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# Epidemiology of Mungbean Yellow Mosaic Virus (MYMV) in Relation to Whitefly Dynamics and Weather Parameters

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## A B S T R A C T

*Mungbean yellow mosaic virus* (MYMV) causes yellow mosaic disease in pulses. Which is most serious disease in greengram, blackgram and many pulses growing areas of North Eastern Karnataka region. The reasons for its higher incidence can be known by studying its epidemiological factors. Hence, the study was carried on epidemiology of MYMV. Epidemiological investigations involve study of weather factors, pathogen, its vectors if any, and host factors. In the present study, epidemiology of MYMV vector whitefly was investigated with weather factors like minimum temperature ($^0$c), maximum temperature ($^0$c), rainfall (mm), minimum relative humidity (%), maximum relative humidity (%) wind speed (Km/h) and sunshine (hours) recorded daily at MARS, Raichur. In the present study, whitefly population was greatly influenced by environmental factors which prevailed during entire observation period of one year stating from 22$^{nd}$ SMW of 2016 to 21$^{st}$ SMW of 2017. The least whitefly population was observed during 40$^{th}$ SMW (16/trap) and 39$^{th}$ SMW (20/trap) when the weekly mean maximum temperature was 28.9$^0$C and 30.4 $^0$C, minimum temperature was 22.8 $^0$C to 22.2 $^0$C and total weekly rainfall was 60.8 mm for 4 days respectively. The highest number of whiteflies was noticed during 50$^{th}$ SMW (1456/trap) when maximum temperature was 29.7 $^0$C, minimum temperature was 16.7 $^0$C and rainfall of 8.2 mm. This indicates that decrease in whitefly population was mainly due to higher rainfall and lower minimum temperature, whereas, increase in whitefly population was due to higher maximum temperature and no rainfall. Correlation and regression analysis was done to know the relationship of weather parameters with whitefly population. Results revealed that, there was a negatively significant correlation between whitefly population and minimum temperature (r= -0.354) and positive significant correlation with maximum temperature (r= 0.250) was recorded. Correlation of whitefly with rainfall was negatively significant (r= -0.456) while other factors like relative humidity (minimum and maximum), sunshine hours and maximum wind speed showed nonsignificant correlation with whitefly population. Sunshine hours recorded shown positive relation with whitefly population (r= 0.631). Regression analysis showed that, all these weather factors were found to contribute up to 69.6 percent towards the whitefly population and obtained multiple regression

## Introduction

The virus is most destructive in Indian subcontinent and adjacent areas of South-East Asia causing 100 per cent yield losses. It causes severe disease and economic losses in mungbean by plummeting seed yield and quality (Kang *et al.,* 2005). The MYMV in India was first time reported by Nariani in 1960 from IARI (Indian Agricultural Research Institute), New Delhi fields with an incidence of 20-30 per cent. Several others reported the occurrence and severity of MYMV incidence from other parts of India, Sri Lanka, Pakistan, Bangladesh, New Guinea, Philippines and Thailand (Honda *et al.,* 1983; Chenulu and Verma, 1988; Malik and Bashir, 1992; Jones, 2003; Ahmad and Harwood, 1973). MYMV also infects mungbean, soybean, mothbean, cowpea, urdbean and few other leguminous hosts (Dhingra and Chenulu, 1985 and Qazi *et al.,* 2007). Crops infected at early stages suffer more with severe symptoms of mosaic, complete yellowing and puckering (Salam *et al.,* 2011). The virus also causes irregular green and yellow patches in older leaves and completes yellowing of younger leaves (Nene, 1973).

Infected plant produces fewer flowers and pods, pods remain small, contain few seeds which are often malformed, shriveled, discolored, affecting qualitatively and quantitatively (Dhingra and Chenulu, 1985). 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 genus Begomovirus has economically destructive and geographically the most wide spread viruses occurring throughout warmer parts of the world (Borah and Dasgupta, 2012). Begomovirus are consisting genomes of either one or two ssDNA genomes of ~2.8 kb. The two components makeup the genomes of bipartite begomoviruses are known as DNA-A and DNA-B (Mansoor *et al.,* 2003 and Jeske 2009).

The weather parameters play a vital role in survival and multiplication of vector 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 present investigation focused on study of epidemiology and vector dynamics in relation to weather parameters of MYMV.

## Materials and Methods

Epidemiological investigations involve study of environment, pathogen and its vectors if any and host factors. To study the epidemiology of MYMV, weather factors like minimum temperature ($^0$C), maximum temperature ($^0$C), rainfall (mm), relative humidity (%) wind speed (Km/h) and sunshine (hours) were recorded daily at MARS, Raichur and computed to weekly intervals before using for statistical analysis. The whitefly population was correlated with these weather factors using correlation analysis software SPSS 16.0.

For assessment of vector (white fly) population, yellow colour sticky traps (insect traps) of 33 × 22 cm size were used at weekly interval at fixed location at plots no 58 MARS, UAS, Raichur campus with GPS position 16.1157468 N Latitude and 77.1934397 E Longitude starting from 22$^{nd}$ Standard week (last week of May) 2016 to 21$^{st}$ Standard week 2017. The vectors trapped were counted using magnifying lens and recorded at weekly interval.

## Results and Discussion

In the present study, whitefly population was greatly influenced by environmental factors which prevailed during entire observation period of one year stating from 22$^{nd}$ SMW of 2016 to 21$^{st}$ SMW of 2017. Observations of weather parameters revealed higher whitefly population (170, 295 and 247/trap) during 22$^{nd}$, 23$^{rd}$ and 24$^{th}$ SMW when mungbean is usually sown in the study area. The maximum temperature in these weeks was 39.8, 33.6 and 35.3 $^{0}$C, minimum temperature was 26.4, 24.3 and 24.8$^{o}$C respectively (Table 1). The least whitefly population was observed during 40$^{th}$ SMW (16/trap) and 39$^{th}$ SMW (20/trap) when the weekly mean maximum temperature was 28.9 $^{0}$C and 30.4 $^{0}$C, minimum temperature was 22.8 $^{0}$C to 22.2 $^{0}$C and total weekly rainfall was 60.8 mm for 4 days respectively. The highest number of whiteflies were noticed during 50$^{th}$ SMW (1456/trap) when maximum temperature was 29.7 $^{0}$C, minimum temperature was 16.7 $^{0}$C and rainfall of 8.2 mm. On subsequent weeks of 51$^{st}$ SMW and 52$^{nd}$ SMW of 2016, vector population was 1386, 1394/trap respectively. This indicates that decrease in whitefly population was mainly due to higher rainfall and lower minimum temperature, whereas, increase in whitefly population was due to higher maximum temperature and no rainfall. When the correlation of whitefly population with weather parameters was studied using statistical analysis, there was a negatively significant correlation between whitefly population and minimum temperature (r= -0.354) and positive significant correlation with maximum temperature (r= 0.250) was recorded (Table 2). Correlation of whitefly with rainfall was negatively significant (r= -0.456) while other factors like relative humidity (minimum and maximum), sunshine hours and maximum wind speed showed non-significant correlation with whitefly population. Sunshine hours recorded shown positive relation with whitefly population (r= 0.631).

Regression analysis was carried out to know the relationships between whitefly population and weather parameters. The results revealed that whitefly population shares significantly positive relation with rainfall (1.587) where as other factors like minimum temperature (-45.512), maximum temperature (-8.937), maximum relative humidity (-15.348), minimum relative humidity (-16.407), sunshine hours (-32.828) and wind speed (-5.193) showed negatively significance. All these weather factors were found to contribute up to 69.6 per cent towards the whitefly population (Fig. 1). The multiple regression equation obtained by analysis was $Y= 3836.283 - 8.937X1 - 45.512X2 + 1.587X3 - 15.348X4 - 16.407X5 - 32.828X6 - 5.193X7$ (Table 3). Gupta *et al.,* (2009) from Madhya Pradesh reported maximum whitefly population during 37$^{th}$ SMW (*kharif* season) and their correlation analysis showed significant positive relation with minimum temperature and rainfall which is contradictory to our findings of negative relation between whitefly population and rainfall and positive relation with maximum temperature. It is mainly due to adoption of whitefly to the higher temperature in NEK region followed by suitable alternate hosts for their survival for minimum of 9 to 10 months across this tropical region.

**Table.1** Influence of weather parameters on whitefly population at weekly intervals during 2016-17

| Sl. No. | Weekly intervals | SMW | Number of whiteflies per trap | Max. Temp (°c) | Min. Temp (°c) | Rainfall (mm) | Rainy Day (No) | Max. RH (%) | Min. RH (%) | Sunshine hours | Wind Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 29/05/2016 | 22 | 170 | 39.8 | 26.4 | 27 | 2 | 74 | 34 | 6.7 | 14.5 |
| 2 | 06/06/2016 | 23 | 295 | 33.6 | 24.3 | 45.6 | 1 | 84 | 50 | 1.7 | 9.8 |
| 3 | 13/06/2016 | 24 | 247 | 35.3 | 24.8 | 0.5 | 0 | 79 | 45 | 3.6 | 15.9 |
| 4 | 20/06/2016 | 25 | 32 | 32.8 | 23.6 | 111.8 | 4 | 88 | 61 | 2.3 | 11.3 |
| 5 | 27/06/2016 | 26 | 35 | 31.8 | 23.7 | 24.2 | 1 | 86 | 58 | 1.1 | 15.1 |
| 6 | 04/07/2016 | 27 | 161 | 33.0 | 24.3 | 5.4 | 1 | 83 | 49 | 1.0 | 16.9 |
| 7 | 11/07/2016 | 28 | 152 | 32.3 | 23.8 | 8.4 | 1 | 81 | 62 | 1.6 | 19.2 |
| 8 | 18/07/2016 | 29 | 200 | 33.3 | 23.4 | 32.4 | 3 | 84 | 55 | 1.1 | 11.2 |
| 9 | 25/07/2016 | 30 | 52 | 30.3 | 23.0 | 26.8 | 4 | 92 | 68 | 0.0 | 8.6 |
| 10 | 01/08/2016 | 31 | 54 | 28.6 | 22.7 | 84.6 | 4 | 91 | 76 | 0.3 | 12.6 |
| 11 | 08/08/2016 | 32 | 89 | 32.3 | 22.8 | 2.4 | 0 | 87 | 51 | 6.6 | 15.3 |
| 12 | 15/08/2016 | 33 | 133 | 33.4 | 22.9 | 2 | 0 | 84 | 47 | 6.5 | 14.1 |
| 13 | 22/08/2016 | 34 | 102 | 33.9 | 22.8 | 12 | 1 | 86 | 45 | 6.6 | 10.8 |
| 14 | 29/08/2016 | 35 | 30 | 31.2 | 23.8 | 47.2 | 2 | 88 | 51 | 2.4 | 7.8 |
| 15 | 05/09/2016 | 36 | 58 | 30.9 | 22.3 | 16.5 | 2 | 87 | 57 | 5.3 | 8.0 |
| 16 | 12/09/2016 | 37 | 33 | 28.6 | 22.8 | 136.2 | 5 | 93 | 79 | 1.0 | 7.5 |
| 17 | 19/09/2016 | 38 | 31 | 28.5 | 22.2 | 79 | 4 | 92 | 63 | 1.4 | 9.3 |
| 18 | 26/09/2016 | 39 | 20 | 28.9 | 22.8 | 60.8 | 4 | 95 | 77 | 2.2 | 6.8 |
| 19 | 03/10/2016 | 40 | 16 | 30.4 | 22.4 | 5.2 | 1 | 90 | 62 | 7.5 | 5.9 |
| 20 | 10/10/2016 | 41 | 28 | 31.2 | 22.2 | 34 | 1 | 90 | 58 | 6.5 | 5.0 |
| 21 | 17/10/2016 | 42 | 58 | 31.6 | 18.1 | 0 | 0 | 80 | 41 | 7.5 | 5.0 |
| 22 | 24/10/2016 | 43 | 63 | 31.4 | 16.6 | 0 | 0 | 77 | 38 | 7.6 | 4.2 |
| 23 | 31/10/2016 | 44 | 86 | 31.6 | 20.2 | 0 | 0 | 86 | 48 | 6.7 | 5.1 |
| 24 | 07/11/2016 | 45 | 132 | 31.2 | 15.6 | 0 | 0 | 81 | 34 | 7.7 | 4.5 |
| 25 | 14/11/2016 | 46 | 193 | 30.9 | 18.1 | 0 | 0 | 88 | 43 | 6.0 | 4.9 |
| 26 | 21/11/2016 | 47 | 360 | 30.4 | 14.8 | 0 | 0 | 85 | 33 | 7.3 | 4.3 |
| 27 | 28/11/2016 | 48 | 890 | 31.4 | 13.5 | 0 | 0 | 76 | 30 | 6.7 | 3.8 |
| 28 | 05/12/2016 | 49 | 910 | 31.2 | 16.7 | 0 | 0 | 82 | 38 | 7.1 | 4.5 |
| 29 | 12/12/2016 | 50 | 1456 | 29.7 | 16.7 | 8.2 | 0 | 75 | 44 | 3.8 | 6.4 |
| 30 | 19/12/2016 | 51 | 1386 | 30.5 | 13.4 | 0 | 0 | 84 | 27 | 7.7 | 4.0 |
| 31 | 26/12/2016 | 52 | 1394 | 30.1 | 13.8 | 0 | 0 | 84 | 28 | 7.6 | 4.4 |
| 32 | 02/01/2017 | 1 | 1096 | 30.4 | 14.6 | 0 | 0 | 74 | 26 | 7.8 | 4.3 |
| 33 | 09/01/2017 | 2 | 998 | 30.4 | 14.7 | 0 | 0 | 76 | 37 | 8.2 | 6.2 |
| 34 | 16/01/2017 | 3 | 961 | 29.9 | 16.4 | 0 | 0 | 78 | 26 | 8.7 | 7.4 |
| 35 | 23/01/2017 | 4 | 996 | 31.0 | 17.9 | 0 | 0 | 78 | 32 | 8.3 | 7.4 |
| 36 | 30/01/2017 | 5 | 906 | 32.6 | 18.7 | 0 | 0 | 71 | 24 | 9.6 | 5.8 |
| 37 | 06/02/2017 | 6 | 996 | 33.1 | 19.7 | 0 | 0 | 56 | 24 | 9.8 | 6.5 |
| 38 | 13/02/2017 | 7 | 1021 | 31.9 | 19.0 | 0 | 0 | 67 | 27 | 10.0 | 8.6 |
| 39 | 20/02/2017 | 8 | 1211 | 36.5 | 20.0 | 0 | 0 | 57 | 14 | 10.2 | 4.8 |
| 40 | 27/02/2017 | 9 | 1080 | 35.7 | 19.1 | 0 | 0 | 54 | 14 | 10.0 | 8.0 |
| 41 | 06/03/2017 | 10 | 1105 | 37.1 | 21.9 | 0 | 0 | 41 | 17 | 8.6 | 6.1 |
| 42 | 13/03/2017 | 11 | 1093 | 34.9 | 22.5 | 30 | 1 | 63 | 29 | 8.2 | 6.9 |
| 43 | 20/03/2017 | 12 | 996 | 37.4 | 23.2 | 0 | 0 | 53 | 17 | 9.9 | 6.2 |
| 44 | 27/03/2017 | 13 | 1008 | 39.5 | 24.9 | 0 | 0 | 44 | 16 | 9.6 | 6.4 |
| 45 | 03/04/2017 | 14 | 1080 | 40.4 | 26.1 | 0 | 0 | 44 | 18 | 8.1 | 6.4 |
| 46 | 10/04/2017 | 15 | 1350 | 40.8 | 25.3 | 0 | 0 | 58 | 26 | 8.6 | 7.1 |
| 47 | 17/04/2017 | 16 | 862 | 41.4 | 27.2 | 0 | 0 | 68 | 28 | 7.9 | 8.3 |
| 48 | 24/04/2017 | 17 | 637 | 40.9 | 25.7 | 7.2 | 1 | 41 | 22 | 9.0 | 8.8 |
| 49 | 01/05/2017 | 18 | 672 | 39.6 | 26.7 | 0 | 0 | 49 | 22 | 9.8 | 7.5 |
| 50 | 08/05/2017 | 19 | 583 | 39.9 | 27.0 | 0 | 0 | 59 | 25 | 7.8 | 9.2 |
| 51 | 15/05/2017 | 20 | 341 | 39.4 | 27.0 | 8.1 | 1 | 71 | 26 | 6.1 | 12.2 |
| 52 | 22/05/2017 | 21 | 244 | 42.3 | 29.5 | 0 | 0 | 59 | 20 | 6.1 | 13.4 |

**Table.2** Correlation analysis between the whitefly population and weather factors during 2016-17 at MARS, Raichur

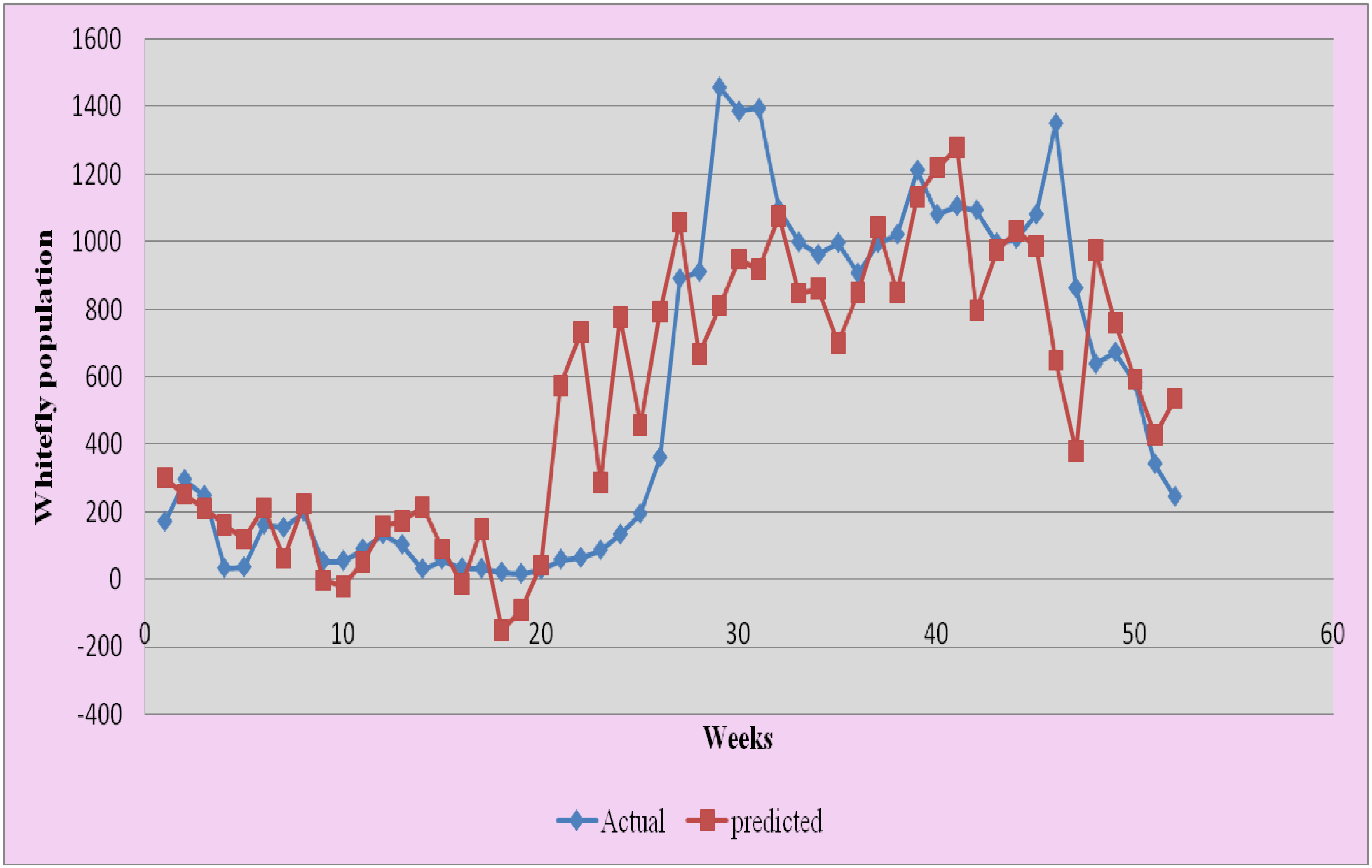
| Pearson correlation | Correlations "r" | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Whitefly population | Maximum temperatu re | Minimum temperature | Rainfall | Maximum Relative humidity | Minimum Relative humidity | Sunshine hours | Wind Speed |
| Whitefly population | 1 | | | | | | | |
| Maximum temperature | .293* | 1 | | | | | | |
| Minimum temperature | -.345* | .635** | 1 | | | | | |
| Rainfall | -.466** | -.326* | .261 | 1 | | | | |
| Maximum Relative humidity | -.635** | -.781** | -.236 | .447** | 1 | | | |
| Minimum Relative humidity | -.761** | -.608** | .163 | .696** | .817** | 1 | | |
| Sunshine hours | .632** | .434** | -.255 | -.670** | -.672** | -.855** | 1 | |
| Wind Speed | -.444** | .152 | .585** | .201 | .180 | .373** | -.522** | 1 |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | | | |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | | | |

**Table.3** ANOVA for regression analysis of rainfall, temperature, relative humidity, sunshine hours and wind speed in relation to Whitefly population during 2016-17

| ANOVA[b] | | | | | |
|---|---|---|---|---|---|
| Model | Sum of Squares | df | Mean Square | F | Sig. |
| Regression | 8329881.101 | 7 | 1189983.014 | 14.041 | .000[a] |
| Residual | 3644254.075 | 43 | 84750.095 | | |
| R | .834[a] | | | | |
| R square | .696 | | | | |
| Multiple regression equation | **Y=3836.283-8.937X1-45.512X2+1.587X3-15.348X4-16.407X5-32.828X6-5.193X7** | | | | |
| a. Predictors: (Constant), Wind speed, Maximum temperature, Rainfall, Sunshine hours, Minimum relative humidity, Minimum temperature, Maximum relative humidity | | | | | |
| b. Dependent Variable: WFP | | | | | |

X1- Maximum temperature; X2- Minimum temperature; X3- Rainfall; X4- Maximum relative humidity; X5- Minimum relative humidity; X6- Sunshine hours; X7- Wind speed

**Fig.1** Actual and predicted weekly distribution of whitefly population during 2016-17 at MARS, UAS, Raichur



Regression analysis revealed 98 per cent contribution of weather variables on whitefly population. Sharma *et al.*, (2013) says that positive correlation between temperature can be attributed to enhanced rate of development and reproduction of whitefly and its ovipositional activity which will be maximum at 33 to 37 $^{0}$C. The negative association between whitefly, rainfall and relative humidity is due to the disturbance of adults by rains particularly when heavy showers and strong winds occur. Cooler weather and high relative humidity are detrimental to whitefly population because whitefly population occurs when maximum temperature ranged between 34 to 36 $^{0}$c, minimum temperature of 24 to 26 $^{0}$c, relative humidity (morning) of 85 to 90 per cent, relative humidity (evening) of 30 to 40 per cent and sunshine duration of 8 to 8.5hours (Sharma *et al.,* 2014). But any increase in relative humidity with cloudy weather throughout the day is going to affect the vector survival. In another study conducted by Marabi *et al.*, (2017), they recorded the whitefly population from 29$^{th}$ to 41$^{st}$ SMW and noticed least whitefly population during 29$^{th}$ SMW and maximum population during 37$^{th}$ SMW. Their correlation coefficient expressed positive significance between whitefly and maximum temperature and sunshine hours. Whereas negative correlation of whitefly population with wind speed and rainfall. Statistically significant values indicate occurrence of whitefly population as its outbreak due to prevailing ecological conditions and impact of climate change, thus our study also concludes that whitefly population is directly responsible for spread of the disease and is positively correlated with maximum temperature and negatively with rainfall.

Epidemiology study can be concluded by correlating weather parameters with whitefly population and results shows positive significant correlation of whitefly population with maximum temperature and negative correlation with minimum temperature and rainfall. It indicates that, increase in maximum temperature increases whitefly population and increase in minimum temperature and rainfall decreases in whitefly population. Thus by understanding the epidemiology one can effectively manage disease and it also helps to develop a prediction model for management of whitefly.

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