karnataka region. Hence the studies were conducted to know the influence of weather parameters on whitefly population and MYMV incidence.

Materials and Methods

Surveillance of MYMV was undertaken during *kharif*, 2016 at three fixed locations of Koppal (Kavalur and Wadaganal) and Raichur (UASR, campus) districts. In each location, farmers field cultivating mungbean and nearby a functional weather observatory (within 1km) monitored by Karnataka State Natural Disaster Management Center (KSNDMC), Yelahanka, Bangalore were selected. The GPS readings of selected plots were noted and in each plot, yellow colour whitefly sticky traps (insect traps) of 33 × 22 cm size were placed at weekly interval beginning from the date of sowing (23rd SMW) till harvest (33rd SMW) of the crop to know the vector population at weekly intervals. The disease incidence was recorded at weekly interval (starting from first appearance of symptoms). The meteorological data at all the three locations was recorded at nearby observatory maintained by KSNDMC. The daily data collected from KSNDMC was computed to weekly interval and used for further correlation studies along with vector population recorded were done using SPSS 16.0 software. Statistical analysis of obtained data was studied through correlation to find the seasonal population dynamics of whitefly on mungbean with different weather parameters *viz*., temperature, Relative humidity, wind speed and rainfall. Relationship between whitefly, MYMV incidence and different meteorological variables were subjected to study using simple correlation and regression.

Results and Discussion

To find the association of whitefly population with weather parameters, data were pooled and correlation was worked out between whitefly population, per cent disease incidence and weather parameters. The results revealed that, disease incidence initially were zero percent at all three locations and incidence started from 26th SMW. The highest whitefly population observed during 26th SMW at Kavalur (Table 1) when maximum temperature of 29.71^{o}C, minimum temperature 22.59^{o}C, rainfall of 23.8 mm, minimum relative humidity (61.40 %), maximum relative (93.84 %) and wind speed (2.29 km/hr). In case of Raichur and Wadagnal high whitefly population noticed at 29th SMW (Table 5) (maximum temperature 34.01^{0}C, minimum temperature 26.00^{o}C, maximum relative humidity 94.81%, minimum relative humidity 59.51 % and wind speed 1.99 km/hr at Raichur) and (Table 3) (maximum temperature 30.29^{0}C, minimum temperature 21.86^{o}C, maximum relative humidity 88.57 %, minimum relative humidity 54.86 % and wind speed 5.04 km/hr at Wadagnal) in each locations during crop growth. The least number of whitefly/trap was observed during high rainfall in all locations which indicates more the rainfall less whitefly population. Correlation analysis made between whitefly population, PDI and

weather parameters showed that maximum temperature and minimum relative humidity was positively significant correlation with whitefly population in three locations Kavalur (r=0.079 and r=0.673) (Table 2), Wadagnal (r=0.721 and r=0.731) (Table 4) and Raichur (r=0.572 and r=0.464) (Table 6). This indicates that rise in maximum temperature and low rainfall is conducive for whitefly population buildup. Whitefly population was negatively correlated but non-significant with minimum temperature in Kavalur and Raichur (r=0.889 and r=0.684 respectively). Similarly, Singh (1990) noted that hot weather with little or no rainfall was conducive for disease development of tomato leaf curl disease and also for multiplication of whitefly. Cooler weather with high relative humidity and rainfall were detrimental to whitefly population and spread. Board *et al.,* (1993) found that population of whitefly and incidence of tomato leaf curl disease was high in August to October wherein rainfall will be very less with dry weather. Non-significant positive correlation of whitefly population with relative humidity observed in present study. These findings were in concurrence with the observations made by Srivastava and Prajapati (2012). Similarly in case of cotton, leaf curl virus, whitefly was found positively correlated with maximum temperature and relative humidity and negatively correlated with rainfall (Kadam *et al.,* 2015).There was a similar finding noticed by Abhishek, *et al.,* (2016), who confirmed the higher incidence of tomato leaf curl disease during October due to higher whitefly population. They also reported a positive correlation between whitefly population and maximum temperature and minimum temperature as observed in our results. Per cent disease incidence was negatively correlated with maximum temperature at Kavalur (r=0.737), Wadagnal (r=0.040) and Raichur (r=0.707). The disease incidence showed positive relation with wind speed r=0.674, r=0.654 and r=0.218 (non-significant) at Kavalur, Wadagnal and Raichur respectively which was similar as reported by Khan *et al.,* (2012) and Majeed *et al.,* (2016). Whereas, per cent disease incidence and whitefly population was positively correlated with each other in all the locations. Similar relation of whitefly and disease incidence was reported by Srivastava and Prajapati, 2012. To estimate the cumulative effects of different weather parameters and white fly population on disease outbreak regression analysis was carried out. Ali *et al.,* (2015) observed that maximum temperature had negative correlation with YMD incidence.

Similarly Gupta and Varma (2015) reported that, whitefly population positively correlated with maximum temperature and non-significant positively correlated with relative humidity, our findings at Kavalur and Raichur are in line with these observations.

GPS positions of selected plots for surveillance of MYMV incidence and its vector Population

Sl. No	Location	District	Taluka	Latitude	Longitude
1.	Kavalur	Koppal	Koppal	15.3355641	75.9196543
2.	Wadagnal	Koppal	Koppal	15.3353694	75.9178290
3.	Raichur (MARS, UASR)	Raichur	Raichur	16.1157404	77.1935041

Surveillance locations	Multiple regression equations
Kavalur	Y= 49.352+1.111X1+0.339X2-10.408X3+15.733X4+4.515X5-8.721X6+20.163X7
Raichur	Y= -516.486+0.125X1-0.024X2-50.125X3+53.975X4+11.594X5-7.991X6+22.303X7
Wadagnal	Y= 176.387-0.210X1-0.418X2-5.238X3-1.846X4+0.205X5-0.140X6+2.121X7

Table.1 Surveillance for whitefly population, MYMV incidence and weather parameters at Kavalur during 2016

Sl. No.	Duration of week (2016)	Standard Meteorological Week (SMW)	Whitefly population /trap	PDI (%)	Rainfall (mm)	Min. Temp (^{0} C)	Max. Temp (^{0} C)	Min. Humidity (%)	Max. Humidity (%)	Max. Wind speed (km/h)
1	June11- 17	24	26	0.00	15.7	22.99	32.84	47.33	89.09	2.47
2	June 18- 24	25	66	0.00	33.7	22.31	30.84	57.07	95.27	2.07
3	June 25- July 01	26	87	2.00	23.8	22.59	29.71	61.40	93.84	2.29
4	July 02- 08	27	85	8.00	11.1	22.99	29.79	62.49	95.46	2.63
5	July 09- 15	28	86	10.00	4.8	22.80	30.31	55.23	90.11	2.16
6	July 16-22	29	63	15.00	3.3	21.73	29.61	58.33	93.31	2.06
7	July 23-29	30	81	25.00	41.3	21.47	29.61	62.09	99.29	2.57
8	July 30-Aug 05	31	56	29.00	5	22.37	28.50	63.34	93.70	2.50
9	Aug 06-12	32	72	32.00	1.3	22.61	30.61	55.37	89.99	2.89
10	Aug 13- 19	33	53	41.00	2.5	21.84	31.93	49.03	94.34	2.79

Table.2 Correlation coefficients between MYMV incidence, whitefly population and weather parameters of Kavalur

Pearson correlation	Correlations							
	Whitefly population	PDI (%)	Rainfall (mm)	Min. Temp (^{0}C)	Max. Temp (^{0}C)	Min. Humidity (%)	Max. Humidity (%)	Max.Wind speed (km/hr)
Whitefly population	1							
PDI (%)	-.059	1						
Rainfall (mm)	.204	-.401	1					
Min. Temp (^{0}C)	-.889**	.031	.147	1				
Max. Temp (^{0}C)	.079*	-.737*	.563	.162	1			
Min. Humidity (%)	.673*	-.054	.292	.675*	-.140	1		
Max. Humidity (%)	.391	.153	.637*	.332	-.063	.589	1	
Max.Wind speed (km/hr)	-.114	.674*	-.251	-.071	-.340	-.166	.005	1
**. Correlation is significant at the 0.01 level (2-tailed).								
*. Correlation is significant at the 0.05 level (2-tailed).								

Table.3 Surveillance for whitefly population, MYMV incidence and weather parameters at Wadagnal during 2016

Sl. No.	Duration of week (2016)	Standard Meteorological Week (SMW)	Whitefly population/trap	PDI (%)	Rainfall (mm)	Min. Temp (^{0} C)	Max. Temp (^{0} C)	Min. Humidity (%)	Max. Humidity (%)	Max.Wind speed (km/h)
1	June11- 17	24	0	0	7.5	23.54	32.23	46.29	81.06	5.60
2	June 18- 24	25	18	0	17.5	22.87	31.84	47.23	72.06	6.29
3	June 25- July 01	26	3	2	23.5	23.03	29.73	31.94	56.90	6.39
4	July 02- 08	27	22	3	12.5	23.56	29.94	43.39	73.47	7.23
5	July 09- 15	28	41	5	2	23.06	29.69	55.47	83.13	7.37
6	July 16-22	29	43	6	3	21.86	30.29	54.86	88.57	5.04
7	July 23-29	30	36	10	10.5	21.60	29.84	58.26	91.77	7.51
8	July 30-Aug 05	31	32	14	14.5	21.83	27.41	65.81	88.73	6.61
9	Aug 06-12	32	28	15	4	22.31	30.13	55.76	87.66	8.46
10	Aug 13- 19	33	16	15	5	21.84	30.86	52.11	91.27	8.41

Table.4 Correlation coefficients between MYMV incidence, whitefly population and weather parameters of Wadagnal

Pearson correlation	Correlations							
	Whitefly population	PDI (%)	Rainfall (mm)	Min. Temp (^{0}C)	Max. Temp (^{0}C)	Min. Humidity (%)	Max. Humidity (%)	Max.Wind speed (km/hr)
Whitefly population	1							
PDI (%)	.407	1						
Rainfall (mm)	-.514	-.377	1					
Min. Temp (^{0}C)	.573	.197	-.367	1				
Max. Temp (^{0}C)	.721*	-.040	-.197	.063	1			
Min. Humidity (%)	.731*	.676*	-.539	.233	.471	1		
Max. Humidity (%)	.600	-.701*	-.760*	.161	.363	.884**	1	
Max.Wind speed (km/hr)	.111	.654*	-.226	.326	-.301	.210	.290	1
**. Correlation is significant at the 0.01 level (2-tailed).								
*. Correlation is significant at the 0.05 level (2-tailed).								

Table.5 Surveillance for whitefly population, MYMV incidence and weather parameters at Raichur during 2016

Sl. No.	Duration of week (2016)	Standard Meteorological Week (SMW)	Whitefly population/trap	PDI (%)	Rainfall (mm)	Min. Temp (^{0} C)	Max. Temp (^{0} C)	Min. Humidity (%)	Max. Humidity (%)	Max.Wind speed (km/h)
1	June 04-10	23	295	0	54.5	23.89	33.73	49.37	95.86	2.30
2	June11- 17	24	247	0	4.0	24.57	33.79	45.40	87.51	3.04
3	June 18- 24	25	32	0	148.0	25.16	33.20	62.26	98.97	2.40
4	June 25- July 01	26	35	5.75	17.5	26.24	33.24	63.91	96.11	2.96
5	July 02- 08	27	161	10	3.0	26.93	34.37	58.97	94.56	3.46
6	July 09- 15	28	152	18	4.0	26.47	33.31	59.21	92.61	4.26
7	July 16-22	29	200	20	38.5	26.00	34.01	59.51	94.81	1.99
8	July 23-29	30	52	26	140.5	25.37	32.40	71.13	99.90	1.66
9	July 30-Aug 05	31	54	32	60.5	25.47	30.91	75.50	99.10	3.07
10	Aug 06-12	32	89	38	0.5	25.73	34.64	58.29	99.56	3.70

Table.6 Correlation coefficients between MYMV incidence, whitefly population and weather parameters of MARS, UAS, Raichur

Pearson correlation	Correlations							
	Whitefly population	PDI (%)	Rainfall (mm)	Min. Temp (^{0}C)	Max. Temp (^{0}C)	Min. Humidity (%)	Max. Humidity (%)	Max.Wind speed (km/hr)
Whitefly population	1							
PDI (%)	.790**	1						
Rainfall (mm)	-.146	.001	1					
Min. Temp (^{0}C)	-.684*	-.864**	-.338	1				
Max. Temp (^{0}C)	.572	-.707*	-.227	.779**	1			
Min. Humidity (%)	.464	.612	.288	-.734*	-.962**	1		
Max. Humidity (%)	.391	.625	.603	-.864**	-.564	.616	1	
Max.Wind speed (km/hr)	.239	.218	-.644*	.103	-.109	.137	-.382	1
**. Correlation is significant at the 0.01 level (2-tailed).								
*. Correlation is significant at the 0.05 level (2-tailed).								

Table.7 Regression analysis of whitefly population, per cent disease incidence and weather parameters of MARS, UAS, Raichur during surveillance of MYMV

ANOVA[b]					
Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1719.398	7	245.628	12.545	.076[a]
Residual	39.159	2	19.579		
R	.989[a]				
R square	.978				
Multiple regression equation	**Y= -516.486+0.125X1-0.024X2-50.125X3+53.975X4+11.594X5-7.991X6+22.303X7**				
a. Predictors: (Constant), Wind speed, Maximum temperature, Rainfall, Sunshine hours, Maximum relative humidity, Minimum temperature, Minimum relative humidity					
b. Dependent Variable: WFP					

Table.8 Regression analysis of whitefly population, per cent disease incidence and weather parameters of Kavalur during surveillance of MYMV

ANOVA[b]					
Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1905.910	7	272.273	16.164	.059[a]
Residual	33.690	2	16.845		
R	.991[a]				
R square	.983				
Multiple regression equation	**Y=899.040+0.037X1+0.017X2-4.571X3-23.563X4-5.544X5+1.710X6+36.719X7**				
a. Predictors: (Constant), Wind speed, Maximum temperature, Rainfall, Sunshine hours, Maximum relative humidity, Minimum temperature, Minimum relative humidity					
b. Dependent Variable: WFP					

Table.9 Regression analysis of whitefly population, per cent disease incidence and weather parameters of Wadaganal during surveillance of MYMV

ANOVA[b]					
Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	320.214	7	45.745	9.349	.100[a]
Residual	9.786	2	4.893		
R	.985[a]				
R square	.970				
Multiple regression equation	**Y= 176.387-0.210X1-0.418X2-5.238X3-1.846X4+0.205X5-0.140X6+2.121X7**				
a. Predictors: (Constant), Wind speed, Maximum temperature, Rainfall, Sunshine hours, Maximum relative humidity, Minimum temperature, Minimum relative humidity					
b. Dependent Variable: WFP					

X1- Whitefly population X2- Rainfall (mm) X3- Minimum temperature (^{0}C) X4- Maximum temperature (^{0}C)
X5- Minimum relative humidity (%) X6-Maximum relative humidity (%) X7-Windspeed (km/hr)

Fig.1 Weekly observation on MYMV incidence in mungbean at Kavalur

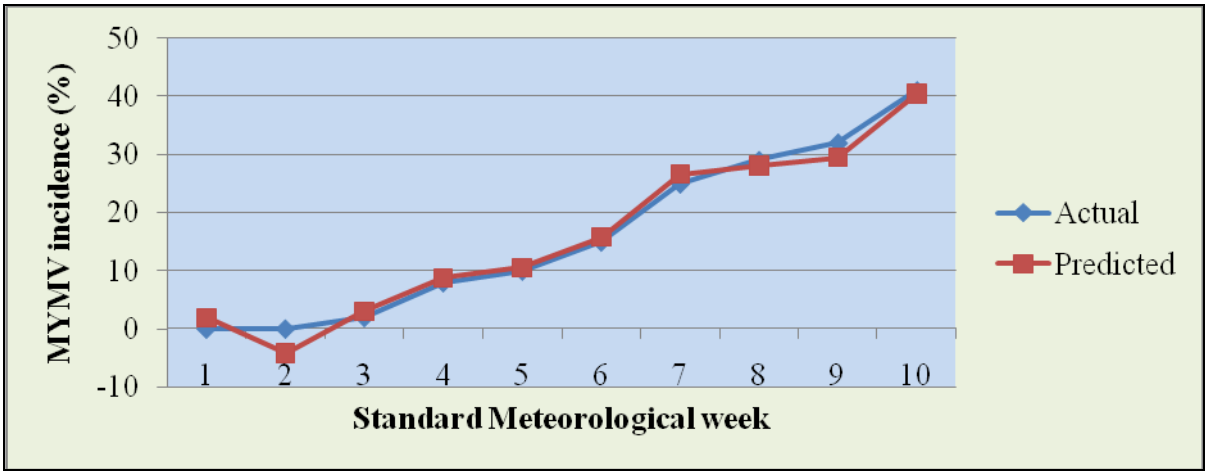


Fig.2 Weekly observation on MYMV incidence in mungbean at Wadagnal

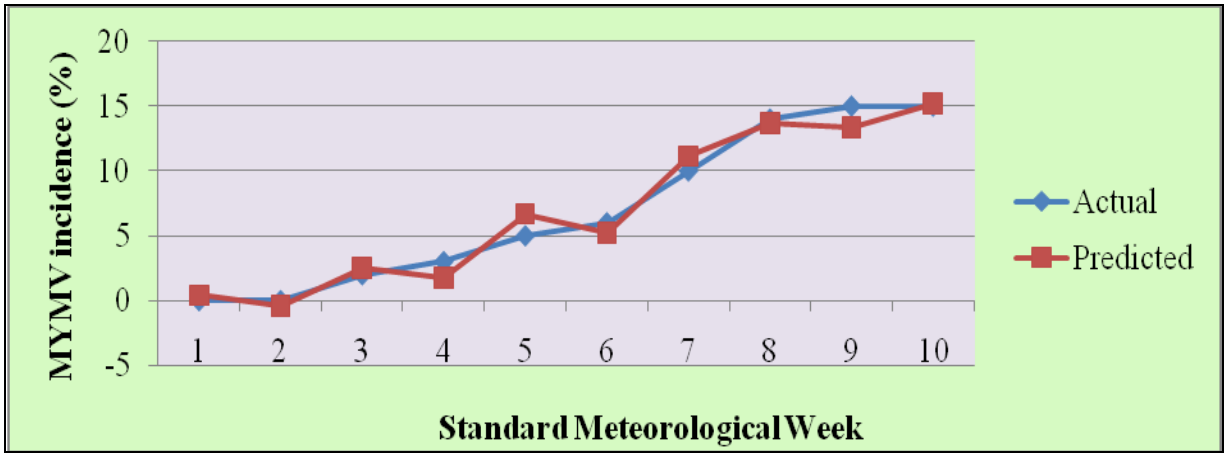
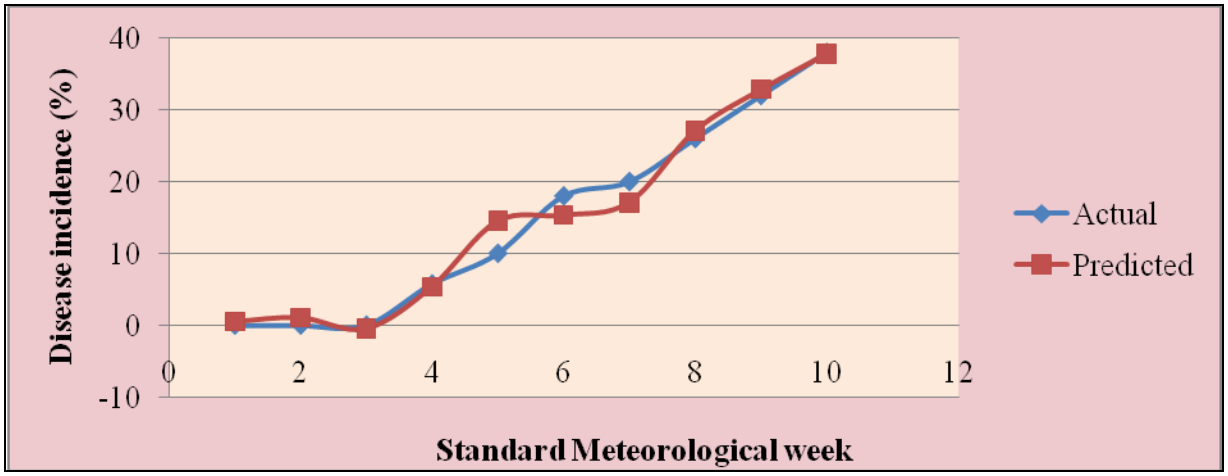


Fig.3 Weekly observation on MYMV incidence in mungbean at UAS, Raichur



The regression analysis revealed that the contribution or influence of weather parameters on whitefly population and disease incidence was of about 97.80 per cent (Fig. 1) (R^2=0.978) at Kavalur (Table 7), 98.30 per cent (Fig. 2) (R^2=0.983) at Wadagnal (Table 8) and 97.00 per cent (Fig. 3) (R^2=0.97) at Raichur (Table 9). Further which are plotted in figures based on differences between actual and predicted values. Following are the equations obtained after multiple regression analysis of data from all the three locations individually for prediction of yellow mosaic disease incidence in surveillance plots.

The above simple rules may be utilized in formulation of bi-weekly district level agromet advisory bulletins and also by extension workers to make tactical decisions for MYMV control measures.

Surveillance studies in all three locations revealed that, weather parameter like maximum temperature had positive significant correlation with whitefly population and disease incidence has correlation with maximum relative humidity and maximum temperature and which intern indicates that higher the maximum temperature more is whitefly population and increase in relative humidity increase in disease. In addition, it was also evident that prediction models of yellow mosaic disease vary from location to location based on the cropping pattern and weather patterns. However, the correlation between whitefly population and maximum temperature was found significantly positive in most of the cases as previously reported.

From the present study it was concluded that out of five weather variables, only minimum temperature and rainfall had statistically significant correlation with MYMV outbreak. Rise in maximum temperature was conducive for development of disease; while increase in relative humidity and heavy rainfall was detrimental to whitefly population. These findings can be used to develop a disease forecasting model for judicious application of chemicals. Long term data on disease incidence should be utilized for refinement of the predictive model and its validation under difference temperature and moisture regimes before putting it into operational use.

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