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# Influence of weather parameters on population dynamics of whitefly (*Bemisia tabaci* Genn.) in soybean [*Glycine max* (L.) Merrill]

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## Abstract
First appearance of whitefly on soybean was observed on 7 days old crop (DOC) and was available up to 105 DOC. The overall mean population of whitefly recorded was 2.45 adult whiteflies/plant during the *Rabi* season. Whitefly population attained its first peak on 35 DOC *i.e.,* $5^{th}$ SMW and the second peak was observed on 63 DOC *i.e.,* $9^{th}$ SMW, whereas third peak was recorded on 91 DOC *i.e.,* $13^{th}$ SMW, Correlation studies revealed that the maximum and minimum temperature, morning vapour pressure and evaporation exhibited significant positive association with whitefly population, while wind speed, sunshine hours, evening vapour pressure and rainfall exhibited positive correlation, while morning RH and evening RH expressed negative correlation with whitefly population, but statistically found to be non-significant. Multiple regression analysis with significant weather parameters showed that independent variables were responsible >74% variation in the whitefly population. Path analysis revealed that maximum temperature had highest positive direct effect on whitefly population followed by evening RH, morning RH, wind speed and rainfall, respectively. However, morning vapour pressure had the maximum negative direct effect followed by evening vapour pressure, evaporation, sunshine and minimum temperature on whitefly population, respectively. Higher $R^2$ value and low residual effect were obtained from multiple regression with significant independent factors and path analysis, respectively indicated that the weather parameters selected for the study were appropriate and were responsible for almost 78% variation in the whitefly population.

**Keywords:** Population dynamics, weather parameters, *Bemisia tabaci*, *Glycine max*

## Introduction
Soybean [*Glycine max* (L.) Merrill] is a most important seed legume crop which is grown in across the world. India contributes 43% and 25% to the total oilseeds and global vegetable oil production, respectively in the global perspective of soybean. It contains rich and cheapest source of nutrients *viz;* protein, vitamins, fats, carbohydrates and other essential compounds [1]. Madhya Pradesh also well known for "Soya State" as it occupies more than 67% area and 56% production in the country. Since last few decades its productivity has significantly declined due to incidence of insect pests, diseases and unfavorable climatic conditions. Among the insect pests, about 150 different insect pests have been reported on soybean in various regions of Madhya Pradesh [2]. Of them whitefly, *Bemisia tabaci* Gennadius has been found to be the major devastating pest which directly suck the phloem sap from the leaves and secretes honey dew which causes sooty mould disease. Indirectly, it acts as a vector of yellow mosaic disease (YMD) in soybean [3]. YMD of soybean has been characterized as mungbean yellow mosaic India virus (MYMIV) which is found to be most prevalent in Madhya Pradesh (Central India) [4-6]. It cause about 85–100% yield loss in soybean depending upon the susceptibility of the crop, time of infection, vector population and favorable abiotic factors [3]. In India, the annual yield losses caused by YMD in legume crops including soybean, blackgram and greengram have been recorded about 300 million USD per year [7]. To manage the whitefly, there are many chemical insecticides are used injudiciously which cause development of resistance in insects, pest resurgence and detrimental to beneficial insects and environmental hazards. Similarly, weather factors are also play vital role in population dynamics of insect pests. Thus, keeping the above facts, the present study was carried out in *Rabi* season to know the effect of weather factors on population dynamics of whitefly which would be useful to develop management strategies in soybean ecosystem.'

## Materials and Methods

An experimental field was laid out to study the population dynamics of whitefly in soybean crop (variety JS-335) and their relation to weather parameters during the *Rabi* season 2015-16 at Breeding seed Production Unit, Live Stock Farm, JNKVV, Jabalpur (MP), India. Soybean crop was grown notably as a test crop in *Rabi* season only for experimental purpose to assess the seasonal fluctuations of whitefly population.

## Experimental layout

An experimental plot size was kept in one acre area with maintaining the spacing of 45x10cm between the rows and plants. All the recommended agronomical practices like fertilizer (N:P:K @ 40:60:40 kg/ha) and weeding operations were adopted except the insecticidal treatments.

## Observation recorded

Observations on adult whitefly population were recorded twice in a standard meteorological week (SMW) from randomly selected 10 plants with the help of cage. Cage was prepared with transparent fiber cylinder of different height and diameter *viz;* 20x15, 25x20, 35x30 cm, respectively and used them accordingly to the plant height. The inner walls of the cylinders were coated with black paint to induce darkness and one end of cylinder was left open while the other end was closed with a transparent glass and was fixed in such a manner that no space was left for escape of the adult whitefly from inside the cage. To record the number of adult whitefly population the cage was placed on an individual plant carefully without disturbing it. The adult whitefly congregated on the inner surface of the glass pane due to its attraction behavior towards the light which enabled to count them easily. The counting of whitefly was initiated immediately after germination and was continued till the availability of the insect or maturity of the crop, whichever was earlier.

## Statistical analysis

The statistical analysis of data was done to determine the relationship in terms of correlation and regression between the whitefly population and weather parameters *viz*., maximum and minimum temperature, morning and evening relative humidity, wind speed, sunshine, morning and evening vapor pressure, evaporation and rainfall [8]. Further, path analysis was also done to better understand the direct and indirect effect of weather parameters on influence of whitefly population following the procedure of Gomez and Gomez [9].

## Results and Discussion

### Population dynamics of whitefly (*Bemisia tabaci)*

First appearance of whitefly on soybean was observed on 7 days old crop (DOC) [1st January, 2016 *i.e.,* 1st SMW (01/01/2016 to 07/01/2016)]. The number of adult whitefly was worked out as weekly average per plant or cage and the data are presented in Table 1. It is evident that the whitefly population was appeared on 7 DOC (1st SMW) and was available for 99 days *i.e.,* 105 DOC (15th SMW, 09/04/2016 to 15/04/2016). Present findings are in conformity with the findings of Barfa [10] and Chandra kumar *et al.* [11], as they also reported its first incidence during 3rd and 4th week of December on tomato and brinjal, respectively. In the present study whitefly was available upto the crop maturity stage which confirmed the findings of Akbar *et al.* [12] and Barfa [10], as they also reported that whitefly was available upto the crop maturity stage in *Rabi* soybean and tomato, respectively.

The overall mean population of whitefly recorded during the *Rabi* season was 2.45 adult whiteflies/plant. The present findings are in agreement with the findings of Patil [13], as he also reported 2.12 whiteflies/leaf on *Rabi* mungbean. However the present findings are partially in accordance with the findings of Akbar *et al.* and Biswas [12, 14]. They reported that the mean whitefly population on *Rabi* soybean was of 0.21/leaf and 7.75/plant, respectively. The difference in the whitefly population may be attributed to the variation in the date of sowing, maturity period of the crop and the susceptibility status of the variety included in the studies. Whitefly population attained its first peak (3.00 adult whiteflies/plant) on 35 DOC *i.e.,* 5th SMW (29/01/2016 to 04/02/2016), when maximum and minimum temperature was 27.70 and 9.10$^0$C, respectively, whereas morning RH and evening RH were 92.00 and 35.00%, respectively. Further, wind speed, sunshine, morning vapour pressure, evening vapour pressure and evaporation were 2.80 km/hr, 9.30 hrs, 8.90 mm, 9.30 mm and 2.50 mm, respectively. There was no rainfall received during this week. Second peak (3.80 adult whiteflies/plant) was observed on 63 DOC *i.e.,* 9th SMW (26/02/2016 to 04/03/2016), when the maximum and minimum temperature was 30.50 and 13.40$^0$C, respectively, whereas morning RH and evening RH were 85.00 and 34.00%, respectively. Further, wind speed, sunshine, morning vapour pressure and evening vapour pressure and evaporation were 3.30 km/hr, 8.50 hrs, 10.70 mm, 11.00 mm and 2.80 mm, respectively. However, no rainfall received during this week.

Third peak (4.60 adult whiteflies/plant) was recorded on 91 DOC *i.e.,* 13th SMW (26/03/2016 to 01/04/2016), when the maximum and minimum temperature was 35.80 and 16.40$^0$C, respectively, whereas morning RH and evening RH were 78.00 and 17.00%, respectively. Further, wind speed, sunshine, morning vapour pressure, evening vapour pressure and evaporation were 2.30 km/hr, 10.00 hrs, 12.90 mm, 7.10 mm and 4.70 mm, respectively. Rainfall received during this week was 8.00 mm. The present findings are in partial agreement with the findings of Patil [13], Panduranga *et al.* [15] and Gopalaswamy *et al.* [16], as they reported that whitefly attained a single peak on 51 DOC (2.12 whiteflies/plant) on *Rabi* soybean, 40 DOC (2nd week of January) (9.55 whiteflies/5 plants) and 45 DOC (and 33.33 whiteflies/5 plants) on *Rabi* mungbean and urdbean, respectively**.** Similarly, Chaudhuri *et al.* [17] and Barfa [10] reported that whitefly attained peak during first and second week of February on tomato, respectively. The present findings indicated that high temperature, coupled with low rainfall were found to be favourable for the build-up of the pest population on *Rabi* soybean [14].

**Table 1:** Correlation coefficient between the weather parameters and influence of whitefly population during *Rabi* season of soybean crop

| SMW | Whitefly/plant | Weather parameters | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | $X_7$ | $X_8$ | $X_9$ | $X_{10}$ |
| 1 | 0.20 | 27.50 | 7.90 | 88.00 | 27.00 | 1.80 | 8.50 | 8.00 | 7.40 | 1.80 | 0.50 |
| 2 | 0.30 | 26.70 | 8.00 | 81.00 | 32.00 | 1.70 | 7.70 | 7.60 | 8.00 | 2.10 | 0.50 |
| 3 | 0.70 | 22.20 | 11.50 | 92.00 | 65.00 | 3.50 | 5.40 | 10.60 | 11.80 | 1.30 | 12.70 |
| 4 | 0.10 | 23.30 | 4.20 | 94.00 | 29.00 | 2.30 | 9.60 | 6.40 | 6.70 | 1.90 | 0.50 |
| 5 | 3.00 | 27.70 | 9.10 | 92.00 | 35.00 | 2.80 | 9.30 | 8.90 | 9.30 | 2.50 | 0.50 |
| 6 | 2.80 | 26.40 | 8.40 | 84.00 | 34.00 | 3.20 | 8.30 | 8.10 | 8.90 | 2.80 | 0.50 |
| 7 | 2.90 | 28.50 | 11.30 | 88.00 | 40.00 | 3.30 | 6.90 | 10.50 | 11.90 | 2.60 | 0.50 |
| 8 | 3.00 | 30.20 | 11.80 | 90.00 | 32.00 | 2.70 | 7.40 | 11.00 | 11.50 | 3.00 | 0.50 |
| 9 | 3.80 | 30.50 | 13.40 | 85.00 | 34.00 | 3.30 | 8.50 | 10.70 | 11.00 | 2.80 | 0.50 |
| 10 | 3.00 | 31.90 | 17.00 | 88.00 | 47.00 | 3.50 | 8.00 | 14.10 | 15.30 | 3.40 | 30.10 |
| 11 | 2.10 | 30.90 | 15.00 | 85.00 | 37.00 | 4.10 | 8.70 | 13.00 | 11.20 | 3.90 | 7.00 |
| 12 | 4.50 | 34.50 | 14.10 | 67.00 | 18.00 | 3.30 | 10.20 | 10.50 | 7.30 | 5.30 | 0.50 |
| 13 | 4.60 | 35.80 | 16.40 | 78.00 | 17.00 | 2.30 | 10.00 | 12.90 | 7.10 | 4.70 | 8.50 |
| 14 | 3.20 | 39.10 | 20.10 | 62.00 | 18.17 | 3.00 | 9.10 | 13.60 | 9.10 | 6.50 | 0.50 |
| 15 | 2.60 | 38.90 | 19.60 | 56.00 | 12.00 | 3.80 | 10.20 | 12.20 | 6.50 | 7.70 | 0.50 |
| Correlation (r) | | 0.66** | 0.61* | -0.40 | -0.36 | 0.39 | 0.39 | 0.59* | 0.13 | 0.55* | 0.06 |

*Significant (P=0.05), $X_1$-Max. T. ($^0$C), $X_2$-Min.T. ($^0$C), $X_3$-Morn. RH%, $X_4$-Even. RH%, $X_5$-Wind speed (km/h), $X_6$- Sunshine (hrs), $X_7$-Morn. vapour pressure (mm), $X_8$- Even. vapour pressure (mm), $X_9$ -Evaporation (mm) and $X_{10}$-Rainfall (mm)

**Correlation studies**

Correlation studies revealed that the maximum and minimum temperature, morning vapour pressure and evaporation exhibited positive association (r= 0.66, 0.61, 0.59 and 0.55, respectively) with whitefly population (Table 1).

The regression equations being:

$\hat{Y}$ = - 3.41 + 0.19x ($R^2$ = 0.44)

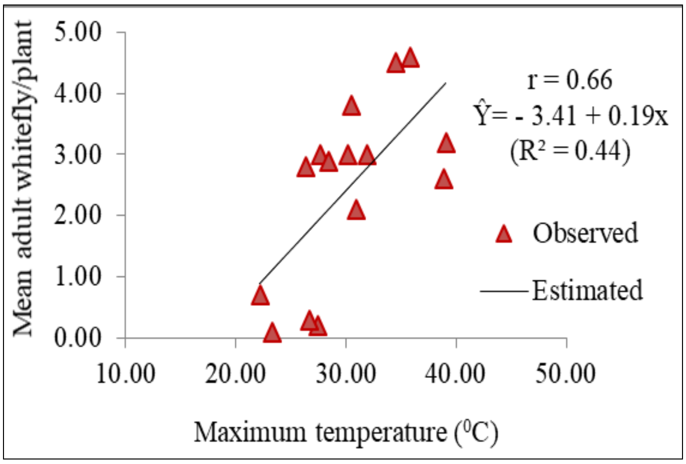
$\hat{Y}$ = - 0.02 + 0.20x ($R^2$ = 0.37)

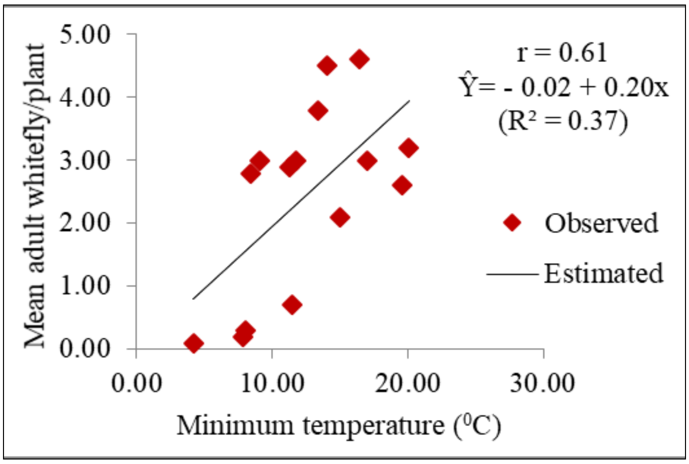
$\hat{Y}$ = - 1.49 + 0.37x ($R^2$ = 0.35)

$\hat{Y}$ = 0.89 + 0.45x ($R^2$ = 0.30)

The above equation, express that with every unit increase in maximum and minimum temperature, morning vapour pressure and evaporation, there was an increase of 0.19, 0.20, 0.37 and 0.45 adult whitefly/plant, respectively (Fig.1). Correlation studies further revealed that wind speed, sunshine, evening vapour pressure and rainfall exhibited positive correlation (r= 0.39, 0.39, 0.13 and 0.06, respectively) with whitefly population, but statistically found to be non-significant. While morning RH and evening RH exhibited negative correlation (r= -0.40 and -0.36, respectively) with whitefly population, but statistically non-significant. Similar findings have been reported by Patil [13] on mungbean. However, it contradicts the findings of Chandrakumar *et al.* [11] and Naik *et al.* [18] on brinjal and Subba *et al.* [19] on tomato, as they reported that the maximum temperature had negative association with whitefly population.

Further, minimum temperature exhibited significant positive impact on whitefly population are in conformity with the findings of Naik *et al.* [18], as they also reported that minimum temperature had positive association with whitefly population on brinjal. On the contrary, Subba *et al.* [19] reported that minimum temperature had shown negative correlation with whitefly population on tomato, but statistically non-significant. Computation of multiple regression analysis with significant weather parameters showed that independent variables were responsible for about 74% ($R^2$ value) variation in the whitefly population on *Rabi* soybean crop.



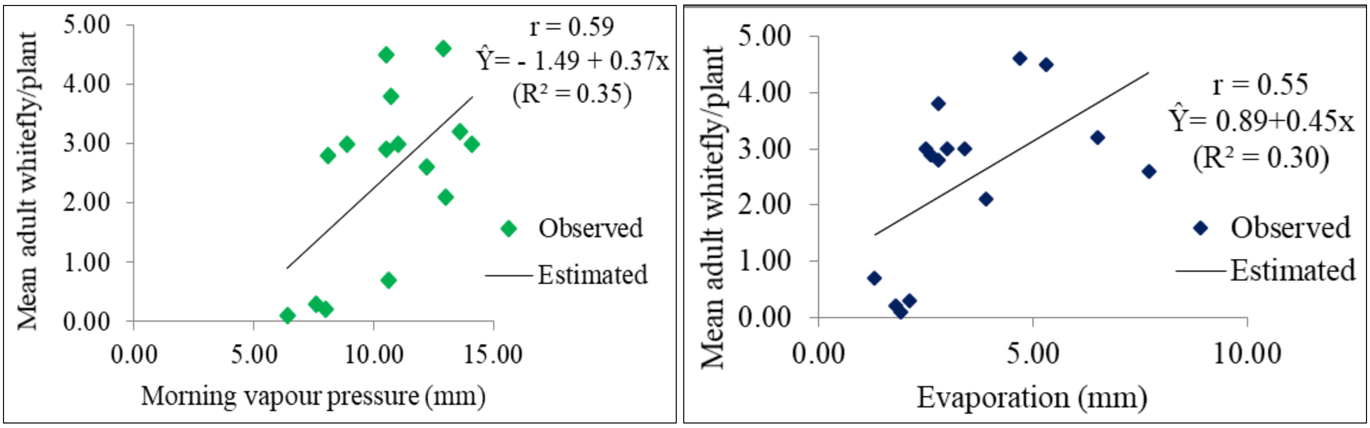



**Fig 1:** Regression of whitefly infesting *Rabi* soybean on maximum temperature, minimum temperature, morning vapour pressure and evaporation.

**Path coefficient analysis**

Path coefficient analysis revealed that maximum temperature had highest positive direct effect (6.6861) on whitefly population followed by evening RH (1.9791), morning RH (1.9618), wind speed (1.0789) and rainfall (0.3837), respectively (Table 2). Present finding is the conformity with the finding of Borad [20] who also found positive effect of maximum temperature on whitefly population. However, morning vapour pressure had the maximum negative direct effect (-2.4967) followed by evening vapour pressure (-1.2277), evaporation (-0.9436), sunshine (-0.5556) and minimum temperature (-0.5011) on whitefly population, respectively. The maximum temperature had the highest positive indirect effect on whitefly population through wind speed (0.3004) followed by evening vapour pressure (0.2093) while, it had maximum negative indirect effect on whitefly population via morning vapour pressure (-1.8043) followed by morning RH (-1.6642), evening RH (-1.4018), evaporation (-0.8867), minimum temperature (-0.4402), sunshine (-0.3329) and rainfall (-0.0014), respectively. Evening RH had maximum positive indirect effect on whitefly population via morning RH (1.3972), evaporation (0.6683), sunshine (0.4772), wind speed (0.2535), rainfall (0.1961), morning vapour pressure (0.1563) and minimum temperature (0.1524), while it exerted maximum negative indirect effect through maximum temperature (-4.7357) followed by evening vapour pressure (-0.9019), respectively. Morning RH exhibited positive indirect effect through evening RH (1.4095) on whitefly population followed by morning vapour pressure (1.0741), evaporation (0.8752), minimum temperature (0.3568), sunshine (0.3067) and rainfall (0.0843), while it had maximum negative indirect effect via maximum temperature (-5.6718) followed by evening vapour pressure (-0.5408) and wind speed (-0.2557), respectively. Morning vapour pressure had the highest negative direct effect on whitefly population, had indirect positive effect through maximum temperature (4.8320) followed by wind speed (0.6389) and rainfall (0.2025), respectively, while it had the highest negative indirect effect via morning RH (-0.8440) followed by evaporation (-0.5877), evening vapour pressure (-0.5541), minimum temperature (-0.4674), evening RH (-0.1239) and sunshine (-0.0406), respectively. Higher $R^2$ (0.783) value and low residual effect (0.5321) were obtained from multiple regression with significant independent factors and path analysis, respectively indicated that the weather parameters selected for the study were appropriate and were responsible for almost 78% variation in the whitefly population.

**Table 2:** Path analysis of weather parameters on adult whitefly population infesting *Rabi* soybean

| Weather factors | Max. T. (°C) | Min. T. (°C) | Morn. RH (%) | Even. RH (%) | Wind speed (km/hr) | Sunshine (hrs) | Morn. VP (mm) | Even. VP (mm) | Evaporation (mm) | Rainfall (mm) | " r " |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Max. T. (°C) | 6.6861 | -0.4402 | -1.6642 | -1.4018 | 0.3004 | -0.3329 | -1.8043 | 0.2093 | -0.8867 | -0.0014 | 0.66** |
| Min. T. (°C) | 5.8737 | -0.5011 | -1.3968 | -0.6018 | 0.6008 | -0.1423 | -2.3286 | -0.2333 | -0.7826 | 0.1233 | 0.61* |
| Morn. RH (%) | -5.6718 | 0.3568 | 1.9618 | 1.4095 | -0.2557 | 0.3067 | 1.0741 | -0.5408 | 0.8752 | 0.0843 | -0.40 |
| Even. RH (%) | -4.7357 | 0.1524 | 1.3972 | 1.9791 | 0.2535 | 0.4772 | 0.1563 | -0.9019 | 0.6683 | 0.1961 | -0.36 |
| Wind speed (km/hr) | 1.8614 | -0.2791 | -0.4650 | 0.4651 | 1.0789 | 0.0355 | -1.4785 | -0.5705 | -0.3708 | 0.1154 | 0.39 |
| Sunshine (hrs) | 4.0063 | -0.1283 | -1.0827 | -1.6996 | -0.0689 | -0.5556 | -0.1823 | 0.7987 | -0.5968 | -0.1032 | 0.39 |
| Morn. VP (mm) | 4.8320 | -0.4674 | -0.8440 | -0.1239 | 0.6389 | -0.0406 | -2.4967 | -0.5541 | -0.5877 | 0.2025 | 0.59* |
| Even. VP (mm) | -1.1400 | -0.0952 | 0.8642 | 1.4538 | 0.5014 | 0.3615 | -1.1267 | -1.2277 | 0.2792 | 0.2551 | 0.13 |
| Evaporation (mm) | 6.2829 | -0.4156 | -1.8196 | -1.4016 | 0.4240 | -0.3514 | -1.5549 | 0.3633 | -0.9436 | -0.0312 | 0.55* |
| Rainfall (mm) | -0.0241 | -0.1610 | 0.4310 | 1.0115 | 0.3246 | 0.1494 | -1.3180 | -0.8164 | 0.0766 | 0.3837 | 0.06 |

Residual effect = 0.5321, *= Significant at 5%, ** = Significant at 1%, “r” = Correlation coefficients of adult whitefly with weather factors, Diagonal values (bold) indicated direct effects.

**Conclusion**

Among the biotic factors, whitefly (*B. tabaci*) is one of the major constraints in soybean production which cause damage the soybean by sucking phloem sap and transmitting the

YMD. The seasonal incidence of whitefly has dynamically influenced by weather factors (abiotic) during the season. Data collection on seasonal incidence of whitefly and YMD in relation to prevalent weather parameters is compulsory for developing weather based forecasting model in IPM system. Thus, sufficient understating about the seasonal activity of whitefly, incidence of YMD is necessary for formulating pest management strategies which should be socially acceptable and economically feasible in a particular region.

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