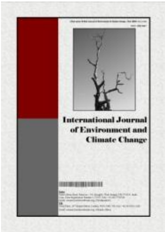

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Relationship between Weather Variables and the Corynespora Leaf Spot Disease in Soybean

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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 present investigation on weather and diseases relationships in soybean to establish forewarning procedures for timely preventive measures was conducted at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad during *kharif* 2017. Due to changing climatic scenario, biotic and abiotic threats are more prominent. It is well known that the biotic stress factors like insect pests and diseases are affected by abiotic factors. Further, the severity and degree of virulence of diseases over a geographical area is dependent on weather factors. Hence, in this context, there is need to study the role of weather parameters in diseases. In this endeavour, the present study has been undertaken with a new concept called lead-time concept for plant disease forecasting helps controlling early before they reach to economic injury level (EIL), and reducing cost of cultivation in use of low use of pesticides and insecticide. Corynespora leaf spot (CLS) is a disease of soybean, which infects mainly to leaves. The weather data was collected from the MARS Dharwad observatory and micrometeorological data collected in crop field and they are collected at three days interval. The Correlation coefficients between disease grade of Corynespora Leaf Spot and 29 weather variables were presented in the data show that the disease grade ratings were positively correlated, with r =0.69 for PRHT (X_{14}), r = 0.69 for PRHM (X_{17}), r = 0.69 for PRHB (X_{20}), and r = 0.28 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; corynespora leaf spot disease; correlation.

1. INTRODUCTION

Soybean *Glycine max* (L.) Merrill is known as golden bean and miracle crop of the 20thcentury [1]. It is a native of 'Northern China' evolved from *Glycine ussuriensis,* a wild legume which belongs to the family *Fabaceae*. It is a versatile and an economically important legume crop with numerous applications even beyond supporting agro-based industries, thereby providing base for wide range of food and industrial products. In India, the crop is predominantly grown and produced in the states of Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, and Gujarat [2]. However, the productivity of soybean at national and state levels is constrained due to abiotic stresses like drought and excess soil moisture as well as biotic stress factors like weeds, insect pests, and diseases. It has been indicated that, the weather conditions that could prevail during projected climate change scenarios, could result in shifts in virulence levels of pathogens as well as the severity of diseases [3]. Globally, loss of more than seven million tonnes of soybean is said to be due to diseases alone [4].

Hence, it is important to know about Weather and disease relationship so in that way we are looking to the relationship between weather variables and the corynespora leaf spot disease in soybean.

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.

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	

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 (2nd 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 the developed by Mayee and Datar [5] as mentioned below.

2.7 Rating Scales for Soybean Diseases

Chart (A). Corynespora leaf spot

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 %.

2.8 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].

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

2.9 Analysis and Interpretation of Data

Correlation analysis was performed for data of disease grades of Corynespora leaf spot diseases 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 Corynespora leaf spot disease and 29 abiotic variables are presented in Table 2. Hence, for the 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 was positively correlated, with r =0.69 for PRHT (X_{14}), r = 0.69 for PRHM (X_{17}), r = 0.69 for PRHB (X_{20}), and r = 0.28 for PRHO (X_{26}).

On the other hand, negative correlation were noticed, with r = - 0.73 for PCT (X_2), r = - 0.69 for DRCT (X_3), r = - 0.69 for PATT (X_5), r = - 0.59 for DRATT (X_6), r = - 0.58 for PATM (X_8), r = - 0.51 for DRATM (X_9),r = - 0.68 for PATB (X_{11}), r = - 0.59 for DRATB (X_{12}), r = - 0.56 for DRRHT (X_{15}), r = - 0.57 for DRRHM (X_{18}), r = - 0.57 for DRRHB (X_{21}), r = - 0.05 for AATO (X_{22}), r = - 0.30 for DRRHO (X_{27}), r = 0.38 for AARAD (X_{28}), r = - 0.52 for PARAD (X_{29}).

Table 2. Correlation coefficients for disease grade of corynespora leaf spot with weather variables

Weather Variables	Correlation coefficients for disease grade of corynespora leaf spot
X_1 (ACT)	-0.10
X_2 (PCT)	-0.72
X_3 (DRCT)	-0.67
X_4 (AATT)	-0.13
X_5 (PATT)	-0.68
X_6 (DRATT)	-0.58
X_7 (AATM)	-0.13
X_8 (PATM)	-0.57
X_9 (DRATM)	-0.50
X_{10} (AATB)	-0.19
X_{11} (PATB)	-0.67
X_{12} (DRATB)	-0.58
X_{13} (ARHT)	0.04
X_{14} (PRHT)	0.67
X_{15} (DRRHT)	-0.55
X_{16} (ARHM)	0.06
X_{17} (PRHM)	0.68
X_{18} (DRRHM)	-0.56
X_{19} (ARHB)	0.04
X_{20} (PRHB)	0.68
X_{21} (DRRHB)	-0.56
X_{22} (AATO)	-0.05
X_{23} (PATO)	-0.19
X_{24} (DRATO)	-0.19
X_{25} (ARHO)	0.01
X_{26} (PRHO)	0.29
X_{27} (DRRHO)	-0.31
X_{28} (AARAD)	-0.38
X_{29} (PARAD)	-0.52

Table 3. Correlation coefficients matrix for disease grade of corynespora leaf spot 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	0.96	1																
X_5	0.96	0.95	1															
X_6	0.90	0.94	0.96	1														
X_8	0.77	0.75	0.81	0.77	1													
X_9	0.75	0.78	0.81	0.84	0.97	1												
X_{11}	0.96	0.92	0.98	0.94	0.80	0.79	1											
X_{12}	0.91	0.92	0.96	0.98	0.77	0.83	0.97	1										
X_{14}	-0.86	-0.81	-0.88	-0.83	-0.69	-0.68	-0.85	-0.81	1									
X_{15}	0.81	0.79	0.83	0.83	0.64	0.68	0.81	0.82	-0.91	1								
X_{17}	-0.85	-0.81	-0.87	-0.82	-0.70	-0.68	-0.85	-0.80	1.00	-0.90	1							
X_{18}	0.81	0.78	0.83	0.83	0.65	0.68	0.82	0.82	-0.91	1.00	-0.91	1						
X_{20}	-0.83	-0.79	-0.85	-0.80	-0.67	-0.65	-0.83	-0.78	0.99	-0.89	0.99	-0.90	1					
X_{21}	0.80	0.78	0.82	0.82	0.62	0.66	0.80	0.81	-0.91	0.99	-0.91	0.99	-0.91	1				
X_{26}	-0.02	0.00	0.05	0.08	0.10	0.13	0.02	0.06	-0.02	0.16	-0.02	0.15	0.00	0.14	1			
X_{27}	0.09	0.03	0.00	-0.04	-0.05	-0.09	0.05	0.00	0.00	-0.08	0.00	-0.08	-0.02	-0.06	-0.96	1		
X_{28}	0.10	0.14	0.16	0.08	0.18	0.12	0.17	0.11	-0.15	0.04	-0.19	0.07	-0.14	0.03	-0.04	0.06	1	
X_{29}	0.31	0.36	0.36	0.30	0.32	0.28	0.34	0.30	-0.31	0.18	-0.34	0.21	-0.29	0.18	-0.11	0.11	0.85	1
DI (Y)	**-0.72****	**-0.67****	**-0.68****	**-0.58****	**-0.57****	**-0.50***	**-0.67****	**-0.58****	**0.67****	**-0.55***	**0.68****	**-0.56***	**0.68****	**-0.56***	**0.29**	**-0.31**	**-0.38**	**-0.52***

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

In addition, the relationship was practically insignificant in the following variables; r = 0.03 for ARHT (X_{13}), r = 0.05 for ARHM (X_{16}), r = 0.04 for ARHB (X_{19}), r = 0.01 for ARHO (X_{25}), r = - 0.10 for ACT (X_1), r = - 0.12 for AATT (X_4), r = - 0.12 for AATM (X_7), r = - 0.18 for AATB (X_{10}), r = - 0.18 for PATO (X_{23}), r = - 0.19 for DRATO (X_{24}) showed in Table 3. The similar work with correlation analysis with weather parameters and disease grades (PDI) supports from the study conducted by Gud et al. [7]reported that alternaria leaf spot is a major destructive fungal disease of safflower (Carthamus tinctorius L.).This infected the leaves, stem, head and seed. The experiment was conducted with a view to study the effect of different weather parameters viz., rainfall, humidity and temperature on the development of Alternaria leaf spot and secondly to develop forecasting model for it. The correlation studies indicated that rainfall, minimum temperature and relative humidity had positive correlation with the disease development in all sowing times whereas the maximum temperature had a negative correlation. Umer Jamshed et al. [8] showed that wheat leaf rust disease severity almost always produced high correlation coefficients with monthly relative humidity and maximum temperature, both of which dictate leaf wetness duration. The models were validated by comparing the predicted disease severity with the actual data, which yielded harmonious results indicating the practicality of the work.

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. Shortlisting of abiotic variables as per criteria resulted in selection of 18 variables**.** The data showed with r =0.69 for PRHT (X_{14}), r = 0.69 for PRHM (X_{17}), r = 0.69 for PRHB (X_{20}) are positively high significant and r = 0.28 for PRHO (X_{26}) has non-significant with disease grade.

On the other hand, negative high significant correlation were noticed, with r = - 0.73 for PCT (X_2), r = - 0.69 for DRCT (X_3), r = - 0.69 for PATT (X_5), r = - 0.59 for DRATT (X_6), r = - 0.58 for PATM (X_8), r = - 0.68 for PATB (X_{11}), r = - 0.59 for DRATB (X_{12}). And significant values with r = - 0.51 for DRATM (X_9), r = - 0.56 for DRRHT (X_{15}), r = - 0.57 for DRRHM (X_{18}), r = - 0.57 for DRRHB (X_{21}), r = - 0.52 for PARAD (X_{29}). In addition, the relationship was practically non-significant in the following variables; r = - 0.30 for DRRHO (X_{27}), r = - 0.38 for AARAD (X_{28}) as shown in Table 3.

4. CONCLUSION

The Correlation matrix for corynespora leaf spot disease with agrometeorological and micrometeorological weather data at Real-time too showed that the correlations coefficient values, showed that humidity plays a very important role in disease incidence and development.

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}].

However, the disease grade of corynespora leaf spot was negatively correlated with all other weather variables. It was also noticed that, the relative humidity variables within the canopy were better compared to the observatory relative humidity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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