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Effect of weather factors on brown leaf spot disease development in potato caused by *Alternaria alternata*

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Abstract
Brown leaf spot disease of potato caused by *Alternaria alternata* has been known as one of the destructive and common diseases of potato and can occur over a wide range of climatic conditions. The field experiment was carried out to study the effect of various weather factors such as maximum and minimum temperature, relative humidity, wind velocity and sun shine on brown leaf spot disease development and progression on potato during Rabi, 2018-19. Results indicated the progression of the disease was varied from 1.68% during 5-11th January, 2019 (1st SMW) to maximum progression 18.18% during 9-15th February, 2019 (6th SMW), appeared the most favorable time for faster disease development. Results of present study found that disease severity were significantly positive correlated with minimum temperature and sunshine (hours), while non-significantly correlated with maximum temperature and wind velocity and only relative humidity had negative correlation with brown leaf spot disease severity.

Keywords: Brown leaf spot, weather factors, correlation, *Alternaria alternata*, multiple regression, disease development

Introduction
Potato (*Solanum tuberosum* L.) belongs to the family Solanaceae, is the third maximum critical international meals crop in phrases of intake and known as 'King of vegetables', grown for its starchy fit to be eaten tubers and is grown in tropics in addition to sub-tropics in the course of the cool as well as dry seasons. Potato is used as mainly as vegetable and in form of processed products including 'potato chips', 'sliced' or 'sliced potatoes' etc., inventory feed and in industries for manufacturing of starch, alcoholic liquids and other merchandise. Potato contained carbohydrates (22%), proteins (2%), fats (zero.1%), water (seventy four %) along side minerals and hint elements *viz*. Potassium, sodium, iodine and magnesium, folic acid, pyridoxine, vitamin C, ascorbic acid and Iron (Sahar *et al*., 2017) [16]. Potatoes yield about 97 kilo calories per a hundred g fresh weight, that's a great deal less than cereals. Potato is fourth most important staple food crop within the global after maize, wheat, and rice, globally cultivated in extra than 20 million hectares with a complete global production of 359 million lots in 2020 (FAO, 2020) [5]. India is biggest producer of potato after china nearly one third of overall potato is harvested via both countries. India produced 53.03 million tones of potato from 2.Sixteen million hectare area with a median yield of 24.Fifty five t/ha during 2018-19, cultivated in nearly all states, among them Uttar Pradesh, West Bengal, Bihar, Punjab and Gujarat are the main kingdom. In Chhattisgarh, potato is grown over an area of 556.Eighty three thousand hectares with a production of 659.66 thousand tones (Anon., 2019) [1].

The intensive and extensive potato cultivation below the maximum favorable environmental conditions in the country failed because of some of production constraints and because of several biotic and abiotic stresses. Fungal, bacterial, nematodes and virus diseases are the main biotic stresses for potato (Stevenson *et al*., 2001) [18]. Among the foliar sicknesses, early blight and brown leaf spot ailment are noticeably negative both below subject and post-harvest level. The devastating potato sickness brown spot is due to Alternaria alternata (Fries) Keissler could be very not unusual and damaging in an area of high moisture and it is disbursed over a extensive variety of climatic situations (Rotem, 1994) [15]. Foliar lesions appear as small, irregular to circular, dark brown spots on lower leaves and range in size from pin point to 1/8 inch, leads to drying out leaflets, often confused with those caused by *Alternaria solani* except for the absence of concentric rings within the necrotic spots (Van der Waals *et al*., 2011) [19]. Yield losses due to brown leaf spot disease were estimated around 30% in South Africa (Van

der Waals *et al*., 2011) [19] can be reached up to 80% in North America if the disease left uncontrolled (Soleimani and Kirk 2012) [17]. Kirk and Wharton (2012) [8] have been reported around 20% yield losses, however there have been cases of 70–80% yield losses, where the disease has been left uncontrolled. These losses can be increased when the disease is combined with other diseases like early blight, black-leg and *Verticillium* wilt (Jansky *et al*., 2008) [7]. The brown spot also appear as necrotic lesion on tuber especially under storage as black pit (Nolte, 2008) and reported post-harvest losses as high as 10% (Boyd, 1972) [2]. Extent of damage greatly depend upon environment conditions, cultivar, aggressiveness of pathogen, post-harvest handling etc. (Droby *et al*., 1984) [4]. *Alternaria alternata* causes leaf spot and blight on many crops such as soybean, tomato, potato, carrot with heavy losses (Nelson, 2001) [10].

Climate factors temperature, relative humidity and rainfall play a key function in the improvement of the disease. Several studies had been carried out at the impact of environmental elements on diseases as a result of Alternaria alternata (Pandey *et al*., 2019; Punia *et al*., 2021) [13, 14] and mounted correlation between climate elements and disorder severity. The present look at will supply an concept approximately the connection between the climate factors and brown leaf spot sickness of potato, that allows you to also allows in to develop the ideal prediction model for the brown leaf spot sickness in potato.

Materials and Methods

The effect of weather factors such as maximum and minimum temperature, relative humidity, wind velocity and sun shine hours on brown leaf spot disease development on potato was studied during Rabi, 2018-19 at Instructional and Research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur. A highly susceptible potato variety "Kufri Pukhraj" was sown on 21th November, 2018 following RBD design with three replications at recommended spacing. The standard agronomic practices were followed without any protection measures taken related to any diseases. Ten plants were selected at randomly, labeled and severity of brown leaf spot disease was recorded from first day of its appearance to till the end of the crop at an interval of seven days by using 0-5 disease rating scale as described by Pandey *et al*. (2003) [12] with little modification. The weather data during the crop period were obtained from Department of Agro Meteorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur. The weekly average data of weather factors had been correlated with ailment severity recorded at each seven days interval. To understand the relationship between the dependent variable i.e., ailment severity and independent variables i.E. Climate factors (Max. Temp., Min. Temp., RH, Wind pace and sun shine hours) multiple regression analysis became achieved by way of fitting equations.

The multiple regression analysis is as under:

$$Y= \alpha+\beta_1X_1+ \beta_2X_2+ \beta_3X_3+ \beta_4X_4+ \beta_5X_5$$

Where,
Y= PDI
X1 =Maximum temperature (°C)
X2 = Minimum temperature (°C)
X3 = Relative humidity (%)
X4 = Wind velocity (kmps)
X5= Sun shine (hrs)

Table 1: Description of disease rating scale (Pandey *et al*., 2003) [12]

Disease grade	Description of reaction
0	Free from infection
1	One or two necrotic spots on a few lower leaves of plants, covering nearly 1-10% of the surface area of the plant
2	A few isolated spots on leaves, covering nearly 11-25% of the surface area of the plant
3	Many spots coalesced on the leaves, covering 26-50% of the surface area of the plant
4	Irregular, blighted leaves, petiole covering 51-75% leaf area of the plant.
5	Whole plants blighted, leaf starting to fall, covering more than 75% leaf area of plant.

Result and Discussion

1. Disease development

This study clearly depicts the relationship between the weather factors such as temperature, relative humidity, wind velocity and sun shine with brown leaf spot disease of potato. The severity of brown leaf spot was varied from 1.68% to 67.34% during Rabi, 2018-19 and the lowest disease severity (1.68%) and highest disease severity (67.34%) were observed at 1st and 7th Standard meteorological week, respectively revealed that the disease development was initially slow but it gradually increased and reached maximum.

During disease development, the maximum temperature ranged from 25 °C (1st SMW) to 31.5°C (7th SMW) and minimum temperature was from 9 °C (1st SMW) to 15.8 °C (7th SMW), relative humidity was in ranged of 80.86% (6th SMW) to 88% (1st SMW), while wind velocity varied from 0.80 kmps (5th SMW)-2.03 kmps (4th SMW), and sun shine (hrs) was in ranged from 6.42 (1st SMW) to 8.5 (5th SMW).

The maximum disease severity (67.34%) was recorded during 16th to 22 February (7th SMW), when the average maximum and minimum temperature were 31.5 °C and 15.8 °C, RH 87.14%, wind velocity 1.73 kmph and sun shine 8.24 (hrs).

Disease progression was started with 1.68% disease severity at 45 DAS and gradually increased with varying rate. The progression of the disease was varied from 1.68% during 5-11th January (1st SMW) to maximum progression 18.18% during 9-15th February (6th SMW) appeared the most favorable time for faster disease development, after that in subsequent week (16.1% disease progression during 16-22th February) decreased progression was observed. The data clearly indicated that the disease progression was lowest during initial appearance of disease which start at early age of crop and gradually increased with varying rate during the entire cropping period, achieved maximum progression, however after that decreased disease progression was observed.

Fig 1: Field view of Experimental field affected with brown leaf spot disease

Table 2: PDI, Disease progression and Weather data during 2018-19 (Weekly avg.)

Date	SMW	PDI (%)	Temp. (Max.) (°C)	Temp. (Min.) (°C)	RH (Max.) (%)	WS (kmph)	SS (hrs)	Disease Progression (%)
5-11th January, 2019	1	1.68	25.0	9.0	88.00	0.91	6.42	1.68
12-18th January, 2019	2	6.31	27.8	10.5	81.15	0.83	7.00	4.63
19-25th January, 2019	3	11.45	29.8	11.7	86.14	1.33	7.45	5.14
26th Jan.-1st February, 2019	4	20.10	22.8	11.3	85.71	2.03	7.50	8.65
2-8th February, 2019	5	33.06	29.9	12.5	86.86	0.80	8.50	12.96
9-15th February, 2019	6	51.24	28.9	11.8	80.86	1.49	8.18	18.18
16-22th February, 2019	7	67.34	31.5	15.8	87.14	1.73	8.24	16.10

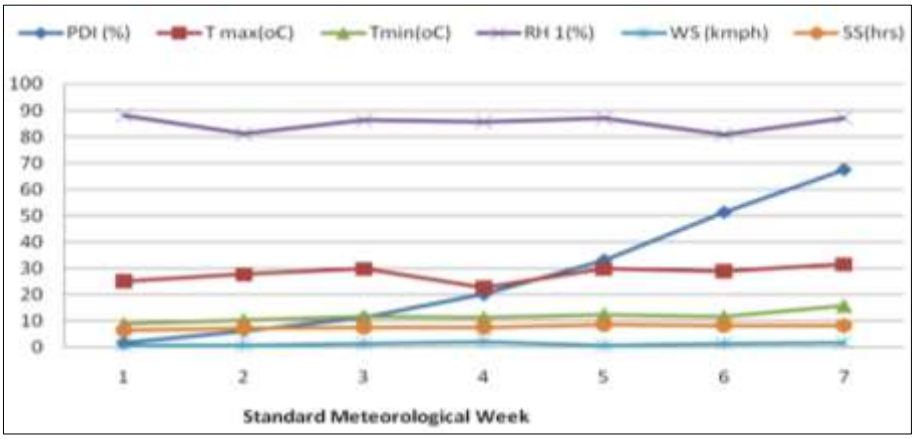

Fig 1: Effect of weather parameters on percent disease index (PDI) of brown leaf spot of potato during Rabi 2018

2. Correlation and multiple linear regression analysis of brown leaf spot severity of potato with weather parameters

The PDI obtained at weekly interval were correlated with weather parameters recorded. The correlation coefficients are presented in table-3 revealed that during 2018-19, maximum temperature (r = 0.58) was non-significantly positively correlated with PDI, minimum temperature (r = 0.87) was significantly positively correlated with PDI. Relative humidity (r = -0.05) was non-significantly negatively correlated with PDI, while wind velocity (r = 0.46) non-significantly positive correlated and sun shine (hrs) (r = 0.82) was found significantly positively correlated with brown leaf spot disease severity. The data are again subjected to multiple linear regression analysis.

The regression equation is

$Y= -48.958-0.019X_1+6.809X_2-1.109X_3+6.262X_4+10.720X_5$

With $R^2 = 0.84$

Where,
Y= PDI
X1 =Maximum temperature (°C)
X2 = Minimum temperature (°C)
X3 = Relative humidity (%)
X4 = Wind velocity (kmps)
X5= Sun shine (hrs)

The multiple regression suit changed into discovered notably significant for the statistics with R2=zero.84 for the PDI. The regression coefficients supplied in desk-four indicated that some of the five climate variables decided on for the observe, simplest minimum temperature and solar shine became located notably high-quality impact on PDI, even as most temperature and wind velocity confirmed wonderful non huge and best relative humidity changed into non vast terrible impact on PDI. In keeping with these fashions, the determined and expected PDI of brown leaf spot ailment of potato had been in near resemblance to every other at some point of 2018-19 because the data of table-five indicated.

These results are in agreement with the earlier studies by Ghewande (1986) who found that temperature between 25 °C to 29 °C and relative humidity of 87 percent were more favourable for the development of *Alternaria* leaf spot of groundnut incited by *Alternaria alternata*.

Similar results were also obtained by Pandey *et al*. (2019) [13] as they found that the average maximum and minimum temperatures and relative humidities were 29.7 °C, 13.6 °C and 87.5, 39.2 percent, respectively during 2002-03 for maximum *Alternaria* leaf spot disease development in chilli caused by *Alternaria alternata*. Punia *et al*. (2021) [14] recorded maximum increase in disease severity between first week of February and last week of February. During this period, the maximum and minimum temperature, relative humidity at morning and evening, maximum and bright sunshine hours and wind speed were higher, which was congenial conditions for severe infection of the *Alternaria* blight disease of mustard.

Table 3: Correlation between disease severities of brown leaf spot in relation to weather parameters during 2018-19

	Disease severity	T max (ºC)	T min (ºC)	RH (%)	WS (kmph)	SS (hrs)
Disease severity	1					
T max (ºC)	0.584^{NS}	1				
T min (ºC)	0.871^{**}	0.689^{*}	1			
RH 1 (%)	-0.051^{NS}	-0.048^{NS}	0.164^{NS}	1		
WS (kmph)	0.468^{NS}	-0.199^{NS}	0.450^{NS}	0.047^{NS}	1	
SS (hrs)	0.825^{**}	0.613^{NS}	0.783^{*}	-0.065^{NS}	0.280^{NS}	1

** Significant at 1% probability * Significant at 5% probability, NS= Non significant

Table 4: Multiple linear regression of disease severity of potato brown leaf spot in relation to weather parameters during 2018-19

Parameter	X_1 T max. (ºC)	X_2 T min. (ºC)	X_3 RH (%)	X_4 WS (kmph)	X_5 SS (hrs)
β -Value (RC)	0.019	6.809	-1.109	6.262	10.722
SE of β (r)	7.804	14.594	3.922	39.606	22.498
Intercept	-48.958				
R^2 value	0.84				
Multiple R-value	0.92				

Multiple linear regression equation

$Y= \alpha+\beta_1X_1+ \beta_2X_2+ \beta_3X_3+ \beta_4X_4+ \beta_5X_5$

$Y= -48.958-0.019X_1+6.809X_2-1.109X_3+6.262X_4+10.720X_5$

Table 5: Observed and predicted PDI of brown leaf spot of potato

SMW (Observation at 7 days interval)	PDI (%)	
	Observed	Predicted
1	1.677	-10.249
2	6.313	13.330
3	11.447	23.961
4	20.097	26.502
5	33.063	36.551
6	51.243	39.309
7	67.34	61.775

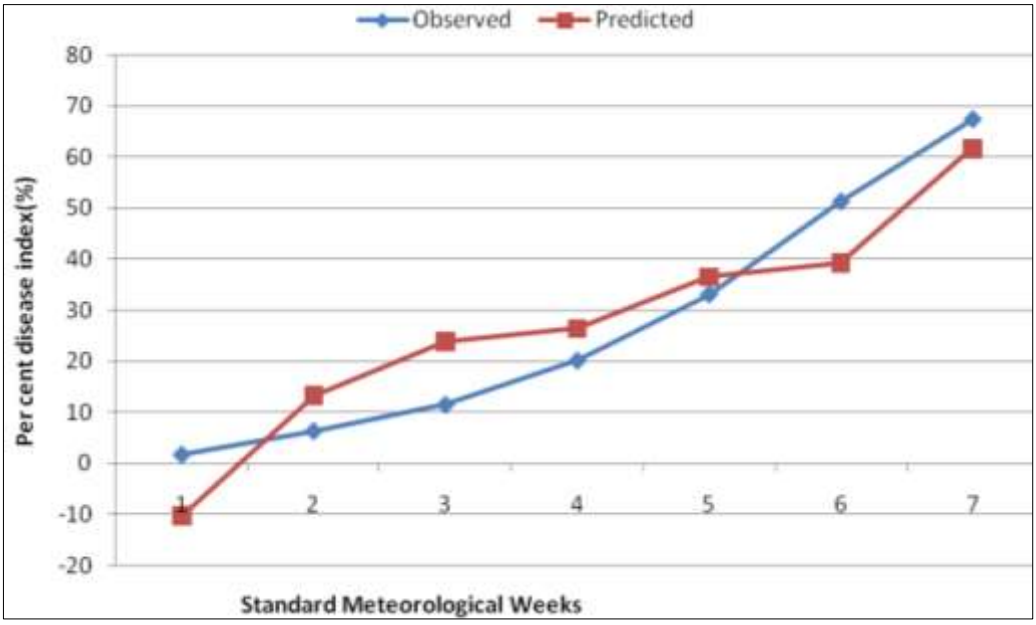

Fig 2: Observed and predicted PDI of brown leaf spot of potato during Rabi 2018

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