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Research Article

Influence of Meteorological Parameters on Mungbean Pests in Northern India

SARABJOT KAUR SANDHU* AND SHUBHAM ANAND

Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana, Punjab

ABSTRACT

The effect of meteorological parameters on incidence and severity of whitefly and mosaic virus in moong crop was studied using weather data of years 2015 to 2019. The meteorological parameters affecting whitefly population and yellow vein mosaic disease severity in mungbean crop were identified. The maximum temperature and rainfall exhibited positive correlation with disease severity while evening relative humidity and sunshine hours exhibited negative correlation with disease severity. The minimum temperature showed positive correlation with whitefly population. The favourable maximum and minimum temperature for whitefly abundance was 33-36^{o}C and 24-27^{o}C, respectively. Similarly for yellow mosaic disease severity, favourable maximum and minimum temperature was 32.5-39^{o}C and 23-28^{o}C, respectively. Hot and humid conditions are conducive for disease development and whitefly abundance. The crop-weather-pest-calendar for mungbean was prepared on the basis of 5-year data. This calendar can be used in agro-advisory for giving forewarning of whitefly and yellow vein mosaic disease to the farmers.

Key words: Mungbean, Yellow vein mosaic, Whitefly, Meteorological parameters, Principal component analysis, Crop weather pest calendar

Introduction

Crop diversification is a pertinent possibility to revitalize green revolution in Northern India. To adopt diversification, pulses can be best alternative to standard rice-wheat cropping rotation (Ludhar *et al.,* 2019). Mungbean, also known as green gram or *Vigna radiata* (L.) Wilczek (syn: *Phaseolus aureus* Roxb.), is a significant pulse crop of Fabaceae family and a significant source of dietary proteins with high biological value, energy, and vitamins and minerals (Shahid and Khan, 2016). Recently, development of some short duration varieties which are having simultaneous maturity with decreased photo-sensitivity and improved yield offers a great scope for their inclusion as a catch crop in rice-wheat or rice-potato cropping system in Punjab. However, the area under mungbean is considerably less i.e. 2.6 thousand hectares producing 2.5 thousand tonnes during 2020-21 in Punjab (Anonymous, 2022).

One of the main bottlenecks in mungbean production is yellow mosaic disease (YMD) (Ambarish *et al.,* 2023). It can cause yield losses up to 10-100% (Kumar *et al.,* 2014). In North India, the higher incidence of YMD is observed during *kharif* season. Management of yellow mosaic disease through development of host resistance has not been successful because of highly variable nature of pathogen and dearth of trustworthy screening methods. Assessment of enormous mungbean germplasms at hot spot locations has resulted in identification of few YMD resistant mungbean lines

*Corresponding author,
Email: skchahal@pau.edu

like ML 818, ML 1349, IPM 02-14 and ML 1628 (Parihar *et al.,* 2017; Nair *et al.,* 2017).

Yellow mosaic disease is caused by different strains and variants of two distinct *Begmovirus* species viz. *Mungbean yellow mosaic virus* (MYMV) and mungbean yellow mosaic India virus (MYMIV). The disease mostly appears as small, scattered yellow to golden yellow colour flecks on the infected trifoliate which consequently develop more severe on freshly developing leaves. The size of pods reduces, wrinkled and recurrently covers small young seeds (Nene, 1972). Once appeared, the disease spread in an alarming proportion causing significant yield losses. Amid the most recent decade, the development of disease has recorded noteworthy changes because of changing weather conditions in Punjab. Singh and Sandhu (2019) reported that maximum temperature had significant positive correlation with disease incidence. A significant negative correlation between disease incidence and weather parameters like minimum temperature, minimum relative humidity, total rainfall and sunshine hours was observed.

Begomovirus are primarily transmitted by whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae). The whitefly has been considered as one of the major insect of cotton, mungbean and some other pulses. The abundance of pests varies with prevalent weather conditions during crop season. The whitefly population increases when maximum/ minimum temperature is within the range of 32-37/ 21-29°C and maximum/minimum relative humidity is within range of 73-90/38-74 %. The light showers of rainfall help the whitefly growth but a heavy rainstorm of >35 mm decreases its population (Prabhjyot-Kaur *et al.,* 2020). Singh and Sandhu (2019) reported a positive correlation between whitefly population and weather parameters *viz.* maximum temperature, relative humidity (morning and evening) and sunshine hours. These results were in accordance with Patel and Mahatma (2016). A direct positive correlation of meteorological parameters vis-à-vis whitefly population and disease incidence was also reported by Singh and Sandhu (2019). Temperature and relative humidity are important meteorological parameters that affect whitefly population and hence development of disease. So understanding of relationships between different meteorological parameters and mungbean insect/disease can be utilized for timely management of pests in mungbean. Keeping all this in vision the present study was conducted to investigate the association between meteorological parameters viz-a-viz whitefly population and yellow vein mosaic disease severity.

Material and Methods

Experimental Site: The trial was conducted during at the Research Farm, Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana. The crop was sown continuously for five years i.e. 2015-2019. The mungbean variety PAU 911 was sown on 15th July of each year. The crop was grown as per recommendations of PAU package of practices for *kharif* crops.

Insect/Disease Data: Whitefly population was counted at weekly intervals from trifoliate leaves (upper, middle and lower leaves) of 10 randomly selected plants before 10 AM. Mean whitefly count per leaf was calculated. Mungbean yellow mosaic virus disease severity was observed on 10 randomly selected plants under different treatments and % disease severity was calculated on the basis of following formulae:

$$\text{Disease severity (\%)} = \frac{\text{No. of diseased plants}}{\text{Total no. of plants examined}} \times 100$$

Meteorological Data: To study the effect of meteorological parameters on whitefly population and yellow vein mosaic disease severity in mungbean crop, the weather data of years 2015 to 2019 were used. The weather data was collected from Agrometeorological Observatory, Punjab Agricultural University, Ludhiana. The agrometeorological observatory is situated at 30.898°N latitude and 75.800°E longitude and altitude of 247 m from mean sea level.

Statistical Analysis: The descriptive statistics of weather data prevailed during five years was conducted. The Correlation coefficients were calculated between whitefly/YMD severity data and different meteorological parameters *viz.*, temperature, relative humidity, sunshine hours. statistical analysis was done by using R software. On the basis of five year weather, insect and disease data crop-weather-pest calendar was developed.

Results and Discussion

Meteorological parameters, whitefly population and yellow mosaic virus disease severity

The descriptive statistics of studied parameters viz. weather during favourable insect/disease period is presented in Table 1. In this table, ranges of different meteorological parameters along with mean and standard deviation are presented for years under study. I-data for year 2015, II-data for year 2016, III-data for year 2017, IV-data for year 2018 and V-data for year 2019. The year 2015 recorded a temperature range of 31 to 35°C for the maximum and 20.5 to 27°C for the minimum during 31st to 40th SMW. In the morning, the relative humidity varied from 82 to 93 %, and in the evening, it varied from 47 to 74 %. A total rainfall of 165.6 mm was recorded throughout the duration. A range of 1.5 and 10.2 of

Table 1. Descriptive statistics of studied parameters for whitefly population and yellow vein mosaic disease severity

Parameter	Minimum	Maximum	Mean	Standard Deviation
Tmax(°C)-I	31	35	33.2	1.15
Tmax(°C)-II	32.2	34.5	33.67	0.90
Tmax(°C)-III	32	35	33.90	1.04
Tmax(°C)-IV	29.9	35.2	33.11	1.64
Tmax(°C)-V	30.2	34.9	33.13	1.84
Tmin(°C)-I	20.5	27	25.11	1.94
Tmin(°C)-II	24.7	27.3	25.7	0.94
Tmin(°C) -III	21	28	25.09	2.22
Tmin(°C) -IV	20.5	27.6	25.11	2.71
Tmin(°C) -V	20.5	27.9	25.59	2.24
RHm(%)-I	82	93	87	3.37
RHm(%)-II	81	91	85.9	2.88
RHm(%)-III	80	88	84.07	2.40
RHm(%)-IV	80	93	86.5	4.06
RHm(%)-V	80	90	86.2	2.9
RHe(%)-I	47	74	61.2	9.68
RHe(%)-II	53	67	59.5	5.66
RHe(%)-III	37.71	74	58.80	11.41
RHe(%)-IV	47	72	62.7	6.99
RHe(%)-V	6	79	60.8	20.37
RF (mm)-I	0	165.6	48.69	53.71
RF (mm)-II	0	68	17.1	22.99
RF (mm)-III	0	100	15.7	30.51
RF (mm)-IV	0	146.8	32.36	46.71
RF (mm) -V	0	208	63.12	70.59
Ssh-I	1.5	10.2	6.81	2.61
Ssh-II	1.1	9.7	5.72	2.77
Ssh-III	3.6	9.93	7.30	2.13
Ssh-IV	4.3	9.6	6.66	1.86
Ssh-V	3.5	8.8	6.27	1.72
WS-I	2.2	7	3.76	1.43
WS-II	0.9	4.5	2.33	1.19
WS-III	1.8	5.6	3.59	1.34
WS-IV	1.8	5.6	3.67	1.15
WS-V	2.1	4.6	3.48	0.75

sunshine hours per day were received. The wind continued to blow between 2.2 and 7 km hour^{-1} during the study period. The maximum temperature in 2016 ranged from 32.2 to 34.5°C, and the minimum temperature ranged from 20.5 to 27°C. The relative humidity ranged from 81 to 91 % in the morning and from 53 to 67% in the evening. The total amount of rain that was recorded between 31st to 40th SMW was 68 mm. Overall, there were 1.1-9.7 sunshine hours per day. The wind speed persisted between 0.9 and 4.5 km hour^{-1} throughout the study period. The year 2017 recorded temperatures with a maximum range of 32 to 35°C and a minimum range of 24.7 to 27°C. In the morning and evening, the relative humidity ranged from 80 to 88% and 37.71 to 74%, respectively. Between the 31st and 40th SMW, 100 mm of rain was recorded. Between 1.5 and 10.2 hours of sunshine hours were experienced. Over the course of the investigation, the wind speed remained constant between 1.8 to 5.6 km hour^{-1}. The maximum temperature in 2018 was between 29.9 and 35.2°C, and the minimum temperature was between 20.5 and 27.6°C. In the morning, the relative humidity ranged from 80 to 93 %, and in the evening, it was between 47 and 72 %. Between the 31st and 40th SMW, 146.8 mm of rainfall was observed. There were between 4.3 and 9.6 sunshine hours/day recorded. Throughout the duration of the investigation, the wind speed remained constant between 1.8 to 5.6 km hour^{-1}. The year 2015 observed temperatures with a maximum range of 30.2 to 34.9°C and a minimum range of 20.5 to 27.9°C. In the morning and evening, respectively, the relative humidity ranged from 80 to 90 and 56 to 79 percent, respectively. The total rainfall recorded during disease/insect active period was 208 mm. Between 3.5 and 8.8 hours of sunshine hours were observed overall. Over the course of the pest favourable period, the wind speed remained in range between 2.1 to 4.6 km hour^{-1}.

Trends in whitefly population and yellow vein mosaic disease severity

Highest whitefly population was observed during year 2015 followed by 2019, 2018, 2017 and 2016 as displayed in Fig. 1. During all the years under study except 2015, whitefly population reached its peak up to 35th SMW and then started declining. During highest whitefly population year (2015), peak population was observed one week ahead i.e. during 34th SMW and later showed a decreasing trend. The disease severity also showed a similar trend as that of whitefly as shown in Fig. 1. Highest yellow vein mosaic disease severity was recorded during 2015 followed by 2019, 2018, 2017 and 2016. The disease severity increased at higher rate during highest disease severity year (2015).

Correlation coefficient between meteorological parameters viz-a-viz disease severity/whitefly incidence

In the years 2015, 2016, and 2017, there was a marginally positive correlation between the maximum temperature and the severity of the disease, but in the years 2018 and 2019, there was a moderately negative correlation (r=-0.73 and r=-0.52) (Fig. 2 to Fig. 6). The maximum temperature, on the other hand, showed a negative correlation with the number of whiteflies during the years with lowest population, such as 2016 (r=-0.47) and 2017 (r=-0.56), while it was a positive correlation with the number of whiteflies during the years with the highest

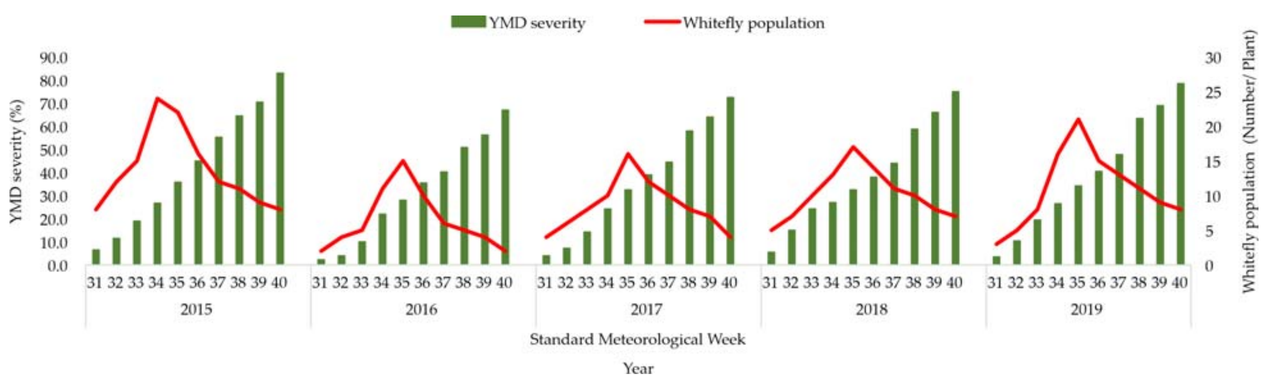

Fig. 1. Trends in whitefly population and yellow vein mosaic disease severity

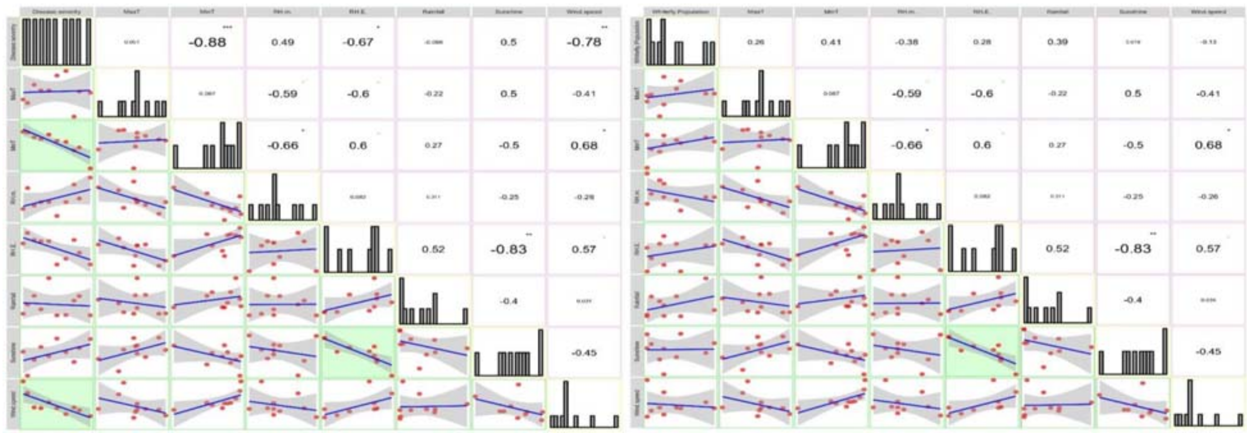

Fig. 2. Correlation matrices between meteorological parameters viz-a-vis disease severity and whitefly population during 2015

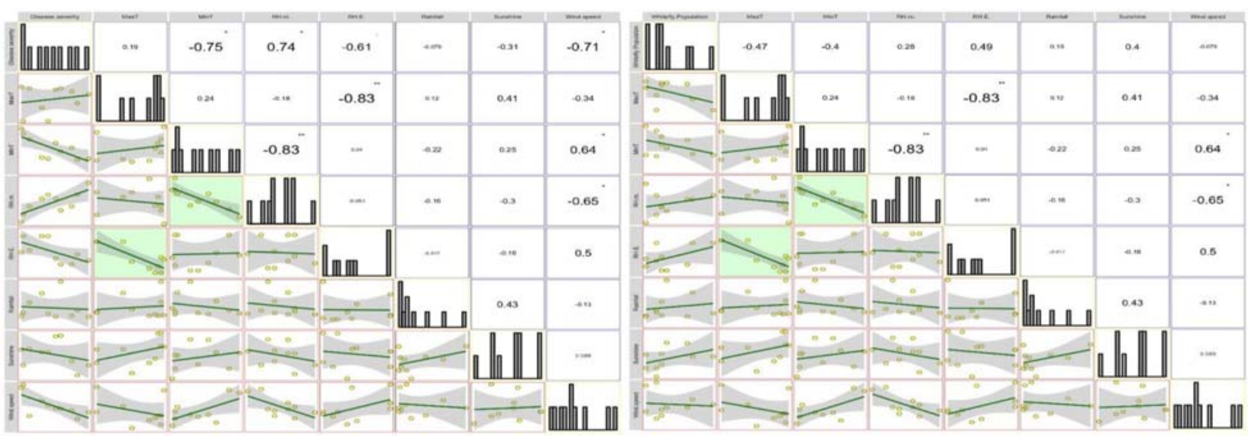

Fig. 3. Correlation matrices between meteorological parameters viz-a-vis disease severity and whitefly population during 2016

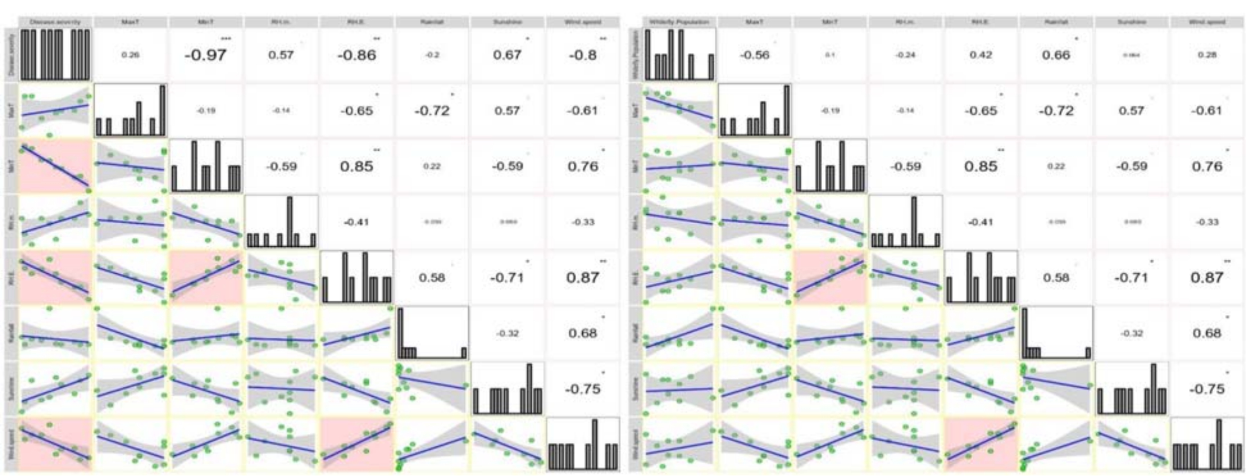

Fig. 4. Correlation matrices between meteorological parameters viz-a-vis disease severity and whitefly population during 2017

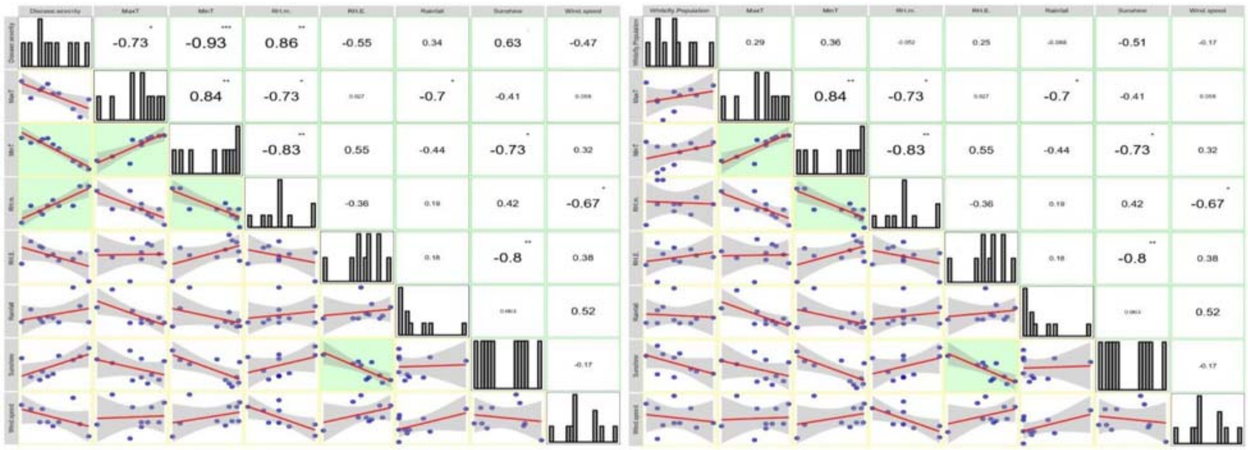

Fig. 5. Correlation matrices between meteorological parameters viz-a-vis disease severity and whitefly population during 2018

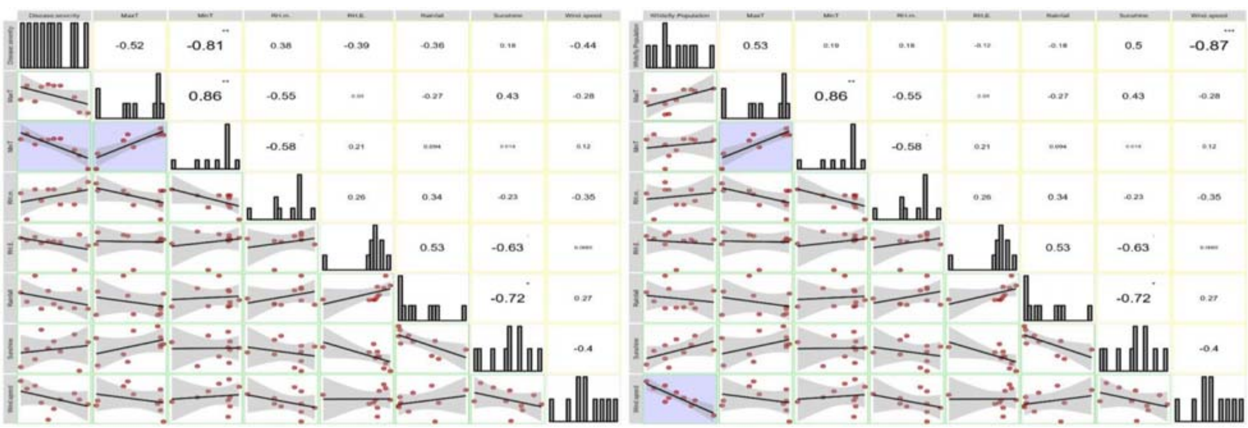

Fig. 6. Correlation matrices between meteorological parameters viz-a-vis disease severity and whitefly population during 2019

population, such as 2015 (r=0.26), 2019 (r=0.53), and 2018 (r=0.29). In all the years under consideration, namely 2015 (r=-0.88), 2016 (r=-0.75), 2017, (r=-0.97), 2018, (r=-0.93), and 2019, (r=-0.81), a strong negative association between the minimum temperature and the severity of the disease was identified. With the exception of 2016 (r=-0.40), the minimum temperature was found to be positively correlated with the population of whiteflies over the study's other years. In all the years under research, namely 2015 (r=0.49) 2016 (r=0.49), 2017 (r=0.57), 2018 (r=0.86) and 2019 (r=0.38), it was found that the morning relative humidity was positively correlated with the severity of the disease. The morning relative humidity and the whitefly population were found to be adversely correlated in 2015 (r=-0.38), favourably correlated in 2016 (r=0.28), and negatively correlated in 2018 (r=-0.052). Throughout the whole study period, which included the years 2015 (r=-0.67), 2016 (r=-0.61), 2017, (r=-0.86), 2018, (r=-0.55), and 2019, a strong negative correlation between evening relative humidity and disease severity was identified. With the exception of 2019 (r=-0.12), the minimum temperature was shown to be positively linked with the population of whiteflies for all the years under consideration. The total rainfall and the severity of the disease were found to be negatively correlated in all of the study years, namely 2015 (r =-0.088), 2016, 2017 (r=-0.2), and 2019 (r=-0.36), with the exception of 2018 (r=0.34). In 2015, 2016, and 2017, there was a positive correlation between total rainfall and the population of whiteflies, while in 2018 and 2019, there was a negative correlation (r = -0.18 and r = -0.088, respectively).With the exception of 2016 (r=-0.31), sunshine hours were positively correlated with disease severity. With the exception of 2018 (r=-0.51), sunlight hours and whitefly populations were likewise positively correlated. Throughout the whole study period, which included the years 2015 (r= -0.78), 2016 (r=-0.71), 2017, (r=-0.80), 2018, (r=-0.47), and 2019, a negative correlation between disease severity and wind speed was observed. With the exception of 2017, wind speed and disease severity had a negative correlation (r=0.28). With an r-value of 1, the maximum temperature showed a significant positive correlation with the severity of the disease, while the minimum temperature showed a strong positive correlation with the number of whiteflies in the pooled analysis (Fig. 7). While rainfall showed a positive association (r=0.88) with disease severity, evening relative humidity (r = -0.95) and sunshine hours (r = -0.81) were shown to be adversely connected with disease severity. Whitefly population and relative humidity (morning and evening) were positively correlated with sunshine hours. Similarly, Binyamin *et al* (2022) observed that wind velocity and high temperature had a negative relation with yellow mosaic occurrence, whereas low temperature, rainfall, and relative humidity, had positive relationship based on linear regression. The environmental conditions responsible for the highest disease incidence were, maximum temperature (32-34°C), relative humidity (72-75%), minimum temperature (27-29°C), rainfall (1.8-2.1 mm) and wind velocity (3-4.5 km/hr). Similarly, Kumar *et al.* (2024) also observed that maximum temp (0.771) and sunshine hours (0.792) were negatively significant and evening relative humidity (0.717) and wind speed (0.708) had a positively significant relation with mean YMD progression.

Crop weather pest calendar for mungbean

Crop weather calendar is the pictographic depiction of comprehensive information for a crop w.r.t sowing and duration of different phenological stages in its life cycle, the optimal climatic requirements during various phenophases of the crop and actual and normal weather for that particular place/location. It comprises of life history of crop (sowing to maturity). It includes information on crop phenophases; normal weather required for the crop growth, forewarnings to be dispensed based on prevalent weather conditions, water requirements of crop during different stages and meteorological conditions congenial for advancement of crop pests and diseases (Prabhjyot-Kaur *et al.*, 2013). Crop weather pest calendar for mungbean was prepared on the basis of five year yellow mosaic disease

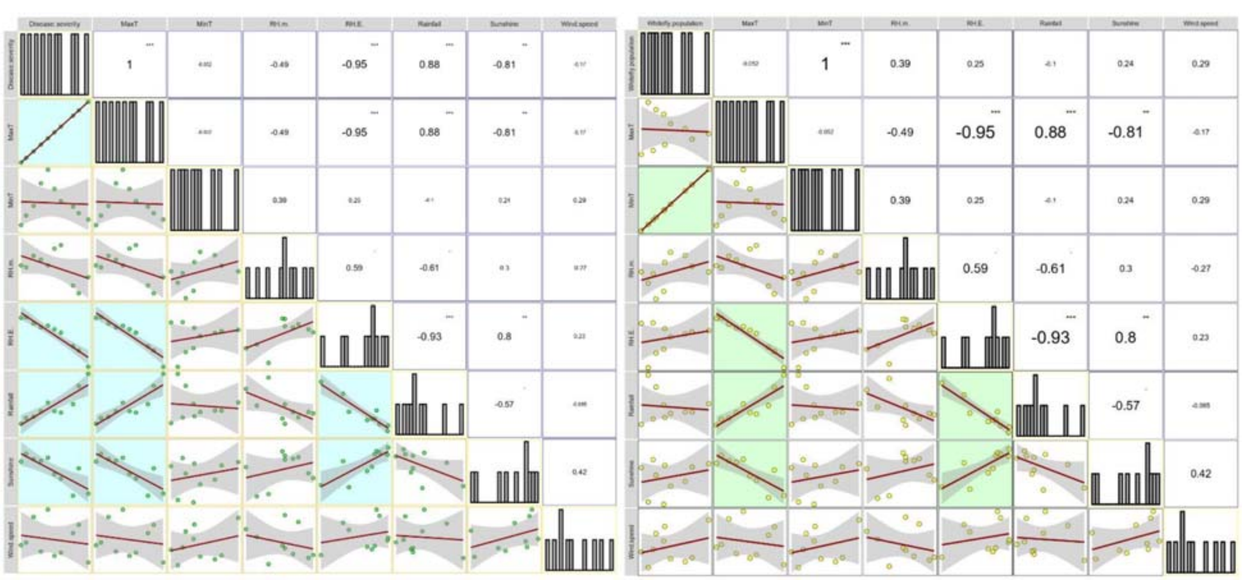

Fig. 7. Correlation matrices between meteorological parameters viz-a-vis disease severity and whitefly population for pooled 5-year data

CROP WEATHER PEST CALENDER FOR MOONG

CROP NAME: MOONG STATE: PUNJAB DISTRICT: LUDHIANA

MONTH	JULY		AUGUST					SEPTEMBER			
Std. met. week / Parameter	29	30	31	32	33	34	35	36	37	38	39
Tmax(°C)	33.9	33.6	33.2	33.3	33.4	33.5	33.5	33.3	33.3	33.4	33.3
Tmin(°C)	26.4	26.4	26.2	26.0	25.6	25.6	25.0	24.2	23.4	22.6	21.1
Tmn(°C)	26.4	26.4	26.2	26.0	25.6	25.6	25.0	24.2	23.4	22.6	21.1
RHm(%)	82.6	83.6	83.8	84.4	81.6	84.5	84.3	84.9	84.7	85.1	83.9
RHe(%)	62.9	64.1	66.4	67.1	62.2	63.8	62.7	60.8	57.7	52.3	47.2
RHmn(%)	72.7	73.9	75.1	75.8	71.9	74.1	73.5	72.9	71.2	68.7	65.6
Rainfall (mm)	45.0	45.2	51.9	49.9	35.2	37.7	41.6	35.3	19.1	21.3	10.2
Ssh(hrs)	6.9	6.6	6.3	6.3	7.6	8.1	8.5	8.0	9.0	9.6	9.4
Pheno phases	Sowing	Emergence	Flower initiation			Pod initiation		Maturity		Harvesting	

Pest/ Pathogen	Symptoms	Climatic Normals
Whitefly 	• Nymphs and adults suck the cell sap from the leaves, thus lowering the vitality of plants. • It excretes honey dew on which sooty mould develops. • It is vector of mungbean yellow mosaic virus	Tmax (ºC) : 33-36 ºC Tmin (ºC) : 24-27 ºC RHm(%) : 82-93 % Rhe (%) : 47-74 %
Yellow mosaic disease 	• Leaves of diseased plants develop irregular yellow and green patches. • Infected plants bear no or only a few pale pods.	Tmax (ºC) : 32.5-39 ºC Tmin (ºC): 23-28 ºC RHm(%) : 75-90 % Rhe (%) : 40-73 %
Control measures	Rogue out diseased plants early in the season. Grow yellow mosaic virus tolerant varieties of moong: ML 1808, ML 2056 and ML 818	

Fig. 8. Crop weather pest calendar for Moong

and whitefly population data (from 2015 to 2019) as shown in Fig. 8. It consists of three parts. Climatic normals for mungbean throughout cropping season were mentioned in the first part. The second part consists of picture description of different phenophases of mungbean crop. Climatic normals for yellow mosaic disease severity and whitefly population were calculated by using field experiment data from 2015 to 2019. According to present study, the favourable temperature for whitefly abundance was 33-36°C (maximum temperature) and 24-27°C (minimum temperature) while relative humidity was 82-93% in the morning and 47-74% in the evening. Similarly for yellow mosaic disease severity, maximum temperature was 32.5-39°C (maximum temperature) and 23-28°C (minimum temperature) while relative humidity was 75-90% in the morning and 40-73% in the evening. Hot and humid conditions are conducive for disease development and whitefly abundance. Symptoms caused by both for yellow mosaic disease and whitefly and the necessary control measures were stated in third part. Taking the week as basic time unit, forecasters use the compiled information that assist in framing weather warnings and forecasts (Anand, 2019).

Conclusion

The findings of this study clearly indicate that whitefly incidence and mosaic disease of mungbean are significantly influenced by different meteorological parameters. The major output of this study is development of crop-weather-pest calendar for mungbean. This calendar can be used in agro-advisory for giving forewarning of whitefly and yellow mosaic disease to the farmers. As the farmers of state are being advised to adopt crop diversification. The atmospheric nitrogen fixing nature and less water requirement of mungbean makes it best suitable for region but its cultivation in *kharif* season faces biggest challenge from attack of whitefly and yellow mosaic disease incidence. This study can be helpful in creating awareness among farmers regarding management of moong pest on the basis of crop-weather-pest calendar developed by using data of five continuous years.

Statement and Declarations

The authors declare that there is no conflict of interest.

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