Original Research Article

Effect of weather factors on severity of early blight incited by *Alternaria solani* (Ellis and Martin) Jones and Grout in potato

Abstract

A study was conducted to find out the influence of weather factors, temperature, relative humidity, bright sunshine hour, rainfall, evaporation and wind speed and spore load on the incidence of *Alternaria solani* (Ellis and Martin) Jones and Grout induced early blight of potato (*Solanum tuberosum* L.) during 2019 to 2022. Eight weather factors taken from the agrometeorological observatory located at Anand Agricultural University, Anand, Gujarat, India, and were subjected to correlation analysis. The relationship between early blight and concerned weather parameters during *Rabi* 2020-21 revealed a highly significant positive correlation with evaporation (0.87) and maximum temperature (0.84) at the 0.01 level. PDI was significantly positively correlated with spore load (0.71) and bright sunshine hour (0.64) at the 0.05 level. Whereas Per cent Disease Intensity was negatively correlated with evening humidity (-0.78) at a 0.01 level. During the year *Rabi* (winter) 2021-22, a substantial negative correlation with evening humidity at the 0.05 level. PDI was positively correlated with spore load (0.79), bright sunshine (0.73) and evaporation (0.68).

Keywords: Correlation study, early blight, potato, spore load, weather factors

Introduction

The potato (*Solanum tuberosum* L.) is a perennial plant that belongs to the family *Solanaceae* and is native to the Andean plateau of South America. It is a popular source of carbohydrates and can be used both for table consumption and for many processed products. It is used primarily to make potato flour, potato chips, frozen potatoes and potato starch. Potatoes grow best at temperatures of 18-20 °C and relative humidity of 85-90 percent. It requires well-drained soil with a pH of 5.20 to 6.40 (Anonymous, 2008). Among potato-producing countries, China ranks first followed by India. The major potato-producing states in India are Bihar, Gujarat, Uttar Pradesh, Maharashtra, Madhya Pradesh, West Bengal, Punjab, Haryana and Assam with a total production of 48662 tons over an area of 2055 hectares and an average productivity of 23.67 tons per hectare in 2019-20 (Anonymous, 2020). While in Gujarat, potato is cultivated in an area of 118 million hectares with a production of 3616 MT accounting for average productivity of 30.6 T/ha during 2019-20

(Anonymous, 2020). Potato production is currently threatened by a number of biotic and abiotic factors. Protection of the crop is a serious problem as it is attacked by a number of pests such as fungi, bacteria, viruses, nematodes and insects followed by the never-ending vagaries of nature that result in significant yield losses in the field and in storage. Despite the potential role of potato in the Indian economy, its productivity is severely affected by early blight outbreaks caused by *Alternaria solani* (Ellis and Martin) Jones and Grout. Both foliage and tubers can be affected by the disease, which can cause yield losses of up to 50 percent. The disease attacks all leaf-bearing parts of the plant and causes large volume reduction (Waals et al., 2001). The disease appears on 3-week-old plants as concentric patches of greyish fungal growth on the leaves. The photosynthetic area of the plants is reduced, resulting in a decrease in the number and size of potato tubers. The pathogen can also infect other Solanaceae hosts such as tomatoes, brinjal and chilies. It is reported to produce a powerful phytotoxin (alternaric) acid which is a non-specific toxin (Reference). Pathogenesis/disease cycle of early blight in potato and inoculums production is highly dependent on prevailing weather variables (Reference). Understanding the influence of weather factors on host stage and disease development is prerequisite to strategically manage the disease. Therefore, the present investigation has been undertaken to study the correlation between Alternaria leaf blight disease and weather parameters.

Materials and methods:

The experiment was conducted during two consecutive cropping seasons i.e. *Rabi* 2020-21 and *Rabi* 2021-22 at Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India. The farm is geographically located at 22.53 °N latitude and 72.98 °E longitude and at an average elevation of 39 meters above the mean sea level. Tubers of susceptible potato variety (K. Lauvkar) [spacing -45×15 and fertilizer dose- 220:110:220 NPK Kg/ha] were shown into the experimental plot under recommended agronomical practices except disease management practices. The plot area of 10 x 10 m was divided equally into four quadrates and ten plants from each quadrate were selected randomly, labelled and the intensity of early blight was recorded at seven days intervals starting from the date of appearance of disease on leaves using 0-5 grade scale (Mayee and Datar, 1986) (Table 1). The disease intensity in the experimental field was recorded when the first infection appeared in the potato plant at seven days intervals following a standard meteorological week up to harvest and correlated with weather parameters (temperature, relative humidity, bright sunshine hour, rainfall, evaporation and wind speed) to determine

the role of weather variables in the development of the early blight epidemic.

Table 1: Per cent disease intensity and the reactions of varieties against early blight of potato

Per cent leaf area covered	Disease grade	Reactions
0	0	Immune (I)
1-5	1	Resistant (R)
6-20	2	Moderately Resistant (MR)
21-40	3	Moderately Susceptible (MS)
41-70	4	Susceptible (S)
>70	5	Highly Susceptible (HS)

The per cent disease intensity (PDI) was calculated by using the following formula (Wheeler, 1969).

$$\text{Disease intensity (\%)} \frac{\text{Sum of individuals disease ratings}}{\text{No. of leaves examined} \times \text{Maximum disease scale}} \times 100$$

Study of Aerobiology

The aerobiology of potato early blight was studied by placing thermoplastic spore traps in two consecutive years (*Rabi* 2020-21 and *Rabi* 2021-22). The microscopic slides were coated with petroleum jelly as a thin transparent layer and attached to the thermo-construction in all directions. The glass slides were attached with transparent tape to the sides of the container facing outward from the adhesive coating. Similarly, six traps were prepared and attached with a plastic rod at various locations throughout the field. The height of the trap bar was adjusted according to the height of plant growth in the field. Slides were removed from the traps once in 7 days and observed with a compound microscope under 40x magnification from November to February/March until harvest.

Results and discussion:

Effect of weather parameters and spore load on the intensity of early blight of potato

Early blight incidence was influenced by weather parameters and their interactions with disease progression from 30 days after sowing to harvest. To establish a correlation, weather parameters were collected for the two consecutive years (*Rabi* 2021 and *Rabi* 2022).

Progressive disease development

***Rabi* 2020-21**

During the growing season, maximum temperatures ranged from 25.70 °C (1st SMW 2021) to 32.70 °C (8th SMW 2021), minimum temperatures ranged from 10.90 °C (5th SMW 2021) to 17.90 °C (50th SMW 2020), morning relative humidity ranged from 74% (52nd SMW 2020/ 8th SMW 2021) to 94% (50th SMW 2020) and evening relative humidity ranged from 23% (6th SMW 2021) to 62% (50th SMW 2021). Sunshine duration ranged from 4.10 hrs/day (1st SMW 2021) to 9.80 hrs/day (5th SMW/ 8th SMW 2021). Wind speed ranged from 1.80 km/hr (3rd SMW/ 7th SMW 2021) to 3.90 km/hr (2nd SMW 2021) and evaporation ranged from 2.00 (50th SMW 2020) to 4.30 (8th SMW 2021). There was 16.40 mm rain in 50th SMW but in 51st to 8th SMW, there was no rain.

Correlation Studies

Disease development under natural conditions was found to be influenced by environmental factors. Data from harvest seasons showed that the disease first appeared on the 52nd day of harvest. Observations were recorded at weekly intervals starting at the 50th SMW. In 2020, the first occurrence of early blight was recorded at 30 DAS and progressed from there (Table 2a). The disease progressed slowly at first, but peaked during the 4th SMW of 2021 (50.67%) which occurred in January and in which 16.33 spores were caught in a spore trap. Table 3 shows a highly significant positive correlation between evaporation (0.87) and maximum temperature (0.84) at the 0.01 level. PDI was significantly positively correlated with spore load (0.71) and bright sunshine hour (0.64) at the 0.05 level. Whereas PDI was negatively correlated with evening humidity (-0.78) at a 0.01 level.

***Rabi* 2021-22**

During the cropping season, maximum temperatures ranged from 23.30 °C (52nd SMW 2021) to 30.70 °C (7th SMW 2022), minimum temperatures ranged from 8.80 °C (4th SMW 2022) to 17.60 °C (49th SMW 2021), morning relative humidity ranged from 78% (51st

SMW 2021) to 91.9% (1st SMW 2022) and evening relative humidity ranged from 33.4% (6th SMW 2022) to 62% (49th SMW 2021), bright sunshine hours ranged from 4.40 hrs/day (49th SMW 2021) to 9.50 hrs/day (7th SMW 2022). Wind speed ranged from 2.00 km/hr (5th SMW 2022) to 4.50 km/hr (49th SMW 2021), evaporation ranged from 1.70 (52nd SMW 2021) to 4.10 (7th SMW 2022). During the 49th to 7th SMW, precipitation ranged from 0.0 to 2.2 mm.

Correlation Studies

Regarding the statistics of the second harvest season, the disease was first observed on the 51st SMW in 2021. Observations were recorded at weekly intervals starting at the 49th SMW. In 2021, early blight was first observed at the 30 DAS and has since progressed (Table 2b). Disease intensity was initially low, but peaked in January 2022 during the 3rd SMW (56.67%) and 17.67 spores were captured on one slide. Table 3 shows a significant negative correlation with evening humidity at the 0.05 level. In 2021-22, PDI and spore load (0.79), bright sunshine (0.73), and evaporation (0.68) were positively correlated.

Complete comments on the role of all-weather parameters (temperature, relative humidity, bright sunshine hour, rainfall, evaporation and wind speed) in the development of the early blight epidemic.

These findings were corroborative with the earlier findings *viz*., Patel *et al*. (2004) and Hussain *et al*. (2022) who found that maximum and minimum temperatures had a significantly positive correlation with the intensity of early blight of potato, whereas, evening relative humidity had a significantly negative correlation.

Singh *et al*. (2020) concluded that temperature (maximum and minimum)had a significant positive correlation with disease intensity whereas relative humidity (morning and evening) was negatively correlated with tomato early blight intensity in Haryana. Gupta *et al*. (2020) reported maximum and minimum relative humidity alongwith rainfall had a significantly negative correlation with the disease intensity of earlyblight of tomato in Jammu. Early blight on lower leaves may be more severe than on upper leavesbecause the environment is most highly favorable within the crop canopy. The altering situation of the early blight of potato was influenced by changes in meteorological conditions during the cropping period

Conclusion:

The relationship between early blight and concerned weather parameters during *Rabi* 2020-21 revealed a highly significant positive correlation with evaporation (0.87) and maximum temperature (0.84) at the 0.01 level. PDI was significantly positively correlated with spore load (0.71) and bright sunshine hour (0.64) at the 0.05 level. Whereas PDI was negatively correlated with evening humidity (-0.78) at a 0.01 level. During the year *Rabi* 2021-22, a substantial negative correlation with evening humidity at the 0.05 level. PDI was positively correlated with spore load (0.79), bright sunshine (0.73) and evaporation (0.68).

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Table 2a: Effect of weather parameters on disease development and intensity of early blight of potato (*Rabi* 2020-21)

n=11

SMW	DI (%)	Increase in PDI	Spores /slide	Weather parameters							
				Atmospheric Temperature (º C)		Relative Humidity (%)		BSS (hrs)	WS (km/hr)	Rainfall (mm)	Evaporation (mm)
				Max.	Min.	Rh_1	Rh_2				
50	0.00	0.00	0.00	27.40	17.90	94	62	4.80	2.30	16.40	2.00
51	0.00	0.00	0.00	26.60	12.60	82	44	8.80	3.70	0.00	2.70
52	3.67	0.00	0.00	26.80	12.30	74	37	9.20	3.70	0.00	3.10
1	10.33	6.66	2.67	25.70	14.90	77	48	4.10	3.40	0.00	2.60
2	17.33	7.00	6.97	27.50	16.10	89	59	5.60	3.90	0.00	2.90
3	30.67	13.34	7.97	29.20	13.60	91	44	8.60	1.80	0.00	2.80
4	50.67	20.00	16.33	26.90	11.10	81	38	9.40	3.10	0.00	3.30
5	65.33	14.66	11.67	28.90	10.90	83	31	9.80	2.70	0.00	3.50
6	77.33	12.00	9.97	29.60	11.00	80	23	9.70	2.70	0.00	3.80
7	86.00	8.67	8.67	31.80	14.70	82	34	9.20	1.80	0.00	3.50
8	86.00	0.00	6.83	32.70	15.60	74	27	9.80	2.30	0.00	4.30
Range of different weather parameters				25.70-32.70	10.90-17.90	74-94	23-62	4.10-9.80	1.80-3.90	0.00-16.40	2.00-4.30
Total	-	-	-	313.10	150.70	907.00	447.00	89.00	31.40	16.40	34.50
Mean	38.85	7.48	6.46	28.46	13.70	82.45	40.64	8.09	2.85	1.49	3.14
SD	35.17	6.99	5.33	2.22	2.33	6.56	12.35	2.15	0.76	4.94	0.63
Correlation	-	-	0.71*	0.84**	-0.28	-0.31	-0.78**	0.64*	-0.58	-0.37	0.87**
SE of r	-	-	0.24	0.18	0.32	0.32	0.21	0.26	0.27	0.31	0.16

Rh_1: Relative humidity (Morning), Rh_2: Relative humidity (Evening)

SMW: Standard Meteorological Week, BSS: Bright sunshine hour, WS: Wind speed

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 2b: Effect of weather parameters on disease development and intensity of early blight of potato (*Rabi* 2021-22)

n=11

SMW	DI (%)	Increase in PDI	Spores /slide	Weather parameters							
				Atmospheric Temperature (° C)		Relative Humidity (%)		BSS (hrs)	WS (km/hr)	Rainfall(mm)	Evaporation(mm)
				Max.	Min.	Rh_1	Rh_2				
49	0.00	0.00	0.00	26.10	17.60	86	62	4.40	4.50	2.20	1.80
50	0.00	0.00	0.00	28.10	16.50	80	49	6.50	3.50	0.00	2.60
51	4.33	0.00	0.00	26.60	11.20	78	38	8.30	4.10	0.00	3.20
52	12.67	8.34	3.83	23.30	12.50	81	48	5.60	2.10	0.60	1.70
1	22.67	10.00	6.07	28.00	17.10	91.9	54.2	5.00	2.80	0.00	2.30
2	34.67	12.00	11.67	23.40	10.00	85.9	40.7	9.10	4.40	0.00	3.10
3	56.67	22.00	17.67	27.20	14.30	90.1	50	8.50	3.30	0.00	2.40
4	73.33	16.66	12.67	24.40	8.80	82.4	38.7	8.10	3.80	0.00	3.40
5	86.00	12.67	15.30	29.00	11.00	89.9	35.3	8.60	2.00	0.00	3.00
6	90.67	4.67	10.43	29.00	12.80	83	33.4	9.30	3.10	0.00	3.30
7	90.67	0.00	8.97	30.70	14.10	78.7	34.6	9.50	2.50	0.00	4.10
Range of different weather parameters				23.30-30.70	8.80-17.60	78.0-91.9	33.4-62.0	4.40-9.50	2.00-4.50	0.00-2.20	1.70-4.10
Total	-	-	-*	295.80	145.90	926.90	483.90	82.90	36.10	2.80	30.90
Mean	42.88	7.85	7.87	26.89	13.26	84.26	43.99	7.54	3.28	0.25	2.81
SD	37.55	7.61	6.34	2.41	2.94	4.84	9.25	1.83	0.87	0.67	0.72
Correlation	-	-	0.79**	0.45	-0.43	0.12	-0.71*	0.73*	-0.43	-0.45	0.68*
SE of r	-	-	0.20	0.30	0.30	0.33	0.24	0.23	0.30	0.30	0.24

Rh_1: Relative humidity (Morning), Rh_2: Relative humidity (Evening)

SMW: Standard Meteorological Week, BSS: Bright sunshine hour, WS: Wind speed

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 3: Correlation coefficient between weather parameters and early disease intensity

Weather parameters	Correlation coefficient 'r' value	
	***Rabi* 2020-21**	***Rabi* 2021-22**
Spore load	0.71*	0.79**
Max. Temp. (°C)	0.84**	0.45
Min. Temp. (°C)	-0.28	-0.43
Rh1 (%)	-0.31	0.12
Rh2 (%)	-0.78**	-0.71*
BSS (hr)	0.64*	0.73*
Wind speed (km/hr)	-0.58	-0.43
Rainfall (mm)	-0.37	-0.45
Evaporation	0.87**	0.68*

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)