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# Population Dynamics of Whitefly, *Bemisia tabaci* and Incidence of Mungbean Yellow Mosaic India Virus (MYMIV) on Blackgram

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**Abstract**

An investigation was conducted on population dynamics of whitefly, *Bemisia tabaci* and incidence of mungbean yellow mosaic India virus (MYMIV) on blackgram during *Kharif* 2015–16. observations of adult whitefly was recorded at weekly interval through yellow sticky trap at the field by installing just above the crop canopy for 24 hours and percent disease incidence of MYMIV was recorded. Results revealed that the whitefly was first observed from 28th SMW (15.83 whiteflies sticky trap$^{-1}$). During this period maximum and minimum temperature was 30.4$^0$C and 24.2$^0$C while morning and evening RH were 91% and 74%, respectively. Further, wind speed, sunshine, rainfall and rainy days were observed 7.3 (kmh$^{-1}$), 6.8 (hrs), 203.2 (mm) and 6 (days), respectively. The whitefly population was reached at its peak (67.83 whiteflies sticky trap$^{-1}$) at 36th SMW. Correlation studies with maximum temperature was exhibited significantly positive (r=0.659), whereas wind speed (r=-0.812) and rainfall (r=-0.809) were showed highly negative significant association with whitefly. Path analysis revealed that evening RH had highest direct positive effect (1.4106) on whitefly followed by maximum temperature (1.0663), sunshine (0.0675), rainfall (0.0501) whereas, direct negative effect was exerted via rainy days (-0.6289) followed by wind speed. The first incidence of MYMIV (2.35%) was recorded on blackgram at 30th SMW which was gradually increased and reached at peak (100.00%) on 36th SMW. Maximum temperature showed significantly positive correlation (r=0.630) with incidence of MYMIV. Results revealed that severe attack of whitefly was occurred as pest outbreak and MYMIV incidence as epidemic form on blackgram due to erratic abiotic factors.

***Keywords:*** Population dynamics, whitefly, *Bemisia tabaci,* incidence, MYMIV, blackgram

## 1. Introduction

Blackgram (*Vigna mungo* (L.) Hepper) is one of the most important legume crop of India. This crop is cultivated both in Kharif and summer seasons particularly in central Indian conditions. Blackgram has been shown to be useful in mitigating elevated cholesterol levels. It has received prominence in Indian diets especially for culinary preparation of Dal, Idli, Vada, Dosa, Papad etc. In last few decades the average production of blackgram has drastically declined due to the fluctuation of biotic and abiotic factors. Among the biotic factors, the insect pests cause detrimental effect for low yield of the blackgram. Chandra and Rajak (2004) recorded eleven insect pests on blackgram, of them whitefly (*Bemisia tabaci* Genn.), jassid (*Empoasca* spp.) and green leaf hopper (*Nephotettix* spp.) are the major sucking insect pests (Kumar et al., 2007). Among them whitefly is considered as the most devastating pest which has become obnoxious pest now. It has been positioned one of the most serious agricultural pests in many areas of the world in recent decades (Yaobin et al., 2012). Both nymph and adult stages of this pest suck the sap from under surface of the leaves and secrets honey dew which causes sooty molds and hamper the photosynthesis activities. Whitefly is also act as a vector of yellow mosaic virus disease in different crop plants. Yellow mosaic virus disease was first documented by Nariani (1960) on greengram from the field of IARI, New Delhi, India in 1960s which is transmitted by whitefly, *B. tabaci.* Later it has been reported this disease as Mungbean Yellow Mosaic Virus (MYMV) on blackgram (Mandal et al., 1997; Maiti et al., 2011). In central India it was reported in the form of Mungbean Yellow Mosaic India Virus (MYMIV) which is a serious disease of blackgram, mungbean and soybean (Usharani et al., 2004; Marabi et al., 2017a). It causes irregular green and yellow specks in older leaves and gets yellowing of younger leaves which looks golden yellow mosaic. Diseased plants produce fewer flowers and pods which often become stunt and mottling, remain small and contain few and small seeds thus affecting yields drastically both qualitatively and quantitatively. This virus is transmitted through whitefly into plants in a persistent manner (Hunter et al., 1998; Sinisterra et al., 2005). The quantum of annual yield loss due to yellow mosaic disease has been estimated about

 

US$ 300 million taking blackgram, mungbean and soybean together (Varma and Malathi, 2003). It has been estimated that the incidence of the disease is highly variable upto 3 to 26 per cent (Biswas et al., 2009) and in severe cases 100 per cent caused yield loss (Proceedings of the ZREAC Kharif 2009-10) depending upon varieties and prevailing weather conditions. Weather parameters play key role to influence the activity of whitefly and incidence of yellow mosaic disease (Marabi et al., 2017b). Thus it was planned to investigate the population dynamics of whitefly and the incidence of MYMIV in blackgram.

## 2. Materials and Methods

A research trial was conducted to study the population dynamics of whitefly and incidence of mungbean yellow mosaic India virus (MYMIV) on blackgram during Kharif 2015-16 at Experimental Field of Entomology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Adhartal, Jabalpur (MP), India. The plot size was kept 40×30 m$^2$ with the spacing of 45×10 cm$^2$ between the rows and plants. All the recommended agronomical practices were applied except the plant protection measures. Observation on population of adult whiteflies was recorded at weekly interval through yellow sticky trap by installing at the field just above the crop canopy for 24 hrs till the availability of the insect or maturity of the crop whichever is earlier. There was total of six yellow sticky traps was installed with the distance of 5 m at field. Trapped whiteflies on sticky traps were brought in laboratory and counted with the help of binocular and their mean was computed. Statistical analysis of data was analyze through correlation coefficient, simple and multiple regression to find the population status of whitefly on crop with different weather parameters *viz.,* temperature, relative humidity, wind speed, sunshine hours, rainfall and rainy days. The incidence of mungbean yellow mosaic India virus (MYMIV) disease was recorded weekly from 20 tagged plants in a particular plot of field. The disease was identified initially on the basis of visual and typical yellow specks and mosaic symptoms and later confirmed by molecular studies. During the study, total and infected plants were counted to calculate as percent disease incidence (PDI) following the method of Singh and Singh (2000).

$$\text{PDI (\%)} = \frac{\text{Total number of yellow mosaic disease infected plants}}{\text{Total number of observed plants}} \times 100$$

The influence of different weather parameters on population of whitefly and MYMIV were studied to know the direct and indirect effect of independent variables through path coefficient analysis (Dewey and Lu, 1959).

## 3. Results and Discussion

### *3.1. Activity of adult whitefly (Bemisia tabaci)*

Data on population dynamics of whitefly revealed that the first appearance of whitefly was recorded at 28$^{th}$ SMW with 15.83 whiteflies/sticky trap (Table 1). Population was increased gradually and reached at its first peak at 30$^{th}$ SMW

Table 1: Correlation coefficient (r) between the adult whitefly population and weather parameters on blackgram during *Kharif*, 2015

| Observation Dates | SMW | Adult whiteflies/ sticky trap | MYMIV PDI (%) | Temperature (0C) | | Relative humidity (%) | | Wind speed (km/hr) | Sunshine (hrs) | Rainfall (mm) | Rainy days |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Maximum | Minimum | Morning | Evening | | | | |
| 13.07.2015 | 28 | 15.83 | 0.00 | 30.4 | 24.2 | 91 | 74 | 7.3 | 6.8 | 203.2 | 6 |
| 20.07.2015 | 29 | 41.20 | 0.00 | 31.5 | 24.2 | 89 | 70 | 5.1 | 2.8 | 72.8 | 5 |
| 27.07.2015 | 30 | 43.83 | 2.35 | 30.6 | 23.5 | 87 | 67 | 5.4 | 4.5 | 84.7 | 2 |
| 03.08.2015 | 31 | 12.62 | 4.08 | 29.8 | 23.6 | 90 | 70 | 8.3 | 4.7 | 149.4 | 2 |
| 10.08.2015 | 32 | 47.71 | 40.26 | 31.2 | 24.2 | 91 | 69 | 3.7 | 4.6 | 14.0 | 2 |
| 17.08.2015 | 33 | 49.83 | 78.93 | 31.2 | 24.5 | 91 | 73 | 6.1 | 3.0 | 116.8 | 4 |
| 24.08.2015 | 34 | 48.63 | 80.48 | 31.3 | 23.6 | 88 | 64 | 6.5 | 7.4 | 9.4 | 1 |
| 31.08.2015 | 35 | 41.63 | 89.80 | 30.4 | 22.9 | 93 | 76 | 4.9 | 3.0 | 104.6 | 5 |
| 07.09.2015 | 36 | 67.83 | 100.00 | 32.2 | 24.2 | 87 | 57 | 3.5 | 6.7 | 8.2 | 1 |
| 14.09.2015 | 37 | 56.80 | 100.00 | 33.5 | 23.1 | 91 | 55 | 3.1 | 8.4 | 3.4 | 1 |
| 21.09.2015 | 38 | 29.24 | 100.00 | 32.0 | 23.7 | 92 | 64 | 5.5 | 5.6 | 70.2 | 3 |
| Correlation (r) with whitefly | | | | 0.659* | 0.030 | -0.363 | -0.573 | -0.812** | 0.156 | -0.809** | -0.488 |
| Correlation (r) with MYMIV | | | | 0.630* | -0.269 | 0.246 | -0.490 | -0.510 | 0.317 | -0.562 | -0.362 |

*: Significant at ($p$=0.05); **: Significant at ($p$=0.01) level; MYMIV: Mungbean yellow mosaic India virus

(43.83 whiteflies/sticky trap). During this week the weather parameters *viz.,* maximum and minimum temperature, morning relative humidity, evening relative humidity, wind speed, sunshine hours, rainfall and rainy days were observed 30.4$^0$C, 24.2 $^0$C, 91%, 74%, 7.3 km hr$^{-1}$, 6.8 hours, 203.2 mm and 6 days, respectively. Thereafter its population was tend to increase and reached again its second and third peaks at 33$^{th}$ and 36$^{th}$ SMW with the population of 49.83 and 67.83 whiteflies/sticky trap, respectively. Gerling and Horowitz (1984) reported the sticky traps caught more adult whiteflies when placed horizontally than vertically. The use of yellow sticky trap has found to be best tool against the whitely on tomato plants in greenhouses (Berlinger, 1980; Gu et al., 2008). Byrne (1991) stated that the weather parameters such as temperature, wind speed, rainfall and relative humidity play important roles towards the population dynamics of whiteflies. The appearance of whitefly was noticed from second week after sowing and the disease intensity peaked by the end of May to first week of June during summer and in the first fortnight of September during rainy season (Yadav and Singh, 2006). The rainfall found to be positive effect on the build-up whitefly population (Ashfaq et al., 2010). Maximum temperature, mean relative humidity and rainfall play an important role in built-up of whitefly population and significantly related to its peak population (Srivastava and Prajapati, 2012). Yaobin et al. (2012) stated that the whitefly densities in the greenhouse with traps were significantly lower than the greenhouse without traps. In the field, traps did not have a significant impact on the population dynamics of adult and immature whiteflies. A similar result was also reported on blackgram by Patidar (2015).

#### *3.1.1. Simple correlation and regression*

Simple correlation studies between adult whitefly and weather parameters exhibited that its population had significantly positive correlation with maximum temperature (r=0.659), while highly negative significant association with wind speed (r=-0.812) and rainfall (r=-809), respectively (Table 1). Other weather parameters *viz;* minimum temperature and sunshine were exhibited positive correlation, whereas morning and evening relative humidity and rainy days were expressed negative correlation but there was found to be statistically non-significant with the influence of whitefly population. The simple regression equations of whitefly population with maximum temperature being as Y=-290.2+10.60x ($R^2$=0.433). From this equation it may be estimated that with every unit increase in maximum temperature there was increase of 10.60 whitefly population. Whereas regression equation with wind speed and rainfall was expressed as Y=86.44-8.345x($R^2$=0.658) and Y=57.02-0.205x ($R^2$=0.654), respectively. According to this equation it may be observed that with every unit increase in wind speed and rainfall there was decrease of 8.345 and 0.205 whitefly population, respectively. The equations of $R^2$ values were showed those weather parameters which played role as independent factors for dynamics of whitefly population. The effect of weather parameters on blackgram, pest incidence revealed high mean ambient temperature and high relative humidity which favor the population build-up of whitefly (Nayak et al., 2004). Occurrence of whitefly population on mungbean and blackgram was exhibited positive correlation with temperature and sunshine (Kumar et al., 2004). Srivastava and Prajapati (2012) reported that maximum temperature exhibited significantly positive correlation while mean relative humidity and rainfall were showed negative correlation with whitefly population on blakgram. In contrast, Yadav and Singh (2013) reported negative correlation with maximum temperature on the influence of whitefly activity on mungbean. Srinivasaraghavan (2014) also recorded positive correlation between maximum temperature and whitefly population, whereas significant negative correlation was recorded between whitefly population and morning relative humidity. Patidar (2015) reported that activity of whitefly on blackgram showed negative correlation with maximum temperature and rainfall but had a positive correlation with minimum temperature and relative humidity. Kumar and Singh (2016) found significant positive correlation between maximum humidity and whitefly population while other parameters were showed non-significant.

#### *3.1.2. Multiple regressions*

Multiple analysis was carried out with eight weather parameter *viz;* maximum temperature ($X_1$) and minimum temperature ($X_2$), morning relative humidity ($X_3$), evening relative humidity ($X_4$), wind speed ($X_5$), sunshine hours ($X_6$), rainfall ($X_7$) and rainy days ($X_8$) as independent factors and population of whitefly and incidence of MYMIV disease as dependent factor was analyzed (Table 2). Multiple linear regression equation studied for adult whitefly population which are being as: $Y=-190.183+9.492X_1-3.833X_2+11.465X_3-1.675X_4+4.490X_5-0.820X_6-0.344X_7-0.496X_8$. From this equation it is expressed that every unit increase in maximum temperature, morning relative humidity and wind speed will increase the population of whiteflies by 9.492, 11.465 and 4.490 units respectively. Whereas with increase in minimum

Table 2: Multiple linear regression equation for whitefly and MYMIV incidence on blackgram during *kharif*, 2015

| Dependent factors | Regression models | $R^2$ value |
|---|---|---|
| Whitefly | $Y=-190.183+9.492\ X_1-3.833\ X_2+11.465\ X_3-1.675\ X_4+4.490\ X_5-0.820\ X_6-0.344\ X_7-0.496\ X_8$ | 0.591 |
| MYMIV | $Y=-1063.240+17.206\ X_1-2.167\ X_2-4.928\ X_3+3.488\ X_4-6.153\ X_5+0.587\ X_6+0.013\ X_7-5.749\ X_8$ | 0.870 |

Where, $X_1$: Maximum temperature; $X_2$: Minimum temperature; $X_3$: Morning relative humidity; $X_4$: Evening relative humidity; $X_5$: Wind speed; $X_6$: Sunshine; $X_7$: Rainfall; $X_8$=Rainy days temperature, evening relative humidity, sunshine hours, rainfall and rainy days will decrease the population of whitefly by 3.833, 1.678, 0.820, 0.344 and 0.496 units, respectively. Influence of weather parameters on population of whitefly clearly indicated that 59% change in their population was affected by above mentioned weather parameters. The results explained that 41% variation was affected due to other factors or error beyond the control of experiment which was not considered in the present investigation. The findings of present investigation are corroborated with result of previous workers (Ashfaq et al., 2010). Similarly regression equation computed for whitefly population on blackgram was $Y=57.37-0.85X_1+1.56X_2-0.37X_3-0.41X_4+0.07X_5$ ($R^2=0.64$) and the influence of weather parameters on the population of whitefly was to the extent of 64% (Srinivasaraghavan, 2014).

*3.1.3. Path coefficient analysis*

Correlation and regression express only mutual association between two variables but these do not deal the cause and effect of independent and dependent variables, whereas path coefficient analysis provides determining the combine, direct and indirect effects of weather parameters on population fluctuation of whitefly (Table 3). Path analysis is advance modification of multiple regressions which provides the combine effect of variables towards the whitefly population. Path studies expressed that evening relative humidity had positive and high direct effect (1.4106) on whitefly population followed by maximum temperature (1.0663), sunshine hours (0.0675), rainfall (0.0501), whereas, it had high and negative direct effect via rainy days (-0.6289) followed by wind speed (-0.5981), morning relative humidity (-0.5950) and minimum temperature (-0.0665), respectively. Path coefficient effect showed that the positive indirect effect of high magnitude of evening relative humidity was recorded via rainfall (0.0373) while negative effects were exhibited via maximum temperature (-0.8754), rainy days (-0.4973), wind speed (-0.3350), morning relative humidity (-0.2529), sunshine hours (-0.0489) and minimum temp (-0.0109), respectively. Indirect positive effect of maximum temperature on whitefly population was recorded via wind speed (0.4442), rainy days (0.2740), sunshine (0.0352), morning relative humidity (0.0290) and minimum temperature (0.0041), respectively.

Table 3: Combined direct and indirect effect of weather parameters on adult whitefly population on blackgram during *kharif*, 2015

| Abiotic factors | Temperature (°C) | | Relative humidity (%) | | Wind speed (km/hr) | Sun-shine (hrs) | Rainfall (mm) | Rainy days | Correla-tion r- values |
|---|---|---|---|---|---|---|---|---|---|
| | Max. | Mini. | Morning | Evening | | | | | |
| Temp (Max.) | (1.0663) | 0.0041 | 0.0290 | -1.1581 | 0.4442 | 0.0352 | -0.0360 | 0.2740 | 0.6586* |
| Temp (Min.) | -0.0654 | (-0.0665) | 0.1398 | 0.2313 | -0.0684 | -0.0133 | 0.0072 | -0.1352 | 0.0296 |
| RH% (Morn.) | -0.0519 | 0.0156 | (-0.5950) | 0.5995 | -0.0205 | -0.0145 | 0.0162 | -0.3120 | -0.3625 |
| RH% (Even.) | -0.8754 | -0.0109 | -0.2529 | (1.4106) | -0.3350 | -0.0489 | 0.0373 | -0.4973 | -0.5726 |
| Wind speed (km $hr^{-1}$) | -0.7918 | -0.0076 | -0.0203 | 0.7901 | (-0.5981) | -0.0107 | 0.0382 | -0.2113 | -0.8116** |
| Sunshine (hrs) | 0.5565 | 0.0131 | 0.1276 | -1.0224 | 0.0945 | (0.0675) | -0.0173 | 0.3367 | 0.1562 |
| Rainfall (mm) | -0.7653 | -0.0096 | -0.1927 | 1.0495 | -0.4558 | -0.0233 | (0.0501) | -0.4621 | -0.8092** |
| Rainy days | -0.4645 | -0.0143 | -0.2952 | 1.1153 | -0.2009 | -0.0361 | 0.0368 | (-0.6289) | -0.4877 |

Residual: 0.1295; The values in parenthesis are denote the direct effect of abiotic factors on adult whitefly population; *: Significant at ($p$=0.05); **: Significant at ($p$=0.01) level; r: correlation coefficients of MYMIV with independent variables

*3.2. Incidence of mungbean yellow mosaic india virus in blackgram*

The perusal of the data on the MYMIV revealed that first incidence was observed at 30th SMW (Table 1). The weather parameters was attained this period *viz;* maximum and minimum temperature, morning relative humidity, evening relative humidity, wind speed, sunshine hours, rainfall and rainy days were 30.6 °C, 23.5 °C, 87%, 67%, 5.4 km $hr^{-1}$, 4.5 hours, 84.7 mm and 2 days, respectively. Disease incidence was very aggressively increased and reached 100% (PDI) which was observed at 36th SMW. During this period maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind speed, sunshine hours, rainfall and rainy days were 32.2 °C, 24.2 °C, 87%, 57%, 3.5 km $hr^{-1}$, 6.7 hours, 8.2 mm and 1 days, respectively. Eventually, the blackgram crop is most susceptible and preferable host of whitefly and MYMIV. If the weather conditions prevail congenial for build-up of whitefly population and incidence of MYMIV then risk of disease incidence become higher in blackgram.

*3.2.1. Simple correlation and regression*

The correlation studies between incidence of MYMIV and weather parameters revealed that incidence was significantly positive correlation with maximum temperature (r=0.630), while rest of weather parameters were exhibited statistically non-significant (Table 1). The regression equation on incidence of MYMIV disease with maximum temperature being Y = - 806.1 + 27.50x ($R^2$ = 0.396). From this equation it may be estimated that with every unit increase in maximum temperature there was increase of 27.50% disease incidence (PDI). Srivastava and Prajapati (2012) stated that the rainfall act as dominant factor for mungbean yellow mosaic virus outbreak in blackgram. A regression model expressed utilizing maximum temperature, mean relative humidity and rainfall and it was found that the model explained 65 per cent variability of the mungbean yellow mosaic virus outbreak in blackgram. Srinivasaraghavan (2014) found that incidence of mungbean yellow mosaic virus (MYMV) disease had exhibited highly significant positive correlation with maximum temperature and significant negative correlation with morning relative humidity. Similarly,between disease severity and maximum temperature was also showed significant positive correlation.

*3.2.2. Multiple regressions*

In order to relative importance of weather parameters for analyzing the variation in the incidence of yellow mosaic disease, the multiple regression equations were computed taking the values of PDI in blackgram as dependent variable and weather parameters as independent variables. The data is depicted in Table 2. Multiple regression equation analyzed for incidence of MYMIV disease which being $Y=-1063.240+17.206X_1-2.167X_2-4.928X_3+3.488X_4-6.153X_5+0.587X_6+0.013X_7-5.749X_8$. From this equation model it may be expressed that with every unit increase above said weather parameters there was significantly increase the disease incidence to the extent of 87 per cent ($R^2$ = 0.870). Similar result was also calculated by Srinivasaraghavan (2014) through multiple linear regression equation for disease incidence (MYMV) which was $Y=59.99+2.15X_1+1.55X_2-1.27X_3-0.49X_4-0.04X_5-0.85X_6$ and influence of weather parameters on the disease incidence was 91 per cent ($R^2$ = 0.91).

*3.2.3. Path coefficient analysis*

The direct contribution of maximum temperature was exhibited positive but lesser magnitude (0.2179) on the incidence of yellow mosaic disease. The path analysis of disease incidence is presented in the Table 4. The perusal of path studies on the influence of MYMIV revealed that morning relative humidity had positive and direct effect with high magnitude (0.5108) followed by maximum temperature (0.2179), wind speed (0.1609), while, high negative effect was observed to rainfall (-0.4988) followed by evening relative humidity (-0.2496), minimum temperature (-0.0437), sunshine hours (-0.0349) and rainy days (-0.0203), respectively.

Table 4: Combined direct and indirect effect of weather parameters on the incidence of MYMIV on blckgram during *Kharif*, 2015

| Abiotic factors | Temperature (°C) | | Relative humidity (%) | | Wind speed (km/hr) | Sun-shine (hrs) | Rainfall (mm) | Rainy days | Correla-tion r-values |
|---|---|---|---|---|---|---|---|---|---|
| | Max. | Mini. | Morning | Evening | | | | | |
| Temp (Max.) | (0.21790) | 0.0027 | -0.0249 | 0.2049 | -0.1195 | -0.0182 | 0.3580 | 0.0088 | 0.6298* |
| Temp (Min.) | -0.0134 | (-0.0437) | -0.1200 | -0.0409 | 0.0184 | 0.0069 | -0.0720 | -0.0044 | -0.2691 |
| RH% (Morn.) | -0.0106 | 0.0103 | (0.5108) | -0.1061 | 0.0055 | 0.0075 | -0.1615 | -0.0101 | 0.2458 |
| RH% (Even.) | -0.1789 | -0.0072 | 0.2171 | (-0.2496) | 0.0901 | 0.0253 | -0.3711 | -0.0161 | -0.4903 |
| Wind speed (km $hr^{-1}$) | -0.1618 | -0.0050 | 0.0175 | -0.1398 | (0.1609) | 0.0055 | -0.3801 | -0.0068 | -0.5096 |
| Sunshine (hrs) | 0.1137 | 0.0086 | -0.1095 | 0.1809 | -0.0254 | (-0.0349) | 0.1724 | 0.0109 | 0.3167 |
| Rainfall (mm) | -0.1564 | -0.0063 | 0.1654 | -0.1857 | 0.1226 | 0.0121 | (-0.4988) | -0.0149 | -0.5621 |
| Rainy days | -0.0949 | -0.0094 | 0.2534 | -0.1974 | 0.0541 | 0.0187 | -0.3665 | (-0.0203) | -0.3624 |

Residual: 0.4084, The values in parenthesis are denote the direct effect of abiotic factors on incidence of MYMIV; *=Significant at ($p$=0.05); **=Significant at ($p$=0.01) level; r=correlation coefficients of MYMIV with independent variables

The maximum temperature displayed positive (r=0.6298) association with MYMIV incidence. The positive indirect effect of maximum temperature was recorded via rainfall (0.3580) evening relative humidity (0.2049) rainy days (0.0088) and minimum temperature (0.0027) whereas negative impact via wind speed (-0.1195), minimum temperature (-0.0437), morning relative humidity (-0.0249) and sunshine hours (-0.0182), respectively. The direct contribution of wind speed was exhibited positive (0.2179) association on the incidence of yellow mosaic disease. The positive indirect effect of wind speed was recorded via morning relative humidity (0.0175) and sunshine hours (0.0055), respectively, whereas, indirect negative effect was obtained via rainfall (-0.3801) followed by maximum temperature (-0.1618) evening relative humidity (-0.1398) rainy days (-0.0068) and minimum temperature (-0.0050). The direct contribution of rainfall was recorded negative (-0.4988) on the incidence of MYMIV disease. The positive indirect effect of rainfall was obtained via morning relative humidity (0.1654), wind speed (0.1226) and sunshine hours (0.0121), respectively, whereas, indirect negative effect was recorded via evening relative humidity (-0.1857) followed by maximum temperature, rainy days and minimum temperature, respectively.

## 4. Conclusion

Favourable environmental conditions were found to be responsible for increasing the whitefly population which further tend to very efficiently played role in transmission of yellow mosaic disease in blackgram. Maximum temperature was exhibited significant role for the build-up of whitefly population and incidence of mungbean yellow mosaic India virus (MYMIV) disease in blackgram. Commencement of erratic rainfall which cause dry spell in agro-ecosystem was also responsible for disease and oscillation of whitefly population during the *kharif* season 2015.

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