Epidemiological studies of Late blight of potato and its correlation with disease severity

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Occurrence and severity of disease of Late Blight of potato revealed that the disease occurred every year at Kanpur and Faizabad district of Utter Pradesh. It was observed that the disease first appeared in the 3 – 4th weeks of December at Kanpur and 3rd weeks of December at Faizabad district of Uttar Pradesh. The infection rate rapidly increased from during 7th to 9th January at Kanpur and 31th December to 2nd January and continue up to 4th January at Faizabad in both the years which might be due to favourable environment factors like cloudiness, slight rainfall, high relative humidity and low sunshine hours. The correlation between disease severity with temperature, relative humidity and sunshine hours were calculated by standard statistical calculation and the results showed that disease severity correlated negatively with temperature and sunshine hours, representing the value (-0.3984) and (-0.4509), respectively, but positively correlated with relative humidity (0.5814), during 2010-11 at Kanpur. The similar observations were also found at Faizabad district, showing partially significant and negative correlation with temperature (-0.4011), partially significant and positive correlation with relative humidity (0.3953), non-significant and negative correlation with sunshine hours (0.1114).

Key words : Potato, Late Blight, temperature, relative humidity, sunshine hours, disease severity, correlation

INTRODUCTION

Potato is grown in about 150 countries of the world and is consumed by over a billion people across the globe, of which half are in the developing countries. The global area under potato production during 2011 was about 19.33 million hectares with a total production of about 321 million tonnes and having productivity of about 17.25 tonnes per hectares. The largest potato growing area in the world is China (4.56 million ha), followed by Russian Federation (3.17 million hectares) and Ukraine (1.57 million hectares). India ranked 4th in position occupying 1.27 million hectares with an annual production of 23.6 million tonnes and having productivity of 18.15 tonnes per hectares (The Hindu Survey of Indian Agriculture, 2006). The 80 per cent potato is grown in Indo-Gangetic plains of Uttar Pradesh, West Bengal and Bihar. Uttar Pradesh is the largest producer of potato with the production of 77 lakh tones from 4.4 lakh hectares of land. The West Bangal ranked first in terms of productivity followed by Gujarat. Despite all this progress, the per capita availability of potato in India is very low (14.8 kg/capita/annum) as compare to North America (63.0 kg/capita/annum) and Europe (86.0 kg/capita/annum). Potato crop suffers from a number of diseases caused by fungi, bacteria and viruses, namely, Early Blight, Late Blight, Leaf Spot, Dry Rot, Charcoal Rot, Black Scurf, Common Scab, Soft Rot and many viral diseases (Gildemacher et al., 2009, Turkensteen 1987 and Rauf et al., 2007). In India, out of almost 100 diseases of potato know to be caused by fungi, bacteria, and viruses (Khurana et al., 1998). Among these, Late Blight of potato caused by *Phytophthora infestans* (Mont.) de Bary is one of the most serious and destructive disease of potato.

In India, late blight pathogen infacts the potato crop in mild to severe form wherever it is grown. But, it is comparatively more devastating in Himalayan and Nilgiri hills and causes severe crop losses. In

Indo-Gangetic plains, severity depends on prevailing weather condition. The early appearance of Late Blight may seriously damage the potato crop and causing worry to potato growers. Koppel (2001) has also reported that high late blight pressure cause of yield reduction from 9.9 to 37.4 t ha⁻¹. Epidemological factors play an important role on severity of disease (Gillespi, *et al.*, 1993). Therefore, the study has been undertaken in the present investigations.

MATERIALS AND METHODS

The present investigation based on laboratory and field experiment were undertaken at Vegetable Research Farm and Department of Plant Pathology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur and Farmer's field adjacent to Narendra Dev University of Agriculture and Technology, Faizabad during 2010-2012. The procedure and techniques applied during the course of investigation were elucidated as below.

Survey for ascertaining the prevalence of disease and its severity under natural condition

Survey was conducted at two different places of Utter Pradesh namely Kanpur and Faizabad during 2010-2011 and 2011-2012 in order to find out the prevalence and disease severity of Late Blight of potato caused by *Phytophthora infestans*. The weather parameters which influenced the development of disease were also collected to correlate between weather parameter and disease intensity.

Collection of weather data

Weather data was collected from Department of Agronomy, C. S. Azad University of Agriculture and Technology, Kanpur, and Department of Meteorology, N.D. University of Agriculture and Technology, Faizabad. The Automatic Weather Station (AWS) data (hourly) was collected from the internet at Disease Forecosting Unit, Department of Plant Pathology, Chandra Sekhar Azad University of Agriculture and Technology, Kanpur.

Field experiments

The field experiments were carried out during *rabi* season of 2010-2011 and 2011-2012 at Vegetable Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. It is located at 26.45⁰ North latitude and 80.31⁰ East longitude having an altitude of 152.40 meters above mean sea level (MSL), in Northern Zone. The mean annual rainfall of Kanpur was 872 mm and more than 80% generally occurred during the monsoon season (June-September). The soil of the experimental field was sandy loam and slightly alkaline with pH 7.5 (1: 2.5 soil: H_2O), EC 0.28 dS/m having low organic carbon (4.25g/kg) and available N (232 kg/ha) and medium in available phosphorus (15.4 kg/ha) and potassium (278 kg/ha) at 0-15 cm soil depth.

Field preparation

Before ploughing of field, the necessary irrigation of plot was done and as the field come into field capacity and moisture, a ploughing (20-25 cm deep) with disc plough was done and field was again ploughed twice with cultivator followed by planking in order to break the clods as well as to make the soil well pulverized. Besides, all the weeds stubble and other grasses were also removed manually. N.P.K. fertilizers were applied @ 120 kg/hectare, 200 kg/hectare and 120 kg/hectare, respectively. Nitrogen, as urea, was applied in two split doses, half as basal dose, applied at the time of last ploughing and remaining half at the time of earthening-up after emergence.

Method of planting

The seed tubers of potato were planted in prepared plots on 12th of November during the year 2010-2011 and 2011-2012. The tuber placed on the surface of plots at a spacing of 60×20 cm. and covered with soil to make the ridges.

Severity of disease

The crop was regularly observed for the first appearance of the individual disease during 2010-2011 and 2011-2012 at both Kanpur and Faizabad. Progress of severity of the disease was also recorded at daily from the first date of disease appearance. Maximum severity of disease, date at which maximum severity was also recorded, days to maximum severity from the first appearance was recorded separately.

Measurement of disease severity

The crop was regularly observed for the first ap-

pearance of the individual disease. Progress of the severity of disease was also recorded daily. The observations on date of first appearance and maximum severity per cent of each disease were recorded separately. Disease severity was recorded using a score chart consisting of 0-9 scale as described by Malcolimson, (1976). Fifty leaves were randomly selected from the field for measurement of disease severity. The leaves with 1-9% infection received 1, 10% infection received 2, 11-25% infection received 3, 26-40% infection received 4, 41-60% infection received 5, 61-70% infection received 6, 71-80% infection received 7, 81-90% infection received 8, 91-100% infection received 9 (Malcolimson, 1976). The disease severity of individual plants was calculated by following formula:-

$$\text{Disease severity (PDI)} = \frac{\text{Sum of numerical rating}}{\text{Total number of leaves examined} \times \text{maximum rating}} \times 100$$

Correlation of disease severity with temperature, relative humidity and sunshine hours

The correlation between disease severity with temperature, relative humidity and sunshine hours were calculated by standard statistical calculation.

RESULTS AND DISCUSSION

Survey and severity of Late Blight of potato

The observations on occurrence and severity of disease of Late Blight of potato observed that the disease occured every year at Kanpur and Faizabad district of Utter Pradesh during *rabi* season, 2010-11 and 2011-12.

The data presented in the Table 1 and 2, showed that the first appearance of Late Blight was observed on 18th December 2010 with the value of 0.5 per cent at 15.7 °C temperature, 90% relative humidity and 6.0 sunshine hours and maximum severity of 9.73 per cent was noted on 15th January, 2011 after 29 days of first appearance of disease at 18°C temperature, 95% relative humidity and 6.9 sun- shine hours (Table1). From the Table1, it was cleared that the increasing rate of infection was observed during 31st December to 5th January, 2011 which might be due cloud covered (0-8) in the sky, sunshine hours very low and rainfall 1.2 mm on 31th December with high relative humidity 91-97 per cent at Kanpur. On the other hand, result enumerated in the Table 2 showed that the first appearance of Late Blight was ob-

served on dated 28th December, 2011 with the value of 0.60 per cent at 13.7° C temperature, 94 per cent relative humidity and 5.7 sunshine hours and maximum severity of 15.15 per cent on 25th January, 2012 after 29 days of first appearance of disease at 11.80°C temperature, 94 per cent relative humidity and 8.9 sunshine hours, respectively. From the Table 2, it was cleared that during 2011-12 cloud covered continuously from 1st January to 10th January and light rainfall occured on 6th and 7th January and high relative humidity persisted in the air considering favourable condition for development of disease, which resulted increased infection rate during 7th to 9th January, 2012.

Two years data of Faizabad district presented in the Tables 3 and 4. It was found that the date of first appearance of Late Blight differed from Kanpur. At Faizabad, the disease was first appeared on 20th December 2010 with the value of 0.35 per cent at 13.0 °C temperature, 84% relative humidity and 6.2 sunshine hours and maximum severity was recorded on 17th January, 2011 with the value of 8.25 per cent at 13.25 °C temperature, 65 per cent relative humidity and 7.0 sunshine hours (Table 3). During 2011-12, it was evident from the Table 2 that the first appearance of disease was occurred on dated 18th December, 2011 with the value of 0.55 per cent when environmental factors were 10.25 °C temperature, 97 per cent relative humidity and 0.0 Octa sunshine hours and maximum severity of disease 13.47 per cent was noted on 15th January, 2012 after 27 days of first appearance of disease at 14.00°C temperature, 90 per cent relative humidity and 7.5 sunshine hours, respectively. From the Table 4 it was cleared that infection rate rapidly increased from 31th December to 2nd January and continued up to 4th January 2012 which might be due to favourable environment factor indicating cloudiness on 2nd January, slight rainfall (4.2 mm) on 2nd January followed by high relative humidity on 2nd and 4th January (91 and 95 per cent) and low sunshine hours.

Correlation between disease severity to temperature, RH%, sunshine hours

The correlation between disease severity with temperature, relative humidity and sunshine hours were calculated by standard statistical calculation. The data presented in the Tables 5 & 6 showed that disease severity correlated negatively with tem-
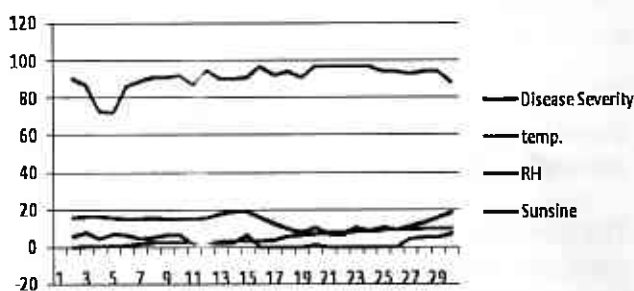
Table:-1. Disease severity of late blight of potato *(Phytophthora infestans)* during 2010-2011 at Kanpur.

Date	Disease severity (%)	Max. temp. (°C)	Min. temp. (°C)	Average Temp (°C)	Rainfall (mm)	RH (%) Max.	RH (%) Min.	Sun-shine (h)	Soil temp.5cm depth (C) Max.	Soil temp.5cm depth (C) Min.	Cloud Cover (h)	
									7.00	14.00		
18/12/2010	0.50	24.0	7.5	15.75	0	90	34	6.0	10.5	23.0	0	0
19/12/2010	0.52	25.0	7.8	16.40	0	87	39	7.8	10.5	20.0	0	0
20/12/2010	0.52	23.0	9.4	16.20	0	73	31	4.3	11.0	21.5	0	0
21/12/2010	0.90	23.4	8.2	15.80	0	72	30	7.4	10.2	21.5	0	0
22/12/2010	1.20	24.0	5.5	14.75	0	86	30	6.4	10.5	19.5	0	0
23/12/2010	1.85	23.4	6.5	14.95	0	89	36	4.8	9.5	22.0	0	0
24/12/2010	1.95	23.8	7.6	15.70	0	91	38	5.3	10.0	21.0	0	0
25/12/2010	2.15	23.4	6.6	15.00	0	91	39	6.5	10.5	21.0	0	0
26/12/2010	2.35	22.8	7.4	15.10	0	92	43	6.6	10.5	20.0	0	0
27/12/2010	2.75	23.0	7.4	15.20	0	87	44	2.0	11.0	22.0	0	0
28/12/2010	2.90	23.8	8.0	15.90	0	95	40	2.8	11.0	23.0	0	0
29/12/2010	3.00	25.8	9.2	17.50	0	90	45	2.1	11.4	24.0	0	0
30/12/2010	3.00	28.0	10.3	19.15	0	90	38	2.4	12.0	24.0	0	0
31/12/2010	3.10	23.4	15.0	19.20	1.2	91	68	6.6	12.0	19.4	8	8
01/01/2011	5.23	21.2	9.8	15.50	0	97	66	0.0	13.0	20.0	0	4
02/01/2011	6.15	17.0	7.8	12.40	0	92	60	0.0	11.0	19.0	0	6
03/01/2011	6.75	15.6	3.4	9.50	0	94	65	0.0	9.0	15.0	0	8
04/01/2011	7.50	12.2	2.8	7.50	0	91	56	0.0	8.0	17.6	0	0
05/01/2011	7.95	15.2	5.0	10.10	0	97	86	1.3	9.0	12.0	0	0
06/01/2011	8.05	9.5	4.4	6.95	0	97	97	0.0	9.0	11.0	0	8
07/01/2011	8.20	7.4	4.8	6.10	0	97	67	0.0	9.0	15.0	0	6
08/01/2011	8.35	14.5	5.4	9.95	0	97	82	0.0	9.0	13.5	0	0
09/01/2011	8.50	12.4	3.4	7.90	0	97	69	0.0	9.0	16.0	0	2
10/01/2011	8.80	14.2	6.0	10.10	0	94	75	0.0	9.0	13.4	0	0
11/01/2011	9.15	13.6	4.6	9.10	0	94	53	0.0	7.0	18.5	0	0
12/01/2011	9.30	19.0	3.2	11.10	0	93	41	4.8	7.0	19.5	0	0
13/01/2011	9.55	21.0	5.6	13.30	0	94	41	4.9	8.0	20.0	0	1
14/01/2011	9.65	24.0	7.6	15.80	0	94	45	5.3	10.0	22.0	0	4
15/01/2011	9.73	25.4	12.0	18.70	0	88	49	6.9	12.5	21.0	0	2

perature and sunshine hours, representing the value (-0.5786) and (-0.4509), respectively, but positively correlated with relative humidity (0.5814), during 2010-11. The similar observations had also been found during 2011-12 (Fig. 1).

The data presented in the Tables 7 & 8 showed that disease severity showed the partially significant and negative correlation with temperature (-0.4011), partially significant and positive correlation with relative humidity (0.3953), non-significant and negative correlation with sunshine hours (0.1114) (Fig 2). Singh (2007) also reported that the optimum temperature required for *P. infestans*
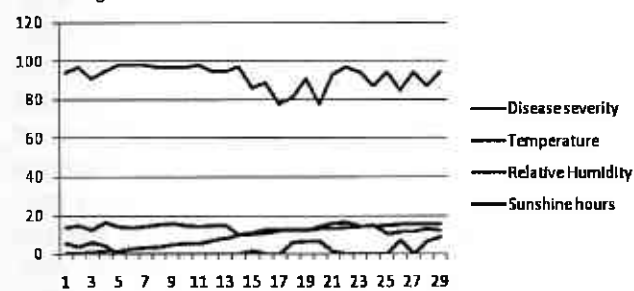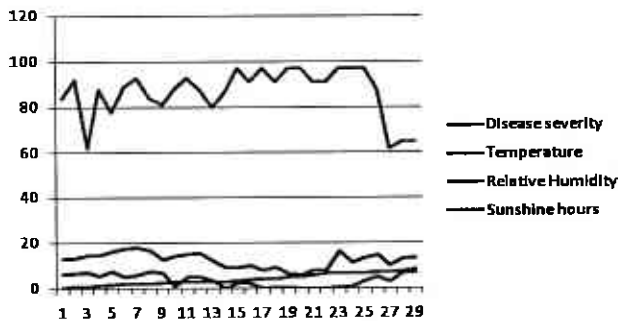
During 2010-2011

During 2011-2012

Fig:-1. Disease severity curve corelated with temperature, reletive humidity, and sunshine houre at Kanpur.

lies between 12-13°C (for germination of sporangia by zoospore production) and 24°C (for germination of zoospores) coupled with excessive humidity (above 90% RH), favours maximum spread of disease. Benker et al. (2010) also reported that after heavy rainfall and high soil moisture, the pathogen *Phytophthora infestans* grown either from the latently infected seed tuber upwards in the stem or on the surface of the planting tuber sporulate. The fungus sporulates rapidly at relative humidity near to 100% and temperature between 16-22 °C. Germination of sporangia takes place only when free water or dew is present on the leaves and at 10-15 °C, it may be completed within 0.5-2 h. After germination period of 2-2.5 h at 15-25 °C is required for penetration of germ

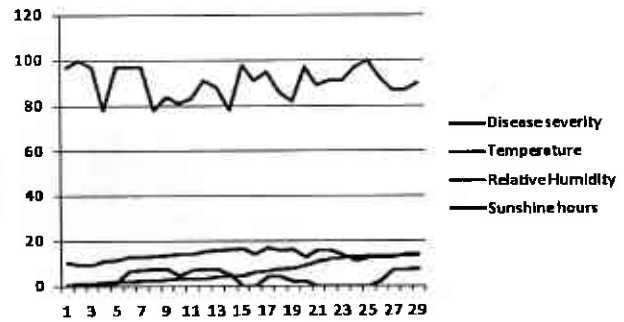During 2010-2011

During 2011-2012

Fig:-2. Disease severity curve corelated with Temperature, Reletive humidity, and Sunshine houre at Faizabad.

Table-2. Disease severity of late blight of potato (Phytophthora infestans) during 2011-12 at Kanpur

Date	Disease severity (%)	Max. temp. (°C)	Min. temp. (°C)	Average temp. (°C)	Rainfall (mm)	RH (%) Max.	RH (%) Min.	Sunshine (h)	Soil temp. Max.	Soil temp. Min.	5cm depth (C)	Cloud Cover
									7.00	14.00		
28/12/2011	0.60	23.0	4.4	13.70	0.0	94	37	5.7	8.0	20.8	0	0
29/12/2011	0.70	23.2	5.4	14.30	0.0	97	48	4.1	8.0	20.0	0	0
30/12/2011	1.15	24.8	4.6	12.70	0.0	91	48	6.3	9.4	21.0	0	0
31/12/2011	1.50	24.0	8.2	16.10	0.0	95	52	4.5	10.0	22.5	0	0
01/01/2012	1.75	24.6	14.2	14.20	7.8	98	91	0.0	16.0	15.0	8	8
02/01/2012	2.50	16.6	10.6	13.60	4.2	98	87	0.0	14.0	15.0	8	8
03/01/2012	3.05	17.6	10.8	14.20	0.0	98	74	0.0	13.5	21.4	0	8
04/01/2012	4.00	21.0	9.2	15.10	0.0	97	69	0.0	13.4	20.2	0	8
05/01/2012	4.95	20.8	10.2	15.50	0.0	97	82	0.0	14.4	20.4	0	6
06/01/2012	5.20	18.6	10.6	14.60	4.8	97	93	0.0	15.0	15.4	0	8
07/01/2012	5.60	15.8	12.2	14.00	6.0	98	77	0.0	14.6	19.0	0	8
08/01/2012	7.10	18.2	10.5	14.30	0.0	95	82	0.0	14.8	16.0	8	8
09/01/2012	8.35	18.6	10.4	14.50	0.0	95	82	0.0	14.8	16.0	0	8
10/01/2012	9.85	14.2	5.6	9.90	0.0	97	69	0.0	11.4	18.0	0	4
11/01/2012	10.14	16.1	5.6	10.80	0.0	86	78	1.5	9.8	19.0	0	4
12/01/2012	10.90	18.0	6.6	12.30	0.0	89	78	0.0	9.6	18.0	0	2
13/01/2012	11.70	18.6	6.2	12.40	0.0	78	75	0.0	9.0	18.5	0	4
14/01/2012	12.00	18.2	6.6	12.40	0.0	81	59	6.1	8.8	17.4	0	2
15/01/2012	12.40	18.0	5.6	11.80	0.0	91	40	6.7	10.0	19.6	0	0
16/01/2012	12.95	19.2	9.0	14.10	0.0	78	61	6.7	12.0	19.6	6	8
17/01/2012	13.05	21.4	10.2	15.80	0.0	93	68	1.0	13.0	16.0	0	6
18/01/2012	13.80	24.2	8.0	16.10	0.0	97	67	0.0	128	18.0	0	6
19/01/2012	14.15	20.8	7.6	14.20	0.0	94	62	0.0	12.0	17.0	4	6
20/01/2012	14.25	21.2	7.4	14.30	0.0	87	60	0.0	11.0	18.0	0	2
21/01/2012	14.80	16.0	4.6	10.30	0.0	94	56	0.0	8.6	18.0	0	0
22/01/2012	15.00	18.0	4.4	11.20	0.0	85	44	7.5	9.4	18.0	0	0
23/01/2012	15.00	18.4	4.8	11.60	0.0	94	73	0.0	9.4	18.0	0	0
24/01/2012	15.05	18.4	7.6	13.00	0.0	87	33	6.4	10.6	16.5	0	0
25/01/2012	15.15	18.2	5.4	11.80	0.0	94	39	8.9	9.4	19.5	6	1

Table 3 : Disease severity of late blight of potato (*Phytophthora infestans*) during 2010-2011 at Faizabad.

Date	Disease severity (%)	Max. temp. (°C)	Min. temp. (°C)	Average Temp (°C)	Rainfall (mm)	RH (%) Max.	RH (%) Min.	SunShine (h)	Soil temp Max.	.5cm depth (C) Min.	Cloud (h)	Cover
									7.00	14.00		
20/12/2010	0.35	23.0	3.0	13.00	0.0	84	35	6.2	9.5	20.0	0	0
21/12/2010	0.65	22.5	4.0	13.25	0.0	92	39	6.5	9.5	21.0	0	0
22/12/2010	0.95	23.0	6.0	14.50	0.0	62	45	7.0	12.0	20.0	0	0
23/12/2010	1.28	23.0	6.5	14.75	0.0	88	31	5.5	15.0	20.0	0	0
24/12/2010	1.73	26.0	6.5	16.25	0.0	78	34	7.5	13.0	21.0	0	0
25/12/2010	1.90	26.5	8.5	17.50	0.0	89	42	5.0	13.0	20.0	0	0
26/12/2010	1.95	26.0	10.0	18.00	0.0	93	34	6.0	13.0	21.0	0	0
27/12/2010	2.05	26.0	7.0	16.50	0.0	84	31	7.5	12.0	20.0	0	0
28/12/2010	2.50	23.0	3.0	12.50	0.0	81	36	6.5	12.0	22.0	0	0
29/12/2010	2.80	23.5	5.0	14.00	0.0	88	73	1.0	13.0	22.0	0	0
30/12/2010	2.90	24.0	6.0	15.00	0.0	93	52	5.0	14.0	21.0	0	0
31/12/2010	2.95	24.0	7.0	15.50	0.0	88	59	5.0	11.0	22.0	4	6
01/01/2011	3.00	19.0	5.0	12.00	1.3	80	64	3.5	14.5	15.0	8	2
02/01/2011	3.05	14.0	3.5	8.75	0.0	87	88	0.0	12.5	13.0	8	8
03/01/2011	3.35	15.5	2.2	8.85	0.0	97	78	2.5	9.5	10.0	8	0
04/01/2011	3.65	16.5	3.0	9.75	0.0	91	69	2.0	9.0	10.0	0	0
05/01/2011	3.90	12.0	3.4	7.70	0.0	97	83	0.0	10.0	11.0	8	8
06/01/2011	4.15	12.5	5.0	8.95	0.0	91	88	0.5	12.0	13.0	8	0
07/01/2011	4.98	9.5	2.5	6.00	0.0	97	80	0.5	10.0	11.0	8	8
08/01/2011	5.05	10.0	1.0	5.50	0.0	97	89	0.0	9.0	10.0	8	8
09/01/2011	5.78	10.5	4.5	7.50	0.0	91	87	0.0	10.0	11.0	8	8
10/01/2011	6.50	13.0	2.2	7.60	0.0	91	84	0.0	10.0	11.0	8	4
11/01/2011	6.65	18.5	1.7	16.10	0.0	97	88	0.5	9.5	10.0	4	0
12/01/2011	6.65	21.5	1.0	11.25	0.0	97	72	1.0	7.5	8.0	0	0
13/01/2011	6.70	24.0	2.5	13.25	0.0	97	69	3.5	9.5	10.0	0	0
14/01/2011	6.80	23.8	5.0	14.40	0.0	88	46	5.0	10.5	11.5	0	0
15/01/2011	7.10	18.5	1.0	9.75	0.0	62	46	3.0	12.5	13.0	2	0
16/01/2011	7.45	20.0	5.4	12.70	0.0	65	43	6.5	10.5	11.0	0	0
17/01/2011	8.25	20.5	6.0	13.25	0.0	65	33	7.0	10.5	11.0	0	0

Table 4 : Disease severity of late blight of potato (*Phytophthora infestans*) during 2011-2012 at Faizabad.

Date	Disease severity (%)	Max. temp. (°C)	Min. temp. (°C)	Average Temp (°C)	Rainfall (mm)	RH (%) Max.	RH (%) Min.	Sun Shine (h)	Soil temp. Max.	5cm depth (C) Min.	Cloud (h)	Cover
									7.00	14.00		
18/12/2011	0.55	15.0	5.5	10.25	0.0	97	78	0.0	13.0	14.0	8	2
19/12/2011	0.95	13.0	6.0	9.50	0.0	100	88	0.0	13.0	14.0	4	4
20/12/2011	1.05	14.0	5.0	9.50	0.0	97	80	0.0	12.0	13.0	4	0
21/12/2011	1.35	15.0	7.0	11.00	0.0	78	80	1.0	13.0	14.0	8	2
22/12/2011	1.95	18.0	5.0	11.50	0.0	97	69	1.5	11.5	12.0	4	0
23/12/2011	2.00	21.5	4.5	13.00	0.0	97	39	6.5	12.0	13.0	0	0
24/12/2011	2.15	21.5	4.5	13.00	0.0	97	38	7.0	13.0	14.0	0	0
25/12/2011	2.35	22.0	4.5	13.25	0.0	78	36	7.5	13.5	14.5	0	0
26/12/2011	2.60	22.5	5.0	13.75	0.0	84	49	7.5	12.5	13.0	0	0
27/12/2011	2.95	23.5	4.5	14.00	0.0	81	52	4.5	11.0	12.0	0	0
28/12/2011	2.95	24.5	4.0	14.25	0.0	83	46	7.0	12.5	13.0	0	0
29/12/2011	3.15	25.0	6.0	15.50	0.0	91	35	7.5	11.5	12.0	0	0
30/12/2011	3.95	25.0	6.5	15.75	0.0	88	47	7.5	11.5	12.0	0	0
31/12/2011	4.20	25.5	6.5	16.00	0.0	78	56	5.0	13.0	14.0	4	6
1/01/2012	4.50	19.5	13.5	16.50	4.2	98	76	0.0	15.5	18.0	8	8
2/01/2012	6.05	17.0	11.5	14.25	5.6	91	90	0.0	14.0	17.6	8	8
3/01/2012	6.50	21.0	13.0	17.00	0.0	95	81	4.0	14.5	18.5	4	6
4/01/2012	7.05	21.0	10.5	15.75	0.0	86	72	4.0	13.5	25.0	4	6

(contd. table 4)

5/01/2012	7.80	22.0	10.5	16.25	0.0	82	65	2.0	14.0	18.0	4	2
6/01/2012	8.95	17.0	9.0	13.00	0.0	97	88	2.0	13.0	17.0	2	2
7/01/2012	10.50	18.0	13.5	15.75	0.0	89	62	0.0	14.5	17.5	8	4
8/01/2012	11.75	20.0	11.5	15.75	0.0	91	81	0.0	13.0	17.0	8	8
9/01/2012	12.05	16.0	11.0	13.50	3.4	91	89	0,0	15.0	15.5	8	8
10/01/2012	12.45	13.5	9.5	11.25	0.0	97	88	0.0	13.0	14.0	8	8
11/01/2012	12.86	16.0	6.5	12.25	0.0	100	78	0.0	12.0	16.5	8	4
12/01/2012	13.00	19.0	5.5	12.25	0.0	92	62	2.5	10.5	16.5	4	2
13/01/2012	13.05	19.5	6.0	12.75	0.0	87	62	7.0	9.5	18.0	0	0
14/01/2012	13.20	20.0	6.0	14.00	0.0	87	56	7.0	8.5	19.5	0	0
15/01/2012	13.45	22.5	5.5	14.00	0.0	90	59	7.5	9.5	20.0	0	0

Table 5 : Correlation between disease severity to temperature, RH%, Sunshine hours at Kanpur 2010-2011

	Disease severity	Temperature	Relative humidity	Sunshine hours
Disease severity	—	-0.5786**	0.5814**	-0.4509*
Temperature		—	-0.4882*	0.7004**
Relative humidity			—	-0.5442**
Sunshine hours				—

Table 6 : Correlation between disease severity to temperature, RH%, Sunshine hours at Kanpur 2011-2012

	Disease severity	Temperature	Relative humidity	Sunshine hours
Disease severity	—	- 0.3977*	0.5125**	- 0.1372
Temperature		—	0.3328	- 0.2318
Relative humidity			—	- 0.4228*
Sunshine hours				—

Table 7 : Correlation between disease severity to temperature, RH%, Sunshine hours at Faizabad 2010-2011

	Disease severity	Temperature	Relative humidity	Sunshine hours
Disease severity	—	- 0.3984*	0.4531**	- 0.3923*
Temperature		—	- 0.2181	0.7305**
Relative humidity			—	- 0.5471**
Sunshine hours				—

Table 8 : Correlation between disease severity to temperature, RH%, Sunshine hours 2011-2012

	Disease severity	Temperature	Relative humidity	Sunshine hours
Disease severity	—	-0.4011*	0.3953*	- 0.1114
Temperature		—	- 0.3586	- 0.3005
Relative humidity			—	- 0.4325*
Sunshine hours				—

tube. After penetration, the mycelium develops rapidly 17-21°C which is optimal for sporulation (Agrios, 2005). According to him, ideal condition for Late Blight are cool night (10 to 15.5°C) and warm day (15.5 to 21.1°C) accompanied by fog, rain, or long period of leaf wetness.

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