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Influence of meteorological variables on severity of anthracnose/pod blight of soybean in Medziphema, Nagaland

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The most detrimental production limitations of soybean are foliar diseases. These diseases are mainly brought about by various pathogens such as fungi, bacteria and viruses which pose a big threat to the agricultural production. One such problem is brought about by a fungal pathogen, *Colletotrichum truncatum* which causes soybean anthracnose. The current investigation was conducted to study on the epidemiology of anthracnose and its association with the weather variables during the *Kharif* season of 2022 at the AICRP Soybean farm, Medziphema, Nagaland. The findings indicated that September and October was the ideal period for anthracnose development in soybean. The correlation studies of disease severity with weather variables revealed that maximum temperature showed a negative correlation with the disease severity over the investigation period, whereas the maximum relative humidity showed a positive correlation.

Keywords: Anthracnose, *Colletotrichum truncatum*, correlation, soybean.

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is one of the most important legume crop in the world, accounting for up to 25% of the world's edible oil, belonging to the family Leguminaceae and sub-family Papilionaceae. Soybean has the highest protein content (40 to 45%) among pulse crops and also contains a good amount of salts, minerals and vitamins (such as Riboflavin and Thiamine). Pathogens such as fungus, bacteria, viruses, and nematodes, many of which are seed-borne and seed-transmitted, harm soybean in various ways. The crop's decreased productivity may be attributed to the prevalence of a number of bacterial and fungal diseases, including seed and seedling rots, bacterial pustules, bacterial leaf blight, aerial blight, anthracnose, charcoal rot and soybean mosaic (Mathpal and Singh, 2017). There are 36 fungi, 3 bacteria, and 4 viruses that are known to affect soybean in India.

Any disease's intensity and transmission are significantly influenced by environmental factors. The development of disease is influenced by favourable host, pathogen, and environmental conditions. Throughout time, a number of environmental factors, such as temperature, relative humidity, prolonged periods of direct sunlight, and rainfall, have a significant impact on how rapidly plant diseases begin to spread and develop (Jeena *et al*. 2022). For a disease to develop, a combination of ideal environmental condition and a plant's vulnerable developmental stage are required (Joshi *et al*. 2018). It may be helpful to investigate the interactions of weather parameters that contribute to the development of the disease in order to assess and predict crop losses and build management strategies for the disease. This will make it possible for researchers to stay informed when epidemics of plant diseases emerge. In order to identify specific weather patterns that cause the disease to manifest itself severely in epiphytic environments, the aim of this research was to investigate the

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association between meteorological variables and the severity of anthracnose.

MATERIALS AND METHODS

During *Kharif* of 2022 soybean seeds of ten cultivars namely JS 95-60, JS 335, Shivalik, JS 93-05, Punjab 1, PK 472, NRC 7, PK 262, Monetta and Macs 1460 were sown in the AICRP Soybean farm which was at located at 25.7566°N and 93.8681°E longitudes at 310 m above sea level on 14th July 2022. The seeds were planted in plots measuring 3 m × 1.35 m, with a row-to-row distance of 45 cm and a plant-to-plant distance of 5 cm, using a Randomised Block Design (RBD) with three replications. To find out more about how diseases spread naturally in the environment and its relationship with the weather parameters, the experiment was conducted in an epiphytotic setting.

The anthracnose disease was identified in the field setting with reference to literatures of various researchers, the soybean plants which were suspected to have been infected by *C. truncatum* were then brought to the laboratory of Department of Plant Pathology, SAS, Medziphema. And further identification was done with the aid of a compound microscope (10X & 40X) and the infected tissue was isolated in potato dextrose agar medium. The PDA was prepared according to the procedure laid out by Ricker and Ricker (1936) which was incubated for 48 – 72 hrs at 25±2°C. For obtaining pure culture of the pathogen, hyphal tip isolation approach was used. This was accomplished by taking a disc of the fungal colony and placing it on PDA plates, where it was cultured for one to two days. The pathogen was identified using a compound microscope (10X & 40X) objective where the mycelium was mounted on a glass slide with lactophenol blue and observed under the microscope. The culture was taken out with cork borer and put on PDA slants where it was kept as a pure culture. Later, morphological studies of the pathogen, *C. truncatum* was done with the help of a compound microscope and the dimensions of the spores and setae were calculated with the help of micrometry.

After the disease incidence, the data was recorded on a weekly basis until harvest. To score the severity of the disease and determine the PDI occurrence, ten randomly chosen plants from each plot were labelled. The chosen plants were rated on a scale of 0 to 9 (Table 1) for disease severity (Mayee and Datar, 1986). Using the following formula, the percent disease index (PDI) of anthracnose in various cultivars were calculated.

Percent Disease Index (PDI) :

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

Data compilation and statistical analysis were performed using MS Excel, the data were angular transformed and mean differences were corrected using the Least Significance Difference (LSD) test at the 5% level of significance (Gomez and Gomez, 1984) while Karl Pearson's correlation coefficient was used to calculate the correlation.

RESULTS AND DISCUSSION

The symptoms of anthracnose were characterized by asymmetrical brown spots on stems, pods, and leaf petioles. Symptoms such as rolled leaves and crimson veins were also seen. Diseased stems and pods exhibited patches of a dark brown or reddish brown tint on their surface. Sunken lesions on stems, petioles and pods and black fruiting bodies (acervuli) of the fungus covered the afflicted areas when the infected tissues reached an advanced level. Plants infected with the anthracnose disease also exhibited veinal necrosis and premature defoliation on their leaves. The findings were in agreement with those of other researchers, including Gupta and Chauhan (2005), Mukhtar and Ahmed (2006), Borah (2019).

The isolated fungus grew into a colony which had a smooth, spherical shape and grew at a medium rate (4-5 days). The colony colour ranged from black, grey, and white-grey which had a fluffy, dense texture. The growth rate of the isolate ranged from 65 – 70 mm. On PDA, conidia generated by *C. truncatum* isolates were abundant and morphologically consistent.

Table 1: Disease Rating scale

Scale	Description
0	No lesions/spots.
1	1% leaf area covered with lesions/spots.
3	1.1–10% leaf area covered with lesions/spots, no spots on stem.
5	10.1–25% of the leaf area covered, no defoliation; little damage.
7	25.1–50% leaf area covered; some leaves drop; death of a few plants; damage conspicuous.
9	More than 50% area covered, lesions/spot very common on all plants, defoliation common; death of plants common; damage more than 50%.

Table 2 :Meteorological data during the period of investigation

Dates of observation	Temperature(?C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days
	T_{max} (?C)	T_{min}(?C)	RH_{max} (%)	RH_{min} (%)		
05-09-2022	33.4	24.4	89	67	21.7	2
12-09-2022	31.9	23.5	91	72	42.8	3
19-09-2022	31.8	23.6	91	71	80.1	2
26-09-2022	32.8	23.2	91	70	81.2	2
03-10-2022	31.9	23.5	95	74	31	3
10-10-2022	31.8	22.7	91	71	2.9	1
17-10-2022	30.9	20.6	94	65	19.7	3

Source: Weather data at ICAR RC – NEH Region, NagalandCentre, Jharnapani, Medziphema – 797106

Single-celled, uninucleate, hyaline, falcate/curved with oil globule in cytoplasm, and with dimensions from the isolate of PDA ranging from 20.7 to 23.7 µm × 3.6 to 4.0 µm, *C. truncatum* conidia were detected. The setae that were seen were black, emerging from a mass of conidia that was mucilaginous and longer than the conidiophores. They were wider at the base and tapered towards the apex, measuring approximately 65.7 to 142.7 µm × 4.3 to 5.3 µm. Such findings were supported by literatures of various researchers, Jagtap and Sontakke (2009) on the morphological characters of conidia, the features of the colony growth and colour corroborated with the findings of Masoodi *et al*. (2013), while the dimensions and measurement of the conidia and setae mirrored the findings of Nagaraj (2013) and Boufleur *et al.* (2021).

The disease assessment came from the field in their natural setting. It has been found that numerous environmental factors influence the onset of disease. During the investigation period, the first week of September saw the onset of the disease symptoms. The disease incidence and severity in the crop during the *Kharif* season of 2022 were observed when the following climatic conditions prevailed: Temperature: 20.6 to 33.4°C, Relative Humidity: 65 to 95%, Rainfall: 2.9 – 81.2 mm, Number of Rainy Days: 1 – 3 in Medziphema, Nagaland (Table 2).

These weather patterns were shown to be favorable for both the occurrence and severity of the disease, which shows that a warm, humid environment favors the onset of anthracnose/pod blight in the field. This is supported by the findings

Table 3: Percent Disease index in different cultivars of soybean infected with anthracnose

Cultivars	Percent disease index (%)							
	5th Sept 2022	12th Sept 2022	19th Sept 2022	26th Sept 2022	3rd Oct 2022	10th Oct 2022	17th Oct 2022	Mean
JS 95-60	10.00 (18.43)	11.11 (19.43)	24.45 (29.58)	26.22 (30.76)	27.78 (31.64)	28.19 (32.06)	32.00 (34.43)	22.82
JS 335	16.67 (23.86)	17.11 (24.36)	20.00 (26.57)	27.78 (31.68)	28.89 (32.45)	37.78 (37.86)	48.89 (44.36)	27.68
Shivalik	10.00 (18.43)	13.33 (21.14)	13.33 (21.14)	22.22 (28.03)	23.97 (29.25)	28.89 (32.41)	33.33 (35.22)	21.20
JS 93-05	15.56 (23.02)	20.22 (26.54)	22.22 (28.02)	25.11 (29.93)	31.49 (34.11)	34.44 (35.90)	53.33 (46.92)	28.91
Punjab 1	16.67 (23.86)	26.67 (31.00)	31.11 (33.89)	31.11 (33.86)	31.55 (34.07)	36.67 (37.22)	37.78 (37.92)	30.22
PK 472	10.00 (18.43)	15.56 (23.22)	20.00 (26.36)	23.33 (28.78)	23.33 (28.85)	24.45 (29.58)	27.78 (31.77)	20.63
NRC 7	12.22 (20.32)	15.56 (23.22)	20.00 (26.14)	22.22 (28.03)	33.33 (35.25)	35.56 (36.52)	40.00 (39.23)	25.55
PK 262	10.48 (18.88)	13.33 (21.14)	17.78 (24.63)	22.22 (28.07)	23.33 (28.85)	23.33 (28.78)	27.33 (31.46)	19.68
Monetta	27.78 (31.79)	28.00 (31.92)	31.33 (34.01)	36.67 (37.25)	39.78 (39.07)	46.67 (43.08)	48.89 (44.36)	37.01
MACS 1460	3.81 (6.59)	7.33 (15.37)	12.48 (20.59)	14.44 (21.92)	21.11 (27.34)	22.00 (27.78)	26.67 (31.00)	15.40
SEm±	2.38	2.00	2.19	2.22	1.80	2.07	1.58	
CD (P=0.05)	7.07	5.93	6.50	6.59	5.34	6.16	4.68	

Figures in the table are mean values and those in parenthesis are angular transformed values

Table 4: Correlation coefficient (r) of percent disease incidenceof different cultivars of soybean caused by *C.truncatum* with weather variables during September to October 2022

Cultivars	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	No. of rainy days
	Maximum	Minimum	Maximum	Minimum		
JS 95-60	-0.756*	-0.359	0.659	-0.109	-0.115	-0.120
JS 335	-0.487	-0.702	0.683	-0.198	-0.220	-0.281
Shivalik	-0.598	-0.702	0.707	-0.045	-0.103	-0.094
JS 93-05	-0.461	-0.672	0.797*	-0.076	-0.277	-0.246
Punjab 1	-0.482	-0.541	0.677	-0.016	-0.053	-0.059
PK 472	-0.655	-0.556	0.700	0.025	0.017	0.016
NRC 7	-0.664	-0.512	0.833*	-0.006	-0.317	-0.162
PK 262	-0.731	-0.548	0.726	0.014	-0.036	-0.009
Monetta	-0.587	-0.609	0.691	-0.169	-0.242	-0.240
MACS 1460	-0.689	-0.513	0.823*	0.000	-0.245	-0.125

y = Disease severity; x = Weather parameters

Table 5: Simple regression between disease severitycaused by *Colletotrichum truncatum* and weather variables during September to October 2022

Simple regression	Regression equation	B	SE(b)	t value	Pr> |t	R^2
Maximum temperature (°C)	y = 0.116x + 34.96	-3.321	1.867	-1.779	0.135	0.388
Minimum temperature (°C)	y = -0.063x + 24.87	-5.753	3.382	-1.701	0.150	0.367
Maximum relative humidity (%)	y = 0.281x + 83.83	2.079	0.781	2.661*	0.045 (<0.05)	0.586
Minimum relative humidity (%)	y = -0.077x + 72.5	-0.064	0.405	-0.159	0.880	0.005
Rainfall (mm)	y = -0.315x + 16.25	-0.112	0.262	-0.428	0.686	0.035
Number of rainy days	y = -0.01x + 0.677	-2.526	7.027	-0.359	0.734	0.025

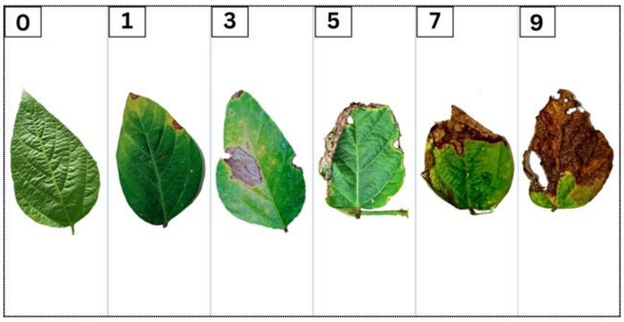

Fig.1: Disease spread as evidenced and following rating scale from 0 to 9 (Mayee and Datar (1986). Ratings are assigned based on standardized criteria for symptom manifestation and severity assessment.

of Gurjar (2021) where in his study reported that maximum temperature (28.5- 33.3°C), minimum temperature (17.1-21.3°C), maximum RH (76-93%), minimum RH (39-79%) and rainfall (7.2-165 mm) remained most favorable for anthracnose disease development.

The disease severity was noted on ten different soybean cultivars over the course of seven weeks for the correlation assessment which ranged from 3.81 (MACS 1460) to 48.89 (Monetta and JS 335) and their PDI ranged from 15.40 to 37.01 for MACS 1460 and Monetta respectively (Table 3).

The analysis of the relationships between the weather parameters and the severity of the disease revealed that the maximum temperature had a negatively significant correlation with 'r' values (JS 95-60 = -0.756) while maximum relative humidity showed a positive significant correlation (JS 93-05 = 0.797, NRC 7 = 0.833, MACS 1460 = 0.823) with the disease severity during the critical period from the first week of September to the third week of October 2022 (Table 4).

However, there was no correlation between the minimum temperature, minimum relative humidity, the total amount of rain, the number of rainy days, and the anthracnose severity. Such differences in the severity of anthracnose, its widespread incidence, and its correlation with meteorological variables, were also recorded by earlier researchers (Rana and Khushal, 2005; Kulkarin, 2009; Mali, 2012). Negative correlation was observed in minimum temperature and disease severity for cultivar JS 95-60 (-0.756) and relative humidity and disease severity were found to be positively correlated for cultivars JS 93-05 (0.797), NRC 7 (0,833) and MACS 1460 (0.823). The findings also corroborated with the study of Dnyanoba (2014) who carried out a research on the prevalence of anthracnose in the soybean cultivars JS-335 and MAUS-71 and reported that there was a significant but negative correlation with temperature (max and min).While the results were in direct opposition to Gurjar (2021) findings from studies he conducted to examine the relationship between weather variables and the severity of disease.

Between disease severity (PDI) of anthracnose and meteorological variables, a linear regression was fitted. This was carried out in order to determine the degree of association between the independent variable (x) which is the weather parameters and the dependent variable (y) which is PDI. The R^2 values of independent variables were as follows: temperature 0.388 (max),0.367 (min); relative humidity 0.586 (max), 0.005 (min); rainfall 0.035 and number of rainy days 0.025 (Table5).

A more detailed understanding of the impact of weather variables on disease severity can be obtained from the regression table. Table 5 illustrates the relative contributions of the following factors to the onset and severity of the disease: maximum temperature 38.8%; minimum temperature 36.7%; maximum relative humidity 58.6%; minimum relative humidity 0.5%; rainfall about 3.5%; and number of rainy days only 2.5%.

Through the present investigation it is plausible to conclude that weather variables does play role in the onset and progression of the disease anthracnose incited by *C. truncatum*. Plant diseases are greatly influenced by weather conditions, and understanding how various weather factors interact to cause severe infections in the field may assist with creating models that forecast for the progression of the disease, so that vital strategies for management can be applied at a favorable time. Early implementation of management practices will help to lessen the need for chemical spraying, stop major infection outbreaks, and reduce production losses. The results of the current study, depending on the analysis, can aid in disease prediction.

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DECLARATIONS

Conflict of Interest: Authors declare no conflict of interest.

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