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Effect of Epidemiological Factors on Anthracnose Disease Development in Green Gram Incited by *Colletotrichum truncatum* in Arid Ecosystem of India

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ABSTRACT

Background: Green gram is attacked by various fungal diseases out of which anthracnose incited by *Colletotrichum truncatum* is predominant in Arid Ecosystem of Rajasthan, India. Occurrence and development of anthracnose disease is significantly affected by epidemiological conditions during the cropping period.

Methods: Epidemiological data collected from ARS, SKRAU, Bikaner for two consecutive years (2023 and 2024) from which disease predictive model was developed for susceptible varieties through stepwise multiple regression.

Result: The results revealed that Tmax, morning and evening relative humidity were statistically significant. Whereas, the Tmin and rainfall (RF) were statistically non-significant. Weather parameters showed significantly correlated with PDI were used to develop suitable anthracnose disease prediction model for susceptible varieties (on pooled basis) of green gram.

Key words: Anthracnose, Arid ecosystem, *Colletotrichum truncatum,* Epidemiological factors, Green gram.

INTRODUCTION

Green gram (*Vigna radiata* L.) belongs to the family *Leguminosae* is one of the most important pulse crops. It is also called as Golden gram because of its nutritional richness (Kaur *et al.,* 2023) and improving the soil fertility by the addition of nitrogen (30 kg/ha/annum) through nitrogen fixation (Guan *et al.,* 2013; Khatik *et al.,* 2022). It is a short duration and fast-growing pulse crop grown in summer and *kharif* season with the least input requirements. It also performs well under heat and drought conditions (Pratap *et al.,* 2013). In India, it is largely growing in the states including Rajasthan, Maharashtra, Madhya Pradesh, Orissa, Andhra Pradesh, Tamil Nadu and Uttar Pradesh. It is primarily cultivated during the *Kharif* season, covering an area of 15.93 million hectares and yielding a production of 3.74 million tonnes (Anonymous, 2022).

The major constraints in cultivation and production of green gram *viz.*, due to abiotic stresses, unavailability of resistant cultivars, insect pests and diseases (Kaur *et al.,* 2023). It is affected by nearly sixty fungal, three bacterial and five viral diseases. Among fungal diseases namely powdery mildew, anthracnose, cercospora leaf spot, web blight and dry root rot are the most prevalent (Shukla *et al.,* 2014; Kumar *et al.,* 2024). Fungal pathogen, *Colletotrichum truncatum* (Schw.) causes anthracnose is one of the economically important diseases which occurs globally, wherever it is cultivated (Marak *et al.,* 2019).

In green gram, anthracnose causes significant damage by reducing both seed quality and yield, with yield losses estimated to range from 18.20 to 86.50% due to involvement of pathogen during both pre- and post-harvest (Roopadevi *et al.,* 2015).

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Environmental factors including temperature, relative humidity, bright sunshine hours and rainfall which play an important role in deciding the severity and spread of any disease over time (Pokhrel, 2021). For the establishment of disease, led by susceptible host, virulent pathogen and weather conditions. Therefore, before proposing the effective management strategy, a comprehensive knowledge is required regarding the epidemiology of the disease. Anthracnose disease, favoured by hot and humid environmental conditions. Temperature nearly 27±2°C coincide with relative humidity of 80% is the most optimum conditions for successful establishment of the disease (Kaur *et al.,* 2014; Aggarwal *et al.,* 2015; Kaur *et al.,* 2023). The disease development also depends on the host cultivar, along with its resistance nature against the pathogen.

Various disease prediction models have been developed till date such as downy mildew in pearl millet (Kumar *et al.,* 2010), anthracnose in betel vine (Sahoo *et al.,* 2012), early blight in potato (Saha and Das, 2013), anthracnose in crops like soybean (Bhatt *et al.,* 2022) and black pepper (Verma and Chakrawarti, 2022) and Alternaria leaf spot in apple (Huang *et al.,* 2022) is very crucial for understanding the effect of weather factors on host-pathogen interactions. These models provide valuable insights for monitoring and analyzing the dynamics of plant disease epidemics, quantifying potential crop losses and developing effective disease management strategies (Nutter, 2007). Therefore, the present study was formulated to study the correlation of epidemiological factors with the severity of anthracnose disease of green gram and also to find out the combination of weather conditions responsible for the occurrence of the disease under field conditions.

MATERIALS AND METHODS

A two-year field study was carried out in 2023 and 2024 at the Experimental Farm, College of Agriculture, SKRAU, Bikaner (28.0939°N, 73.1838°E, 223.88 m), India to investigate the role of weather factors on anthracnose disease on sixteen green gram varieties/genotypes *viz.* Vasudha, PDM 139, Heera, Virat, IPM-02-03, GM 7, Soorya, Kanika, Shreya, MH 421, Narsha, Megha, Pusa Vishal, Pusa 1431, MH 125 and Pusa 1033. The sowing of all sixteen varieties was done on 1st July, 2023 and 16th July, 2024, in a randomized block design (RBD) with three replications. Each experimental plot measured 3 × 3 m2 with of spacing 30 cm × 10 cm. The experimental field soil was sandy loam with a pH of 8.4. All the required agronomical practices of a crop were followed as well as no fungicides were sprayed and complete natural epiphytotic conditions were maintained for the proper establishment of disease in field.

Collection of data on weather factors

Weekly data on different weather parameters *viz.* maximum (T_{max}) and minimum (T_{min}) temperature, rainfall (RF), morning relative humidity (MRH) and evening relative humidity (EMH) were collected from the Agricultural Research Station (ARS), SKRAU, Bikaner, Rajasthan, India.

Per cent disease scoring

Randomly 30 plants marked (each replication) of each varieties/genotypes were selected and per cent disease index (PDI) at weekly interval, during 2023 and 2024 was calculated using the formula given by McKinney (1923):

$$\text{PDI} = \frac{\text{Sum of numerical disease rating}}{\text{Total no. of samples} \times \text{Maximum disease grade}} \times 100$$

Disease reaction of each variety was determined by using rating scale (1-9) given by Xu *et al.* (2023). The mean area under the disease progress curve (AUDPC) for each replicate was calculated as follows (Pandey *et al.,* 1989).

$$\text{AUDPC} = \sum_{i=1}^{k} \frac{1}{2} (\text{Si} + \text{Si} - 1)\, \text{d}$$

Where,

k = No. of successive evaluation of disease.

i = Period.

Si = Last disease severity.

Si -1 = First disease severity.

d = Time interval.

Data analysis

Correlation analysis was carried out between weekly PDI and weather parameters such as maximum (T_{max}) and minimum (T_{min}) temperature, rainfall (RF), morning relative humidity (MRH) and evening relative humidity (EMH) for pooled data. All sixteen green gram varieties/genotypes were classified in to two groups such as susceptible and non-susceptible based on disease reaction. Stepwise multiple regression analysis was used for the development of models for susceptible and non-susceptible varieties against anthracnose disease in green gram varieties/ genotypes by using SPSS software.

RESULTS AND DISCUSSION

Effect of epidemiological factors on anthracnose disease occurrence

Data presented in Table 1 showed that the PDI, disease reaction and AUDPC for anthracnose disease of green gram for sixteen varieties/genotypes screened under artificially inoculated conditions. The incidence of anthracnose was at their peak in last July-early August (2023) and last August-early September (2024), during which the weather parameters including relative humidity morning (RHM) and relative humidity evening (RHE) were also high. Incidence of disease were considerably reduced from September in both the years. Among various epidemiological parameters studied, RHM (0.701**- 0.885**) and RHE (0.817** - 0.925**) (Table 2) were found statistically significant and positively correlated whereas, T_{max} (-0.764** to -0.872**) was found statistically significant and negatively correlated with anthracnose disease of green gram (**Represent significant at 1%).

Stepwise multiple regression (SMR) model

Epidemiological factors recorded statistically significant were used for development of SMR model through stepwise multiple regression analysis. 50% of the varieties/ genotypes were found to be susceptible for anthracnose disease. Mathematical model for anthracnose disease of green gram prediction for susceptible varieties/genotypes is:

$$Y = -68.66 - 0.94\,(T_{max}) + 0.54\,(\text{RHM}) + 0.56\,(\text{RHE})$$

T_{max} and RHM and RHE showed 64.32% variability in susceptible varieties/genotypes (R^2 = 0.98 and R^2_{adj} = 0.93).

The present investigation showed that disease severity is highly influenced by various weather parameters and it also showed that a positive correlation with relative humidity whereas negative correlation with temperature on PDI for both 2023 and 2024. The present findings are in line with the observations of other researchers in developing prediction models for disease assessment. Bhattiprolu and Monga (2018) studied multiple regression of pooled data (2013-2016) on Alternaria leaf spot showed T(max), T(min), number of rainy days and wind speed which

Table 1: Per cent disease index (PDI), disease reaction and area under disease progress curve (AUDPC) for anthracnose of green gram of different varieties/genotypes (2023 and 2024).

Varieties/ genotypes	PDI (%) 2023	PDI (%) 2024	PDI (%) Pooled	Disease Reaction	AUDPC 2023	AUDPC 2024	AUDPC Pooled
Vasudha	6.21 (14.43)	12.91(21.06)	9.56 (18.01)	R	43.47	86.42	64.94
PDM 139	55.79 (48.32)	58.45 (49.86)	57.12 (49.09)	S	386.96	393.33	390.15
Heera	24.98 (29.99)	26.67 (31.09)	25.83 (30.54)	MR	172.74	175.64	174.19
Virat	41.65 (40.19)	43.48 (41.25)	42.56 (40.72)	MS	287.71	291.89	289.80
IPM 02-03	28.20(32.07)	30.02 (33.22)	29.11 (32.65)	MR	195.81	200.79	198.30
GM 7	53.52 (47.02)	55.55 (48.19)	54.54 (47.60)	S	371.00	373.03	372.02
Soorya	9.10 (17.56)	11.71 (20.01)	10.41 (18.82)	R	63.32	78.02	70.67
Kanika	8.66 (17.11)	10.03 (18.46)	9.35 (17.80)	R	59.36	66.64	63.00
Shreya	37.93 (38.01)	39.48 (38.93)	38.70 (38.47)	MS	264.77	265.97	265.37
MH 421	71.79 (57.92)	72.79 (58.56)	72.29 (58.24)	HS	487.32	489.06	488.19
Narsha	52.67 (46.53)	53.34(46.92)	53.01 (46.72)	S	366.29	355.70	360.99
Megha	37.34 (37.67)	37.97 (38.04)	37.66 (37.85)	MS	257.90	254.21	256.06
Pusa Vishal	43.57(41.31)	44.86 (42.05)	44.22 (41.68)	MS	301.19	294.05	297.62
Pusa 1431	23.17 (28.77)	24.95 (29.97)	24.06 (29.37)	MR	161.22	166.53	163.88
MH 125	30.28 (33.38)	34.32 (35.86)	32.30 (34.63)	MR	210.29	230.55	220.42
Pusa 1033	7.63 (16.04)	8.06 (16.49)	7.85 (16.27)	R	53.41	53.62	53.52

Table 2: Correlation between per cent disease index (PDI) of anthracnose of green gram in relation to weather parameters of different varieties/genotypes (Pooled basis).

Varieties	Weather parameters (Pooled basis)				
	T_{max} (°C)	T_{min} (°C)	RHM (%)	RHE (%)	RF (mm)
Vasudha	-0.788**	-0.493	0.838**	0.918**	0.256
PDM 139	-0.773**	-0.407	0.872**	0.925**	0.297
Heera	-0.843**	-0.492	0.814**	0.863**	0.152
Virat	-0.796**	-0.387	0.859**	0.886**	0.252
IPM 02-03	-0.787**	-0.477	0.828**	0.910**	0.225
GM 7	-0.777**	-0.388	0.885**	0.895**	0.303
Soorya	-0.827**	-0.431	0.831**	0.873**	0.207
Kanika	-0.847**	-0.517*	0.701**	0.820**	0.098
Shreya	-0.799**	-0.435	0.795**	0.894**	0.183
MH 421	-0.872**	-0.529	0.771**	0.853**	0.125
Narsha	-0.844**	-0.471	0.778**	0.848**	0.134
Megha	-0.825**	-0.488	0.758**	0.848**	0.135
Pusa Vishal	-0.845**	-0.535*	0.764**	0.817**	0.156
Pusa 1431	-0.785**	-0.449	0.860**	0.923**	0.294
MH 125	-0.819**	-0.440	0.791**	0.842**	0.136
Pusa 1033	-0.764**	-0.449	0.861**	0.923**	0.286

** Significant at 1% probability; * Significant at 5% probability; T_{max}= Maximum temperature; T_{min}= Minimum temperature; MRH= Morning relative humidity; ERH= Evening relative humidity; RF= Rainfall.

gradually influenced the (R^2 =0.984) disease development whereas, T(min) and evaporation influenced the development of grey mildew disease in cotton (R^2 = 0.976). Moreover, results of Kulkarni (2019) also supported the present investigation who found negative correlation with temperature and a positive correlation with relative humidity and rainfall on PDI and spore load of mung bean anthracnose disease. Similarly, the results of Amrate *et al.* (2021) also in confirmation with the present study who developed a disease forecasting/prediction model for Rhizoctonia aerial blight of soybean with three significant weather variables (mean RH, T_{min} and rainfall).

CONCLUSION

The anthracnose disease of green gram is significantly influenced by epidemiological parameters including morning and evening relative humidity in Arid ecosystem of Rajasthan, India. Epidemiological factors found statistically significant were considered for the construction of models for commonly grown green gram varieties.

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Conflict of interest

All authors declared that there is no conflict of interest.

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