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Effect of Weather Variables and Yellow Mosaic Virus Disease (YMV) on Soyabean

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The presented research work for studied the link between weather and diseases in soybean to determine the effect of weather in disease occurrences and development measures was conducted at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad during kharif 2017. Biotic and abiotic threats are becoming more significant as of the climate changes. Abiotic stress factors, such as insect pests and diseases, are well recognised to effect biotic stress factors. Furthermore, weather influences the severity and virulence of diseases throughout a geographical area. As a result, there is a need to investigate the impact of meteorological characteristics in diseases in this context. The current study was done in this effort to understand the relationship between weather and diseases in order to treat diseases early before they reach economic injury levels (EIL) and minimize cultivation costs by using low-cost insecticides and pesticides by building a forewarning system. Yellow Mosaic Virus Disease (YMV) is a disease of soybean, which infects mainly to leaves. The weather data was collected from the MARS Dharwad weather data collected in crop field. The Correlation coefficients between disease grade of Yellow Mosaic Virus Disease (YMV) and 29 weather variables were presented in the data show that the disease grade ratings were correlated positively, with r = 0.45 for PRHT (X_{14}), r = 0.46 for PRHM (X_{17}), r = 0.49 for PRHB (X_{20}), and r = 0.34 for PRHO (X_{26}). And remining were negative correlated. Hence, the weather plays an important role in the disease incidence and development.

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Keywords: Soybean; weather variables; Yellow Mosaic Virus Disease (YMV); correlation.

1. INTRODUCTION

Soybean *Glycine max* (L.) is renowned as the 20th century's golden bean and miracle crop. It evolved from *Glycine ussuriensis*, a wild legume in the Fabaceae family, and is a native of 'Northern China.' It is a versatile and economically important legume crop with a wide range of applications beyond agro-based industries, serving as a foundation for a wide range of food and industrial products. Being a leguminous crop, soybean is also important from agriculture point of view. It improves the soil fertility by fixing atmospheric nitrogen at the rate of 125 - 150 kg N ha^{-1} and leaves about 30 - 40 kg N ha^{-1} for succeeding crop. The plant residues that are added to soil decompose in a shorter period and improve the soil physical conditions and fertility status of the soil. Being rich in protein, carbohydrates and minerals, soybean cake is used also as manure. Soybean is also essential in agriculture because it is a leguminous crop. It enhances soil fertility by fixing 125-150 kg N ha-1 of atmospheric nitrogen and leaving about 30-40 kilogramme N ha-1 for subsequent crops [1]. Plant residues that are put to soil decompose more quickly and improve the soil's physical characteristics and fertility status. Soybean cake is used as manure because it is high in protein, carbohydrates, and minerals. The largest soybean-producing states in India include Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, and Gujarat. In recent years, soybean has risen to prominence as one of the most important rainy-season cash crops in Madhya Pradesh, which has named itself "Soya State" due to its dominance in terms of acreage (77%) and production (72%). Furthermore, Karnataka ranks eighth in soybean output, with 0.318 million hectares producing 0.237 million tonnes and a productivity of 745 kilogrammes per hectare [2]. The crop is primarily farmed in the districts of Dharwad, Belagavi, Haveri, Bidar, and Bagalkot in Karnataka. Moisture stress and biotic stress factors such as weeds, insect pests, and diseases are responsible for low soybean productivity at the national and state levels. Diseases are claimed to have caused the loss of more than seven million tonnes of soybeans globally [3]. Sixty-six fungi, six bacteria, eight viruses, and seven nematodes are among the main pathogens known to impact the soybean crop [4]. Most abiotic elements, such as rainfall distribution pattern, radiation/sunshine, wind velocity, temperature, cloudiness, and humidity parameters, are known to be caused or promoted by biotic environmental circumstances. The same can be said for soybean diseases. Furthermore, it has been suggested in the projected changing climate scenarios that meteorological conditions may trigger a shift in pathogen virulence patterns as well as disease severity.

2. MATERIALS AND METHODS

An experiment was carried out under rainfed condition on the farms of Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad (UASD) during the *kharif* season of 2017. For convenience, the details of weather variables collected in the experimental field are presented in Table 1.

2.1 Canopy Temperature

Canopy temperature was measured with the help of infrared thermometer (CENTRE 350). Observations were made with the observer's back to the sun, and the instrument inclined at 45 degrees to the horizontal, from an approximate distance of 3 meters to cover major portion of the plot in the field of view of the instrument. The observations were made at an interval of three days at 0700 LMT and 1400 LMT synchronous with the time of observations in Agro-meteorological observatory, located 50 meters away.

2.2 Canopy Air Temperature and Relative Humidity Within the Canopy

Air temperature and relative humidity were measured at top, middle and bottom level of canopy with the help of weather tracker (Kestrel 4000 and company name Nielsen-Kellerman) at an interval of three days at 0700 LMT and 1400 LMT.

2.3 Photosynthetically Active Radiation (PAR)

The photosynthetically active radiation (PAR) ($watt/m^2$), was measured above the crop canopy and inside the crop canopy using line quantum sensor (Spectrum Technologies, Inc). The measurements were made above the canopy with sensor positioned horizontally at 1 meter above the crop canopy and facing the sky to account for incident radiation (I_0) and with the sensor facing downwards to account for reflected radiation (I_r) from the canopy. The instrument was placed horizontally on the ground across the rows with the sensor facing upwards to account for transmitted radiation (I_t) through the canopy. The above measurements were made at 0700 LMT and 1400 LMT at an interval of three days.

2.4 Agrometeorological Data

The daily weather data on maximum and minimum temperatures, relative humidity and rainfall corresponding to the period of experiment were collected from the records of department of agricultural meteorology, UAS Dharwad.

2.5 Monitoring of Disease Complex

Disease complex was monitored from germination to harvesting of crop. Observations on major diseases that prevailed during the season, were recorded at three days interval ten plants each were tagged in individual plot (2^{nd} from border) and monitored for diseases throughout the season on days synchronous with the measurement of micro meteorological data.

2.6 Disease Scoring

The disease scoring was made on 0-9 disease scale as per established procedure adopted by developed by Mayee and Datar [5] as mentioned below.

2.7 Rating Scales for Soybean Diseases

2.7.1 Disease grade or percent disease index (PDI)

The disease observations made at three days interval from the time of first incidence of disease were converted to PDI (percent disease index) or disease grades using the formula given by Wheeler [6].

$$PDI = \frac{\text{Sum of individual rating}}{\text{Number of leaves examined}} \times \frac{100}{\text{Maximum disease rating}}$$

2.7.2 Analysis and interpretation of data

Correlation analysis was performed for data of disease grades of yellow mosaic virus disease with various weather and micrometeorological variables measured on corresponding days. This analysis was worked out for all 29 abiotic variables. The correlation work was performed using SPSS software.

3. RESULTS AND DISCUSSION

The Correlation coefficients between disease grade of YMV and 29 abiotic variables are presented in Table 2. Hence, for sake of brevity, the results for unprotected conditions are explained hereunder, it is more appropriate to relate natural disease incidence with agrometeorological and micrometeorological variables. The data show that the disease grade ratings were correlated positively, with r = 0.45 for PRHT (X_{14}), r = 0.46 for PRHM (X_{17}), r = 0.49 for PRHB (X_{20}), and r = 0.34 for PRHO (X_{26}).

On the other hand, negative correlation was noticed, with r = - 0.34 for PCT (X_2), r = - 0.33 for DRCT (X_3), r = - 0.31 for PATT (X_5), r = - 0.28 for DRATT (X_6), r = - 0.2 for PATM (X_8), r = - 0.23 for DRATM (X_9),r = - 0.31 for PATB (X_{11}), r = - 0.27 for DRATB (X_{12}), r = - 0.39 for DRRHT (X_{15}), r = - 0.40 for DRRHM (X_{18}), r = - 0.42 for DRRHB (X_{21}), r = - 0.33 for DRRHO (X_{27}), r = - 0.36 for AARAD (X_{28}), r = - 0.37 for PARADL (X_{29}).

Chart 1. (A) Yellow Mosaic Virus Disease

Rating	Description
0	No lesions/spots
1	1% leaf area covered with lesions/spots
3	1.1 to 10% leaf area covered with lesions/spot, no spots on stem
5	10.1-25% of leaf area covered no defoliation; little damage.
7	25.1 to 50% leaf area covered; some leaves drop; death of a Few plants.
9	More than 50% area covered, lesions/spot very common on All plants, defoliation common; death of plants common; Damage more than 50%.

In addition, the relationship was practically insignificant in the following variables; r = 0.07 for ARHT (X_{13}), r = 0.10 for ARHM (X_{16}), r = 0.1 for ARHB (X_{19}), r = 0.03 for AATO (X_{22}), r = 0.17 for ARHO (X_{25}), r = - 0.07 for AATT (X_4), r = - 0.05 for AATM (X_7), r = - 0.09 for AATB (X_{10}), r = - 0.07 for PATO (X_{23}), r = - 0.09 for DRATO (X_{24}).

The similar work with correlation analysis with weather parameters and disease grades (PDI) supports from the study conducted by Chattopadhayay et al [7] conducted experiment on oil seed Brassica. The study also looked at different strategies to cope with effects of climate change on diseases of oil seed crops. Alternaria brassicae sporulated at 35 0C and several isolates increase fecundity at higher Relative humidity.

Gadre et al [8] studied the effect of weather parameters on leaf blight, white rust and powdery mildew of mustard. The results indicated that there was a positive correlation for maximum air temperature, minimum air temperature, sunshine period, crop age with PDI of this disease. The multiple regression analysis showed that sunshine and crop age were highly significant with among the incidence of disease. However, maximum and minimum air temperatures were significant for powdery mildew only.

Venkatesh et al [9] identified the meteorological variables influencing incidence of alternaria blight disease on four genotypes of cotton during various disease growth phases through correlation analysis.

Venkatesh et al [10] identified the meteorological variables influencing incidence of Grey Mildew disease in Cotton during various disease growth phases through correlation analysis.

Table 1. The details and acronyms of weather variables collected in the experimental field

Variables	Acronym	Description	S I Units
X_1	ACT	Morning Canopy temperature	^0C
X_2	PCT	Afternoon Canopy temperature	^0C
X_3	DRCT	Diurnal range of Canopy temperature	^0C
X_4	AATT	Morning Air Temperature at top level of canopy	^0C
X_5	PATT	Afternoon Air Temperature at top level of canopy	^0C
X_6	DRATT	Diurnal range of Air Temperature at top level of canopy	^0C
X_7	AATM	Morning Air Temperature at middle level of canopy	^0C
X_8	PATM	Afternoon Air Temperature at middle level of canopy	^0C
X_9	DRATM	Diurnal range of Air Temperature at middle level of canopy	^0C
X_{10}	AATB	Morning Air Temperature at bottom of canopy	^0C
X_{11}	PATB	Afternoon Air Temperature at bottom of canopy	^0C
X_{12}	DRATB	Diurnal range of Air Temperature at bottom of canopy	^0C
X_{13}	ARHT	Morning Relative Humidity at top level of canopy	%
X_{14}	PRHT	Afternoon Relative Humidity at top level of canopy	%
X_{15}	DRRHT	Diurnal range of Relative Humidity at top level of canopy	%
X_{16}	ARHM	Morning Relative Humidity at middle level of canopy	%
X_{17}	PRHM	Afternoon Relative Humidity at middle level of canopy	%
X_{18}	DRRHM	Diurnal range of Relative Humidity middle level of canopy	%
X_{19}	ARHB	Morning Relative Humidity at bottom of canopy	%
X_{20}	PRHB	Afternoon Relative Humidity at bottom of canopy	%
X_{21}	DRRHB	Diurnal range of Relative Humidity at bottom of canopy	%
X_{22}	AATO	Morning air temperature at Observatory	^0C
X_{23}	PATO	Afternoon air temperature in Observatory	^0C
X_{24}	DRATO	Diurnal range of air temperature in Observatory	^0C
X_{25}	ARHO	Morning Relative Humidity in Observatory	%
X_{26}	PRHO	Afternoon Relative Humidity in Observatory	%
X_{27}	DRRHO	Diurnal range of Relative Humidity in Observatory	%
X_{28}	AARAD	Morning time absorptance of radiation by canopy	w/m^2
X_{29}	PARAD	Afternoon time absorptance of radiation by canopy	w/m^2
Y	DI	Disease incidences	

Table 2. Correlation coefficients for disease grade of yellow mosaic virus disease (YMV) with weather variables

Weather Variables	Correlation coefficients for disease grade of yellow mosaic virus disease
X_1 (ACT)	-0.01
X_2 (PCT)	-0.32
X_3 (DRCT)	-0.31
X_4 (AATT)	-0.08
X_5 (PATT)	-0.3
X_6 (DRATT)	-0.26
X_7 (AATM)	-0.06
X_8 (PATM)	-0.27
X_9 (DRATM)	-0.22
X_{10} (AATB)	-0.09
X_{11} (PATB)	-0.29
X_{12} (DRATB)	-0.25
X_{13} (ARHT)	0.07
X_{14} (PRHT)	0.44
X_{15} (DRRHT)	-0.38
X_{16} (ARHM)	0.1
X_{17} (PRHM)	0.44
X_{18} (DRRHM)	-0.38
X_{19} (ARHB)	0.1
X_{20} (PRHB)	0.48
X_{21} (DRRHB)	-0.41
X_{22} (AATO)	0.02
X_{23} (PATO)	-0.08
X_{24} (DRATO)	-0.1
X_{25} (ARHO)	0.17
X_{26} (PRHO)	0.36
X_{27} (DRRHO)	-0.35
X_{28} (AARAD)	-0.37
X_{29} (PARAD)	-0.37

3.1 Correlation Coefficients Matrix for Selected Variables

The variables showing highest correlation coefficient (> $\pm$ 0.25) with diseases were shortlisted and correlation matrix was performed. Even through the selection is made automatically by the software (SPSS), it is necessary to have knowledge on inter-variable relationships other than with biotic factors.

The correlation matrixes are presented in Table 3 for yellow mosaic virus disease shortlisting of abiotic variables as per criteria resulted in selection of 18 variables. The data show that the disease grade was positively correlated, significant values are r = 0.46 for PRHM (X_{17}), r = 0.49 for PRHB (X_{20}). In addition, non-significant with r = 0.45 for PRHT (X_{14}), r = 0.34 for PRHO (X_{26}). On the other hand, negative correlation were noticed, with r = **-** 0.34 for PCT (X_2), r = **-** 0.33 for DRCT (X_3), r = **-** 0.31 for PATT (X_5), r = **-** 0.28 for DRATT (X_6), r = **-** 0.29 for PATM (X_8), r = **-** 0.23 for DRATM (X_9), r = **-** 0.31 for PATB (X_{11}), r = **-** 0.27 for DRATB (X_{12}), r = **-** 0.39 for DRRHT (X_{15}), r = **-** 0.40 for DRRHM (X_{18}), r = **-** 0.42 for DRRHB (X_{21}), r = **-** 0.33 for DRRHO (X_{27}), r = **-** 0.36 for AARAD (X_{28}), r = **-** 0.37 for PARADL (X_{29}).

Table 3. Correlation coefficients matrix for disease grade of yellow mosaic virus (YMV) with weather variables

	X_2	X_3	X_5	X_6	X_8	X_9	X_{11}	X_{12}	X_{14}	X_{15}	X_{17}	X_{18}	X_{20}	X_{21}	X_{26}	X_{27}	X_{28}	X_{29}
X_2	1																	
X_3	0.94	1																
X_5	0.91	0.89	1															
X_6	0.85	0.90	0.96	1														
X_8	0.81	0.79	0.83	0.79	1													
X_9	0.66	0.70	0.57	0.62	0.84	1												
X_{11}	0.94	0.91	0.95	0.92	0.85	0.70	1											
X_{12}	0.88	0.91	0.91	0.96	0.81	0.75	0.96	1										
X_{14}	-0.78	-0.74	-0.76	-0.73	-0.68	-0.60	-0.80	-0.76	1									
X_{15}	0.76	0.76	0.75	0.77	0.66	0.64	0.79	0.81	-0.89	1								
X_{17}	-0.77	-0.73	-0.75	-0.72	-0.68	-0.61	-0.79	-0.76	0.99	-0.88	1							
X_{18}	0.75	0.74	0.74	0.76	0.66	0.65	0.79	0.81	-0.89	0.99	-0.90	1						
X_{20}	-0.74	-0.71	-0.72	-0.70	-0.65	-0.59	-0.76	-0.74	0.99	-0.88	0.99	-0.89	1					
X_{21}	0.73	0.74	0.73	0.76	0.63	0.63	0.77	0.80	-0.88	0.99	-0.88	0.99	-0.89	1				
X_{26}	-0.15	-0.14	-0.12	-0.09	-0.06	0.00	-0.12	-0.09	0.20	-0.01	0.18	-0.01	0.20	-0.03	1			
X_{27}	0.19	0.16	0.15	0.10	0.09	0.02	0.17	0.12	-0.16	0.04	-0.15	0.04	-0.16	0.06	-0.96	1		
X_{28}	0.02	0.04	0.06	0.01	0.08	0.01	0.05	0.02	-0.02	-0.04	-0.04	-0.02	-0.02	-0.04	-0.11	0.13	1	
X_{29}	-0.02	0.09	-0.01	0.05	0.03	0.12	0.00	0.05	0.08	-0.01	0.07	-0.03	0.04	0.02	-0.08	0.07	0.66	1
Y (DI)	-0.32	-0.31	-0.30	-0.26	-0.27	-0.22	-0.29	-0.25	0.44*	-0.38	0.44	-0.38	0.48*	-0.41*	0.36	-0.35	-0.37	-0.37

*Note: *values are significant at 5% level of significance and **value are significant at 1% level of significance*

4. CONCLUSION

The Correlation matrix for yellow mosaic virus disease with weather data at Real- time too showed that, the correlations coefficient values, as noticed in the previous chapter on "Results".

The results also revealed that disease grade was positively correlated with the afternoon (1400 hrs LMT) relative humidity parameters in crop canopy, *i.e.* at top level, middle level and bottom level [X_{14}, X_{17}, and X_{20} respectively] as well as with the afternoon relative humidity in the observatory [X_{26}].

The disease grade of YMV was negatively correlated with all other agrometeorological and micrometeorological variables. It was also noticed that, the relative humidity variables within the canopy were better related compared to the observatory relative humidity. This indicates the importance of micrometeorological variables in disease incidences.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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