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**Research Article**

# Influence of Weather Parameters on Outbreak of Mungbean Yellow Mosaic Virus in Black Gram (*Vigna mungo* L.) of Bundelkhand Zone of Central India

A.K. SRIVASTAVA[1]* AND R.K. PRAJAPATI[2]

[1]*College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Tikamgarh - 472001, Madhya Pradesh*

[2]*Krishi Vigyan Kendra, Tikamgarh - 472001, Madhya Pradesh*

**ABSTRACT**

Field surveys were conducted to find out the influence of weather factors and their association with white fly population and Mungbean Yellow Mosaic Virus (MYMV) incidence in Black gram during *kharif* seasons of 2008-2011 in Tikamgarh district of Bundelkhand Agro-climatic zone. Maximum temperature, mean relative humidity and rainfall play an important role in white fly population built-up and significantly related to its peak population. The correlation coefficients were found to be 0.82 for maximum temperature, -0.83 for mean relative humidity and -0.56 for rainfall. The preceding week weather conditions and white fly population as well as highest disease incidence week's rainfall act as determinant for MYMV outbreak. A regression model was developed utilizing these three variables and it was found that the model explained 65 per cent variability of the MYVY outbreak. MYMV outbreak may be estimated through minimum temperature and white fly population of the 34-37$^{th}$ SMW and rainfall of 37-39$^{th}$ SMW. The present analysis enables scientists to devise a system to monitor and develop management strategies for the control of MYMV disease and white fly vector.

**Key words:** Black gram, MYMV, Weather factors, Correlation, Forewarning model

## Introduction

Black gram (*Vigna mungo* L.) is important native pulse crop of India and is grown under mono, mixed and multiple cropping systems during rainy (*kharif*), spring and summer seasons under wide range of agro-climatic conditions. In Madhya Pradesh, its cultivation is mainly confined to Jhabua, Tikamgarh, Chhatarpur, Jabalpur and Ashoknagar districts. Tikamgarh district contributes 14.32 per cent in area and 16.17 per cent in production of Black gram in the state. The productivity of Black gram is very low in Bundelkhand agroclimatic zone due to its cultivation on marginal lands under poor management. The major constraints responsible for lower yield potential are inappropriate production technologies *viz.*, broadcast method of sowing, usage of MYMV susceptible local varieties (T-9), no use of fertilizer and untimely weed (45-DAS) management (Tomar *et al*., 2009). Among the varieties cultivated in Tikamgarh district; T-9 alone contributes 43.3 per cent area of black gram.

Mung bean yellow mosaic virus (MYMV) is a major constraint to the cultivation of grain legumes in India, particularly mungbean and blackgram. Gupta and Pathak (2009) reported that in epidemic year, 100 per cent yield loss was

*Corresponding author,
Email: ajay_weather@yahoo.com

observed from MYMV infested blackgram in Bundelkhand agroclimatic zone. The viral diseases of pulses account upto 80 per cent yield losses with poor quality of seed, while the MYMV alone is capable to produce losses upto 80 to 100 per cent in green gram and black gram (Naimuddin, 2001).

Among all the viruses, mungbean yellow mosaic virus (MYMV) is the most destructive one and spreads mainly through white fly. The MYM virus is not seed or soil borne or sap transmissible (Nene, 1973). The white fly *B. tabaci* (Hemiptera: Aleyrodidae), causes severe damage to crops by feeding on sap, secreting honey dew and transmitting virus diseases (Jose and Usha, 2003). The temperature of insects is approximately the same as that of the environment; hence temperature has a profound effect on distribution and prevalence of white fly (James *et.al*, 2002; Hoffmann *et. al.*, 2003). The weather parameters play a vital role in survival and multiplication of white fly (*B. tabaci,*Genn*)* and influence MYMV outbreak in Black gram during monsoon season. Therefore, understanding of weather factors and their association with MYMV incidence is required to provide baseline information for developing disease prediction system. The main objective of the study was to identify the congenial weather conditions for the outbreak of MYMV and development of weather based forewarning model.

## Material and Methods

Field surveys were conducted to obtain the white fly population and MYMV incidence data in Black gram in three blocks of Tikamgarh district (24°43'North latitude,78°49'East longitude and 358 meter height above msl). The data were collected from the farmer's field on local variety T-9 cultivated under *rainfed* conditions during *kharif* season in 2008 to 2011. The data were taken at weekly intervals starting from 27$^{th}$ standard meteorological week (SMW) to 39$^{th}$ SMW from 2008 to 2011. The data of white fly population and MYMV incidence were recorded in the field under their natural incidence without any insecticidal intervention.

The crop was sown during last week of June in the year 2008 and 2011, and first and second week of July in the year 2009 and 2010, respectively with NPK @ 10, 30 and 20 kg/ha. The crop was harvested at the end of September to mid October. Daily weather data of rainfall, maximum, minimum temperature, relative humidity of morning and afternoon hours were collected from meteorological station of India Meteorological Department (located at Tikamgarh District Head quarter) and weekly values were computed for standard meteorological weeks (SMW). The quality of weather data was checked before analysis.

### *Collection of insect and disease data*

Five leaves were randomly selected from ten plants from each field, in such a way, that one upper leaf from the first plant, one middle leaf from the second and one bottom leaf from third plant, and so on, were considered for the white fly population count.

To know the incidence of MYMV disease, field survey was carried out in black gram fields of 2 villages in three blocks, namely, Tikamgarh, Baldevgarh and Jatara of the Tikamgarh district when the crop was 2 months old. In each village 2 fields and in each field, one square meter area was randomly selected. The total number of plants and the number of plants showing the typical yellow mosaic symptoms were recorded. The percent incidence (PI) was calculated by using the formula given below:

$$\text{Percent incidence} = \frac{\text{No. of plants infected /m}^2\text{ area}}{\text{Total no. of plants /m}^2\text{ area}} \times 100 \qquad (1)$$

### *Statistical analysis*

Data were statistically analyzed and averages were calculated. The significant level was set at $P<0.05$ and $P<0.01$. The data were subjected to correlation and regression analysis to find out co-relationship. The significance of correlation and regression was determined based on t and F test.

Step-wise regression analysis was performed to find out outbreak of the MYMV.

## Results and Discussion

### *Weather during crop period*

The daily weather data from 2nd July (27th SMW) to 30th September (39th SMW) were converted into weekly data and mean values were computed and presented in figure 1. During the crop period a total rainfall of 627.0, 555.0, 540.2 and 875.8 mm was received during 2008, 2009, 2010 and 2011, respectively. The maximum temperature varied from 29.6 (2011) to 37.8 (2009) and minimum temperature ranged between 21.2(2011) and 27.0(2009). The mean weekly relative humidity varied from 62(39th SMW) to 83(33rd SMW) per cent during the crop period.

### *Whitefly population and MYMV incidence during the study period*

Distribution of whitefly population in different blocks was recorded from farmer's fields and mean weekly values were computed. The weekly mean population of whitefly, from 27th SMW to 39th SMW, is presented in figure 2. A perusal of this figure indicates that it started rising from 2.9 insects during third week of July and reached upto 14.9, the highest in the second and third week of September. Population started decreasing continuously from the third week of September till the second week of October. Similar trend of whitefly population was found for the district however, the population was differed within the blocks with a slight variation between villages. Higher incidence of white fly was observed in the late sown black gram.

The cultivar T-9 was highly susceptible and moderate to high incidence of the disease was observed. The disease incidence was highest during 2008 followed by 2009 and 2011. The incidence of disease was observed from the 3 week after sowing and highest incidence was observed between 35 to 39th SMW. There was a lag of 1-2 weeks between highest white fly population and disease incidence. It was noticed that the crop infected at early stages suffered more with severe symptoms with almost all the leaves

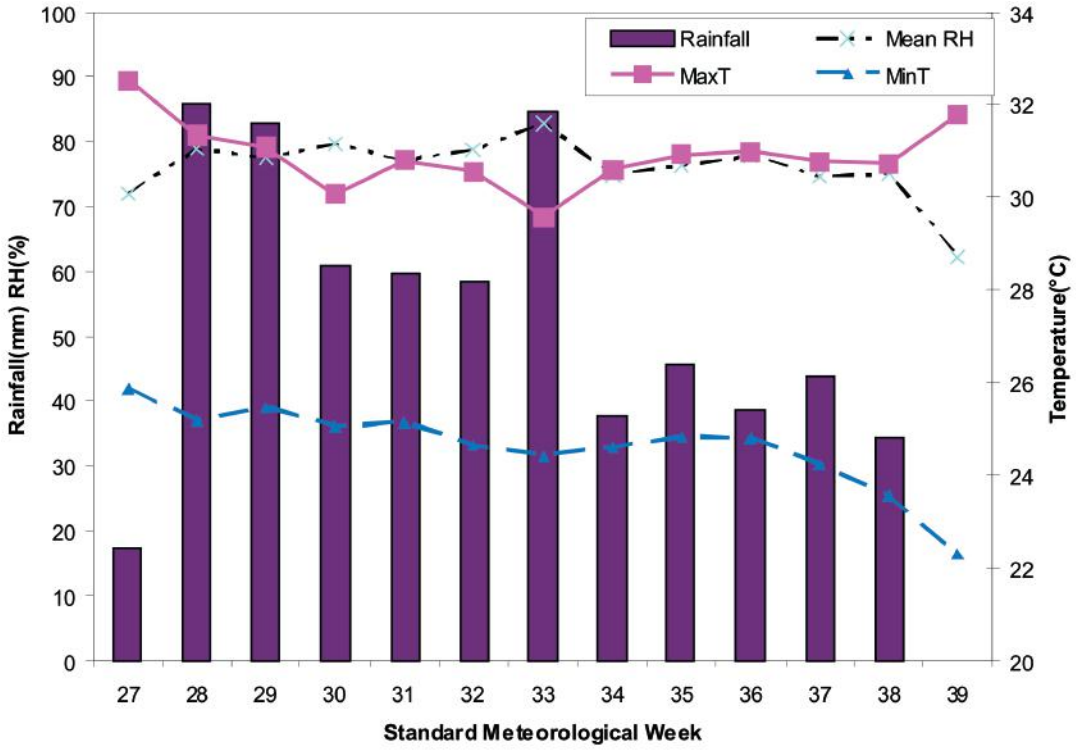


**Fig. 1.** Mean weekly weather pattern during *kharif* 2008-11 at Tikamgarh

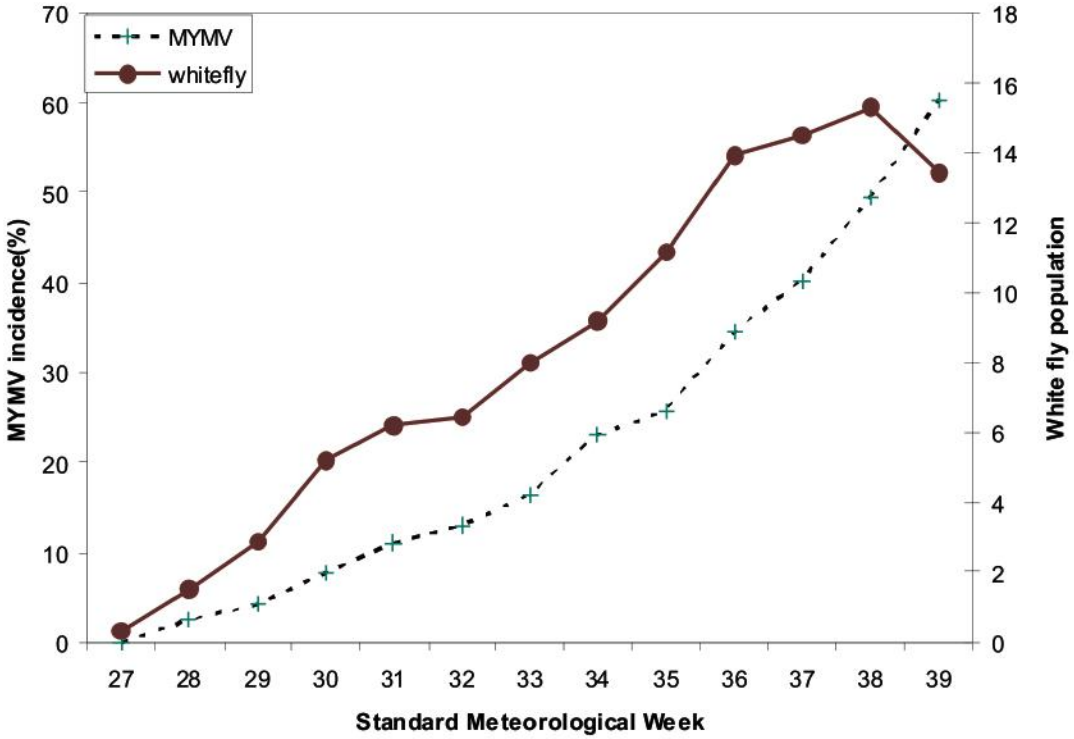


**Fig. 2.** Weekly distribution of white fly population and MYMV incidence in Blackgram at Tikamgarh

exhibiting yellow mosaic and complete yellowing and puckering. Invariably whiteflies were found feeding in most of the fields surveyed along with thrips and pod borers in some of the fields.

### *Yield and disease incidence*

The incidence of MYMV affected the yield of black gram. The district level year-wise area, production, yield and disease incidence is shown in Table 1. It was observed that disease incidence on reproductive stage of crop is very detrimental. Lowest yield was observed during the year 2010 and highest yield during the year 2011. Though the incidence of the disease was highest during the year 2008, but the lowest yield of 2010 was due to cultivation of unsuitable cultivar for the area (distributed by state agriculture department to farmers) by farmers and disease incidence at pod bearing stage. Singh *et al.* (1982) reported that high disease attack at pod bearing stage is a major set back for black gram yield and it also delayed the pod maturity. The blackgram yield varied between 361 kg/ha to 933 kg/ha.

### *Association of whitefly population and weather factors*

Temperature and rainfall influence the white fly population and dynamics (Horowitz *et al.,* 1984, Horowitz, 1986). To find out the association of white fly population with weather

**Table 1.** Area, production, yield of Black gram and MYMV incidence in Tikamgarh

| Year | Area (000, ha) | Production (000, tones) | Yield (kg/ha) | MYMV mean incidence(%) |
|---|---|---|---|---|
| 2008 | 31.2 | 14.0 | 448 | 28.6 |
| 2009 | 62.5 | 28.1 | 450 | 22.1 |
| 2010 | 64.2 | 29.1 | 361 | 28.0 |
| 2011 | 74.0 | 69.0 | 933 | 18.7 |

**Table 2.** Correlation between weather parameters, white fly population and disease incidence

| Variable | Weather factor | | | | | |
|---|---|---|---|---|---|---|
| | Maximum temperature | Mean temperature | Morning relative humidity (%) | Afternoon relative humidity (%) | Rainfall (mm) | Disease incidence |
| White fly population | 0.59* | 0.43 | -0.53* | -0.57* | -0.50* | 0.75** |
| Per cent MYMV incidence | 0.39 | -0.23 | -0.40 | -0.38 | -0.52* | - |

*Significant at 5% level, ** Significant at 1% level

parameters, data were pooled and correlation coefficients were worked out between weather parameters and white fly population. The data on the above analysis is shown in Table 2, which shows that there was a significantly positive correlation between temperature variations and whitefly population; whereas humidity was negatively correlated with the whitefly population. These findings are in agreement with the findings of Rote and Puri (1991) and Wahla *et. al.* (1996), who reported a positive and negative correlation of the whitefly population with temperature and relative humidity, respectively. A non-significant and positive correlation between the mean temperature and whitefly population was also found; whereas a negative and significant association was observed with the rainfall. The present finding is in conformity with the result demonstrated by Bashir *et. al*. (2001), who concluded that rainfall negatively correlated with whitefly population. Sudden heavy rainfall were negatively correlated with white fly population (Horowitz,1986). However, Seif (1980) and Gupta *et al.* (1998) reported that with increase in temperature and relative humidity, population of whitefly also increased.

### *Correlation between peak and preceding weather and white fly population*

Correlation coefficient between peak white fly population (35-37$^{th}$ SMW) and corresponding week's weather parameters were worked out and correlation coefficients values of highly correlated weather variables are given below:

Maximum temperature : 0.82**,
Mean temperature : 0.71**
Rainfall : -0.56*
Mean relative humidity : -0.83**

(*Significant at 5% level,** Significant at 1% level)

It is observed that dry weather conditions with maximum temperature of 32 to 37$^{o}$C during peak population week coupled with low to medium rainfall (0.0 to 50mm/week) are found to be congenial conditions for the peak white fly population.

Correlation coefficient between peak white fly population (35-37$^{th}$ SMW) and preceding week's weather (31-34$^{th}$ SMW) were worked out and it is observed that correlation between preceding week weather parameters and peak white fly population were non -significant.

Maximum temperature ranged from 32 to 37$^{o}$C (fig.3), while the mean temperature ranged from 28 to 31$^{o}$C (fig.4) during peak white fly population weeks. The mean relative humidity varied between 65 and 83 per cent (fig.5) corresponding to 0.0 to 49.5mm weekly rainfall (fig.6) and was observed to peak white fly population. The ability of insects to survive thermal stress, together with other factors, plays an important role in determining distribution of a species (Bale *et.al*. 2002). White fly adults survival was affected by temperature regime of 26 to 39°C. Their survival was upto 41°C and above this maximum temperature; adults were showing dying symptoms and got killed by 45°C (Cui *et al*., 2008).

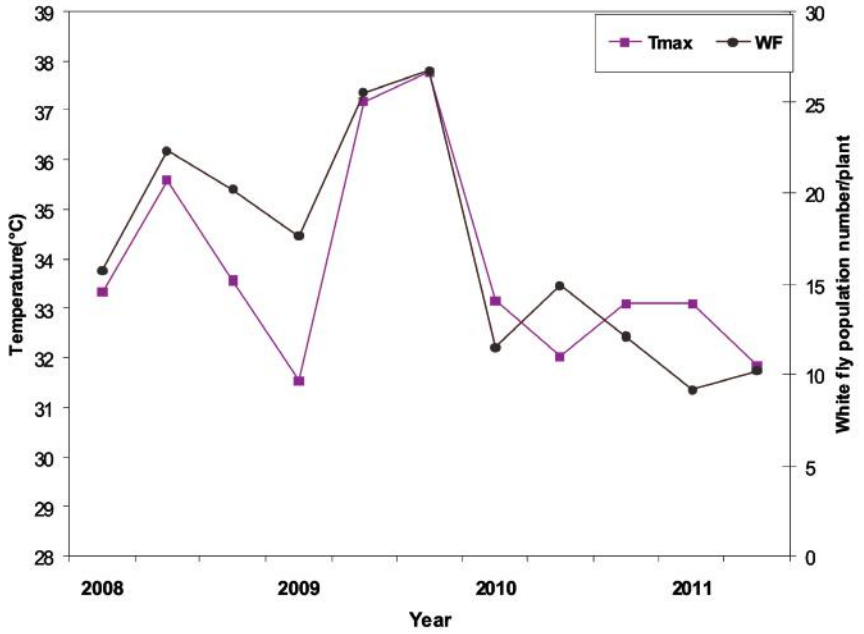


**Fig. 3.** Weekly pattern of peak white fly population and corresponding week's maximum temperature in Blackgram

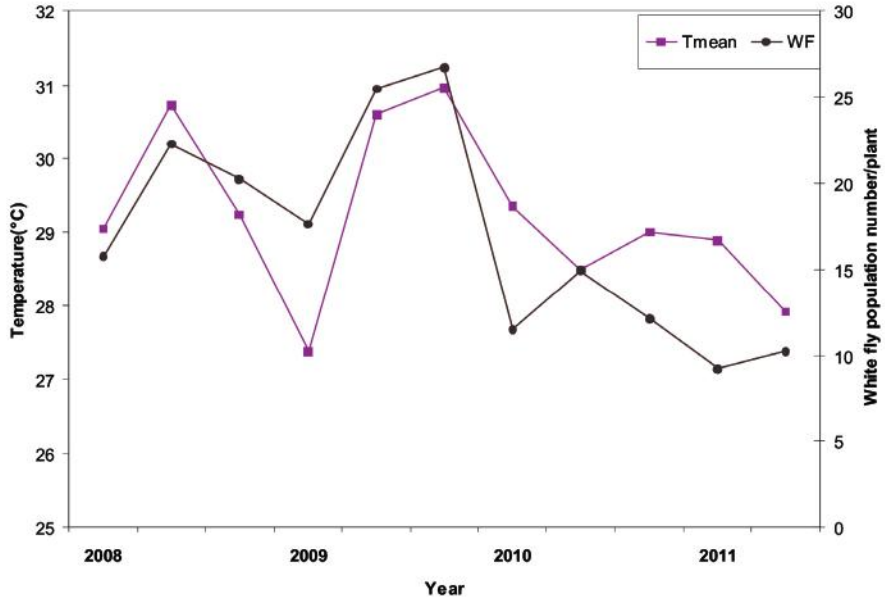


**Fig. 4.** Weekly pattern of peak white fly population and corresponding week's mean temperature in Blackgram

### *Association of MYMV incidence and weather factors*

Higher temperature has been found to be positively correlated with white fly population in 20-30 days old crop and with symptoms of disease incidence in 45 days old crop. In the Tikamgarh district, Baldevgarh block has shown the highest (27.30 %) disease incidence followed by Jatara, and Tikamgarh with 23.80 and 28.20 percent, respectively. The variation in disease incidence over locations might be due to the local variation in temperature and relative humidity that may have direct influence on vector population and its migration. The effect of climate on biology

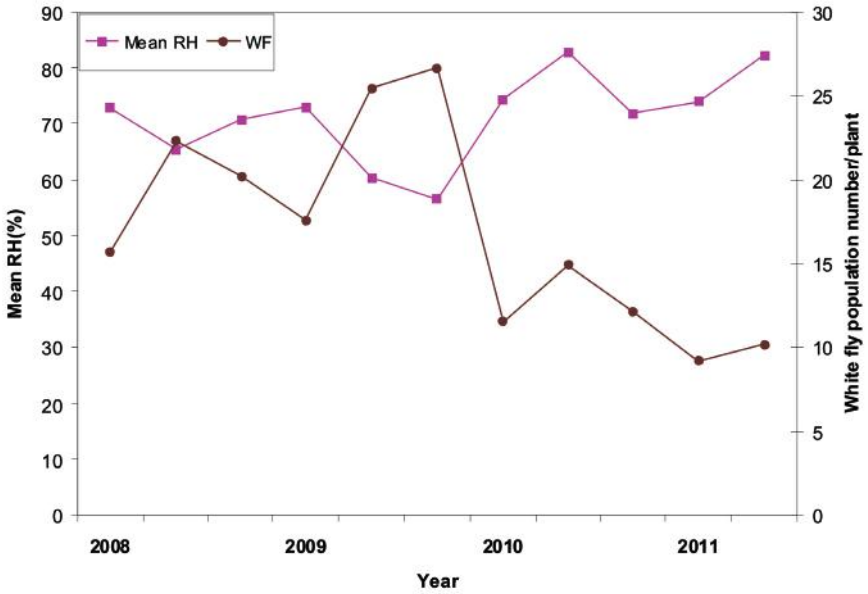


**Fig. 5.** Weekly pattern of peak white fly population and corresponding week's mean RH in Blackgram

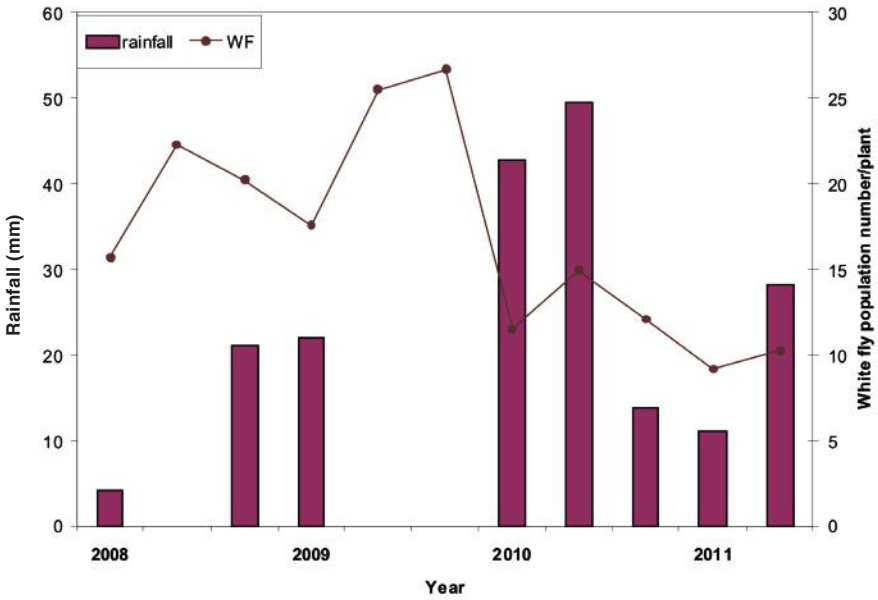


**Fig. 6.** Weekly pattern of peak white fly population and corresponding week's rainfall in Blackgram

and distribution of vector, (*Bemisia tabaci* Genn.) was earlier discussed by Singh and Gurha (1994) and Nath and Saikia (1995).

### *Correlation between peak MYMV incidence and weather parameters*

It was noticed that corresponding as well as preceding week's weather and white fly population have influenced the peak incidence of the disease in the study period. The correlation coefficients between peak disease incidence (37-39$^{th}$ SMW) weeks with corresponding week (37-39$^{th}$ SMW) weather were calculated. The high correlation coefficient values were only found for minimum temperature (0.36) and rainfall (-0.39). The preceding week's weather parameters (35-37$^{th}$ SMW) and peak disease incidence week were also correlated and minimum temperature was

significantly correlated (0.55) with incidence of disease.

### *Weather based MYMV forewarning model*

To estimate the cumulative effects of different weather parameters and white fly population on disease outbreak; regression analysis was carried out; following step wise regression analysis. The outbreak or highest disease incidence was recorded during 37-39$^{th}$ SMW and highly correlated with white fly population and minimum temperature (35-37$^{th}$ SMW), rainfall of peak incidence period (37-39$^{th}$ SMW) were taken into consideration for working out the predictive model after pooling the data. The equation for the prediction of outbreak is

$$Y= -165+9.4X_1-0.05X_2-0.2X_3 , R^2=0.65* \quad (2)$$

Standard error =12.3

*significant at 5% level

Where

$Y$ = MYMV % incidence on black gram

$X_1$ = Minimum temperature of preceding week (35-37$^{th}$ SMW)

$X_2$ = Peak white fly population of preceding week (35-37$^{th}$ SMW)

$X_3$ = Rainfall during highest MYMV incidence week (37-39$^{th}$ SMW)

It is found that minimum temperature, afternoon relative humidity, rainfall and white fly population are the major determinants of MYMV disease incidence. These parameters explained 65 percent variability of disease outbreak in black gram. The dependent variables are available at district level in Bundelkhand agroclimatic zone which may be utilized for estimation of MYMV outbreak. District level medium range weather forecast round the years is also provided by India Meteorological Department to all the districts of this zone.

Based upon these three variables a MYMV watch and tactical management box was prepared and is presented below

| | |
|---|---|
| $\mathbf{A^+B^+C^+}$<br>Outbreak - Control measures | $\mathbf{A^+B^+C^-}$<br>Alarm- Prophylactic spray |
| $\mathbf{A^+B^-C^-}$<br>Congenial- Keep watch | $\mathbf{A^-B^-C^-}$<br>No threat – No Action |

Where

$A^+$ : When minimum temperature of 34-37$^{th}$ SMW is above normal

$A^-$ : When minimum temperature of 34-37$^{th}$ SMW is below normal

$B^+$ : When mean white fly population of 34-37$^{th}$ SMW is around 15/plant or above

$B^-$ : When mean white fly population of 34-37$^{th}$ SMW is much below 15/plant

$C^+$ : When weekly rainfall of 37-39$^{th}$ SMW is upto 50mm/week

$C^-$ : When weekly rainfall of 37-39$^{th}$ SMW is above 50mm/week or heavy rainfall

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.

## Conclusions

The black gram variety T-9 which occupied 43 percent of the area in the district under study was found susceptible to MYMV disease during the survey. The reported observations of this study may enable the scientists to devise a system to monitor and develop management strategies in controlling the spread of mungbean yellow mosaic virus disease and the vector white fly, *Bemisia tabaci* and also to screen resistant black gram varieties for this disease for this region.

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 thermal and moisture regimes before putting it into operational use.

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