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Short Communication

Temporal progress and spatial distribution of phytophthora blight of pigeonpea in Deccan plateau of India

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Pigeonpea [*Cajanus cajan* (L.) Millsp.], is the fourth most important food legume in the world after dry bean (*Phaseolus vulgaris* L.), field pea (*Pisum sativum* L.) and chickpea (*Cicer arietinum* L.). Globally it is cultivated in 5.41 m ha with an annual production of 4.49 m tones and India alone contributes 72.5% of world cultivated area with 62.5% of world production.In India, pigeonpea is the second most important food legume crop after chickpea. It is a multipurpose crop, being grown not only for grain but also for fuel and fodder (Nene and Sheila, 1990).

Phytophthora blight caused by *Phytophthora cajani* is a potentially important disease of pigeonpea in India after wilt and sterility mosaic disease (Kannaiyan *et al*., 1984). The first suspected occurrence of PB on pigeonpea in India was reported in 1966 by Williams *et al*., (1968). Though the disease is sporadic in nature, occasionally it assumes epidemic proportions in places of heavy and frequent rainfall leading to mortality of young plants (Kannaiyan*et al*., 1984). The disease caused heavy plant mortality at seedling and vegetative stages, resulting in poor plant stand and lower yield (Mishra and Shukla, 1987). Characteristic symptoms of the disease are water-soaked lesions on the leaves and slightly sunken lesions on stems and petioles. Lesions girdle the stem and the foliage dries up (Vishwa Dhar *et al.,* 2005).

Recurrence of PB as a major threat to pigeonpea production and productivity in the Deccan Plateau of India, irrespective of cropping system, soil type and cultivars (Sharma *et al*., 2006).Further, the disease has been spreading at an alarming rate all over the pigeonpea growing tracts during the last 15 years. The knowledge of weather parameters *viz*.temperature, relative humidity,rain fall and soil type on disease development is a prerequisite to predict the occurrence of the disease.In this context a periodical survey was conducted at ICRISAT, Patancheru to establish correlation between weather parameters and development of disease. Further a roving survey was also conducted in major pigeonpeapockets of India to record the occurrence and distribution of PB disease.

Survey area and assessment of disease

Periodical survey was conducted in last week of July, August, September, October and November during 2012 and 2013 in the pigeonpea fieldsof ICRISAT, Patancheru.A total of 39 pigeonpea fields were selected irrespective of soil type and cultivars to document and to determine correlation between weather parameters and development of disease. Additionally a roving survey was conducted between second and third week of August 2012 and 2013 in the three major pigeonpea growing states (Telangana, Karnataka and Maharashtra) in DP, India. Stops were made after every 10-20 km en-route depending on the frequency of the crop. Total 109farmers fields in three states (19 fields in Andhra Pradesh, 32 in Karnataka and 58 in Maharashtra) in DP, India were surveyed for PB incidence. The crop was in active vegetative growth stage (30-60 days) during the survey. The per cent disease incidence (PDI) was calculated based on total number of plants present and number of plants showing typical PB symptoms.Average PDI of a location = Sum of the average per cent incidence in individual fields/Total number of fields surveyed.

The weather parameters of ICRISAT location was correlated to periodical incidence of the disease at same location by using the Karl Pearson's correlation coefficient (r). Further, the data were subjected to multiple linear regression analysis to find out the linearity of the independent variables for prediction.

The disease severity was graphically analyzed for estimation of disease development and to predict the intensity. The 2nddegree polynomial model was used to estimate the disease progression. $Yx = a + b_1X + b_2X^2 + b_3X^3$ Where, Yx: Expected disease severity at time x, X: Time interval in days, a : Intercept and b_i : Coefficient, Where, a

Table 1: Temporal progress of disease

S. No.	Field number	Soil type	Per cent disease incidence at different DAS*				
			30	60	90	120	150
***Kharif*-2012**							
1	RCW-01	Red	08.0	09.0	10.0	12.0	15.0
2	BP-05	Black	21.0	24.0	28.0	35.0	38.0
3	BP-15B	Black	36.0	40.0	44.0	57.5	59.0
***Kharif*-2013**							
1	RCE 23 A	Red	12.5	19.0	22.0	22.0	22.0
2	DHF 04	Red	5.3	7.1	9.0	11.3	14.3
3	BP 14 A	Black	11.0	13.8	17.1	27.0	29.8
4	BP 14 B	Black	0.0	0.0	15.0	17.4	21.0
5	BP 14 C	Black	11.0	18.0	48.3	52.0	55.0
6	RL 17	Red	20.0	26.0	29.0	31.0	32.0

*Mean of five replications.

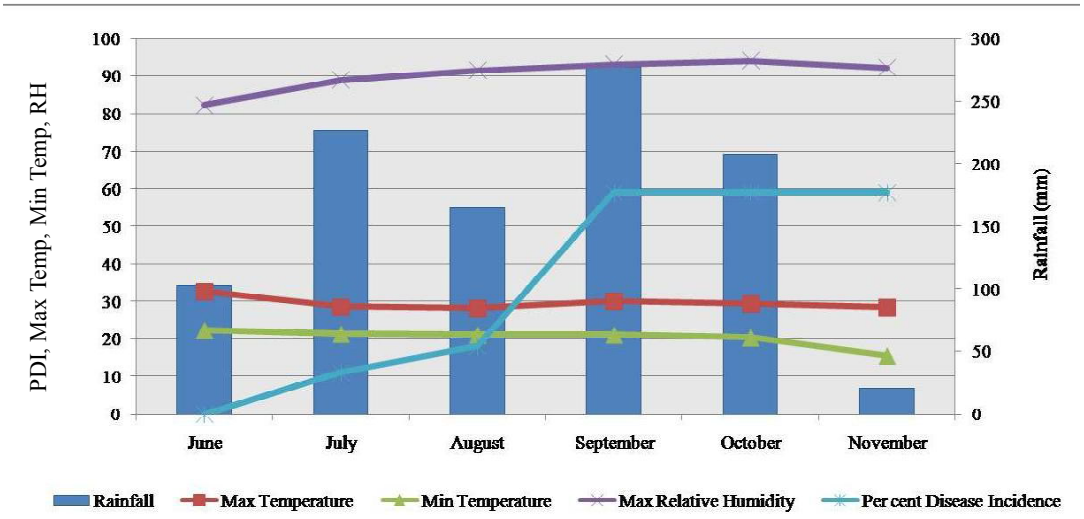

Fig.1: Influence of weather attributes on incidence of Phytophthora blight disease

Table 2: Correlation of weather attributes and incidence of Phytophthora blight disease

S. No.	WeatherParameters	*kharif* - 2012	*kharif* - 2013	Pooled data of *kharif* 2012 and 2013
1	Rainfall	0.98**	0.96**	0.95**
2	Max. temp (T_{max})	0.84*	0.70	0.48
3	Min. temp(T_{min})	-0.93**	-0.57	-0.42
4	Max. RH(RH_{max})	-0.41	0.51	0.92**
5	Min. RH(T_{min})	-0.99**	-0.83*	-0.54

* Significant at 5 per cent probability level, ** Significant at 1 per cent probability level

and bi are intercept and regression coefficients, respectively for Yx indicated expected disease severity at time x of seven days interval (Snedecor and Cochran, 1989).

The data were statistically analyzed using the SAS 9.2 version developed by the SAS institute, NC, USA. The percentage values of the disease incidence were transformed

Table3: Spatial distribution of disease during *kharif* 2012 & 2013

State	District	PDI (%)	State	District	PDI (%)
kharif - 2012			*kharif* -2013		
Telangana	Adilabad	1.00	Telangana	Rangareddy	5.80
	Rangareddy	14.35		Mahbubnagar	2.90
Karnakata	Gulbarga	11.10	Karnataka	Glubarga	8.90
	Bidar	30.21		Bidar	5.80
Maharashtra	Hingoli	11.00		Bellary	11.58
	Akola	32.85	Maharashtra	Aurangabad	9.10
	Amravati	5.77		Buldhana	2.59
	Yavatmal	11.68		Akola	2.57

to arcsine. Data was subjected to analysis of variance (ANOVA) at two significant levels ($P< 0.05$ and $P< 0.01$) and means were compared by Tukey's Honesty significant difference (HSD).

Temporal progress of disease

The percent disease incidence varied during both the years of study (Table 1).In*kharif* 2012, the disease incidence ranged from 0.0 to 59.0 per cent with an average incidence of 7.47 per cent. Among all 15 fields,field no. BP-15B showed the highest disease incidence (59.0 %), followed by BP-05 (38.0 %) and RCW-01 (15.0 %).In *kharif* 2013, the disease incidence ranged from 0.0 to 55.0 per cent with an average incidence of 7.25 per cent. Among the twenty four pigeonpea fields the field no. BP-14C showed the highest incidence of 55.0 per cent followed by RL-17 (32.0 %).

The disease incidence occurred irrespective of the soil type and pigeonpeagenotypes grown in both the years. The variation in disease incidence in different pigeonpea fields may be due to varied distribution of soil inoculum and inoculum potential of the pathogen and varieties cultivated with different genetic makeup.

Correlation and multiple regressions analysis

Correlation of incidence of the disease and weather parameters for *kharif* 2012 and 2013 indicated that cumulative rainfall, average maximum temperature and average maximum relative humidity showed positive correlation, whereas average minimum temperature and average minimum relative humidity showed negative correlation. However, cumulative rainfall and average maximum relative humidity had significant positive correlation at both 0.01 and 0.05 probability level(Table 2, Fig. 1).A simple linear regression disease prediction model was developed depicting maximum correlation with given PDI, which can be used to predict the incidence of disease.

$$PDI = 67.20 + 0.10 * Rain - 1.64 * T_{max} + 0.26 * RH_{max} \qquad R^2 = 0.94^{**}$$

Kumar and Gupta (2016) showed that the correlation coefficient of *Bemisia tabaci* population (vector of potato apical leaf curl virus disease) was significantly and positively correlated with the different weather variables.Kumar*et al*. (2018) reported that high soil moisture positively correlated with high incidence of black scurf disease of potato caused by *Rhizoctonia solani.* The present study reveals that the high rainfall period caused water stagnation which favored the multiplication and spread of inoculum of *P. cajani*. Similar observations were made by Kannaiyan*et al*.,(1984) and Sharma *et al*.,(2006)that low lying, poorly drained soil with high soil moisture was conducive for the incidence of Phytophthora blight. Agarwal *et al*. (2002) reported that, sporangia were formed during the period with low maximum temperature (24.0-28.5 ^{o}C), high relative humidity (88-100 %) and 100 % rainy days.

Occurrence and distribution of disease

In the study, widespread occurrence of PB in pigeonpea was noticed in across the fields in Telangana, Karnataka, Maharashtra and Madhya Pradesh and incidence ranged from 1.0-14.35 %, 30.21 %, 5.77-32.85 %and 11.30 %, respectively (Table 4). Of all the districts, Akola showed the highest incidence of 32.85 per cent followed by Bidar (30.21 %), while least incidence was recorded in Adilabad (1.0 %). During *kharif* 2013, Disease incidence ranged from 2.9 – 5.8 % in Telangana, 5.8-11.58% in Karnataka, 0.0-9.1 % in Maharashtra and 15.96% in Madhya Pradesh.Of all districts Sehore showed highest disease incidence (15.96 %) followed by Bellary (11.58 %).

The intermittent rains during cropping season followed by low levels of field topography and poor soil

surface drainage is probably predisposed the pigeonpea crop for PB development in Deccan Plateau. High incidence of PB could be due to that resulted in water stagnation and favored the multiplication and spread of soil inoculum. The varied disease incidence from locality to locality because of environmental conditions especially rainfall, cropping patterns of the location and distribution of inoculum in the soil, inoculum potential of the pathogen and existence of the physiological races in the pathogen.

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