Vol. 19, No. 1, pp. 67-75 (2019)
Journal of Agricultural Physics
ISSN 0973-032X
http://www.agrophysics.in

Research Article

Temporal and Spatial Variability of Potato Early Blight and its Association with Weather Variables

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ABSTRACT

Field experiment, as well as roving survey of farmers' field, was conducted in blocks of Tikamgarh district of Bundelkhand agro-climatic zone VII of Madhya Pradesh to record the temporal and spatial variability of potato early blight during *rabi* 2018-19. Weekly data on early blight of potato from the field experiment and fortnightly data from the farmer's field were collected. The spatial and temporal variability on the incidence and intensity of the diseasewere noted. The lowest incidence and intensity were recorded at Prithvipur and Palera block, respectively and the highest disease incidence and intensity at Baldeogarh block. The rainfall and temperature were correlated with disease intensity. The rainfall and temperature are closely associated with the disease severity. Mean and minimum temperatures above 15 and 6°C accompanied with rainy days are congenial weather conditions for increase in intensity of the disease.

Key words: Early blight, Potato, Incidence, Intensity, Weather

Introduction

Potato (*Solanum tuberosum* L.) is known as a king of vegetable crop of Madhya Pradesh as well as India. It is consumed as a popular source of carbohydrate, and can be used both for table consumption as well as in many processed products. More than 75 per cent of the dry matter of the potato is starch but it also contains protein, fibers and small amount of fatty acids (Prokop and Albert, 2008). It is also rich in minerals such as potassium, phosphorus, magnesium and vitamins like B1, B3 and B6 (Camire *et al.,* 2009).

Potato is grown in more than 100 countries, under temperate, sub-tropical and tropical climatic conditions. It is essentially a cool season crop and temperature being the main limiting factor for its production. India is the second largest producer of potato after China, with an area of 2.16 million ha, with production of 46.55 million ton and productivity 21.5 t/ha in 2016-17 (Anonymous, 2017 a). In India, Uttar Pradesh is the major potato producing state with the production of 15.56 million tons and share 31.54 per cent, followed by West Bengal, Bihar, Gujarat and Madhya Pradesh (Anonymous, 2018).

Potato is one of the important tuber crops cultivated in Tikamgarh district in *rabi* season. The annual production was 0.037 million tons from 0.003 million hectares area with an average productivity 14.5 t/ha (Anonymous, 2017 b).

Early blight of potato is caused by two pathogens viz. *Alternaria solani* (Jones & Grout) and *A. alternata* (Fr.) Keissler, but in some areas only *Alternaria solani* is considered as the causative organism of this disease. The spores of

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this disease are abundant in the atmosphere and in the soil (Iglesias *et al*., 2007). Whenever, weather conditions become conducive for its infection, this disease became a threat for the potato production (Leiminger and Hausladen, 2012). Bhattacharya and Raj (1977) reported that early blight is the most common, wide spread and destructive disease of potato in India, and may cause up to 40 per cent loss in potato yield. Fontein and Aighewi (1992) estimated losses to the extent of 54 per cent in potato yield due to this disease. Thus this disease is serious threat for potato production. Gupta and Thind (2006) has estimated up to 49.28 per cent loss in potato yield due to early blight. An *Alternaria solani* disease had not been evaluated on the spatial and temporal scale in Tikamgarh district of Bundelkhand area of Madhya Pradesh. Therefore, the present investigation was carried out to find out the spatial and temporal variability of potato early blight and to screen out the critical weather variables for high disease intensity.

Materials and Methods

The experiment was carried out during the *rabi* season of 2018-19 using random block design and with recommended dose of N:P:K (120:60:40 kg/ha). The cultivar *Kufri Chandramukhi* with seed rate 25-30 q/ha (seed tuber) was sown in 3 × 3 m^2 plot with three replication on 3rd November 2018, near meteorological observatory of research farm of the College of Agriculture, Tikamgarh (Latitude: 24°43′ N, Longitude: 78°49′ E, Elevation: 358 meter above MSL). The row-to-row distance was 45 cm and plant-to-plant 15cm with 1m^2 distances between the replication. The crop was harvested on 29th February, 2019. Weather variables, *viz.,* maximum and minimum temperatures, relative humidity and rainfall were collected from meteorological observatory. Development of the disease in terms of intensity was recorded periodically at seven days intervals starting from the first appearance of the disease. The observations on five randomly selected plants were examined for disease intensity in 0-5 scale. The correlation of disease development with different weather variables were worked out.

Table 1. Details of districts and village selected for survey

S.No.	Block	Village
1.	Tikamgarh	Gopalpura
2.	Prithvipur	Atarra
3.	Jatara	Jagatnagar
4.	Baldeogarh	Banpura
5.	Palera	Deriapura
6.	Niwari	Ghughasi

To study micro level variability of the incidence and intensity of the early blight disease on Potato disease in Tikamgarh district, fortnightly random roving survey was conducted during *rabi* 2018-19 in six blocks of Tikamgarh district *viz.,* Tikamgarh, Baldeogarh, Pallera, Prithvipur, Niwari and Palera. One village was selected randomly from each block (Table 1). Two fields from each village were selected and from each field ten (10) plants for disease incidence and five (5) plants for disease intensity were examined randomly. Disease incidence and intensity were scored by using 0-5 scale (Table 2) (Pandey and Pandey, 2002). The survey was made 30 days after planting at 15 days interval up to maturity stage in the months of November, December and January of 2018-19.

Table 2. Description of disease scale (0-5)

Disease Grade	Leaf area infected (%)
0	No disease symptoms
1	1-10 % leaf area infected
2	11-25% leaf area infected
3	26-50% leaf area infected
4	51-75% leaf area infected
5	>75 % leaf area infected

The percentage of disease intensity and percent of disease incidence were calculated by using following formulae:

Measurement of disease intensity

Percent disease intensity (PDI) was calculated using formula of Wheeler (1969), asgiven below:

$$\text{PDI} = \frac{\text{Sum of numerical ratings}}{\text{Total number of leaves observed} \times \text{maximum disease rating}} \times 100$$

Disease incidence (%) was calculated by formula advocated by James (1974).

$$\text{Disease incidence (\%)} = \frac{\text{No. of diseased plants}}{\text{Total no. of observed plants}} \times 100$$

The highly and significantly correlated weather variables werescreened out and presented in this study.

The coefficient of correlation (r) was calculated between variables using the formula:

$$r = \frac{\sum(XY)}{\sum x^2 Y^2}$$

The t test with help of SPSS software was used for testing thesignificance of correlation coefficient at 5% level.

Results and Discussion

The disease appeared in the form of small, scattered dark colored areas, which revived brown to black spots, up to 1 cm in diameter andconcentric rings were formed in the lesions. Later these spots increased in size and coalesced covering larger leaf area. The block wise disease incidence and intensity were worked out. The micro level scatterness (deviation from mean value) of disease incidence and intensity were calculated for each block of Tikamgarh and are presented in figure 2 and 3, respectively. It was observed that the incidence scatterness was more in Prithvipur and Baldeogarh as compared to other blocks (Fig.1). In case of intensity, scatternesswas found to be higherin Palera and Baldeogarhand minimum at Jatara and Tikamgarh (Fig. 2).

Early blight on potato appeared in almost all the villages and its incidence ranged from 42.9 to 50 percent (average 46.8%) and intensity from

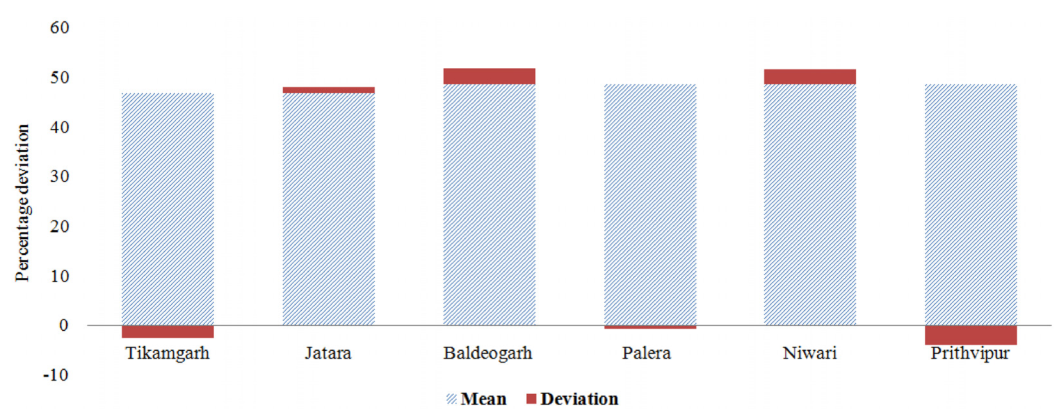

Fig. 1. Deviation of potato early blight incidence at Tikamgarh

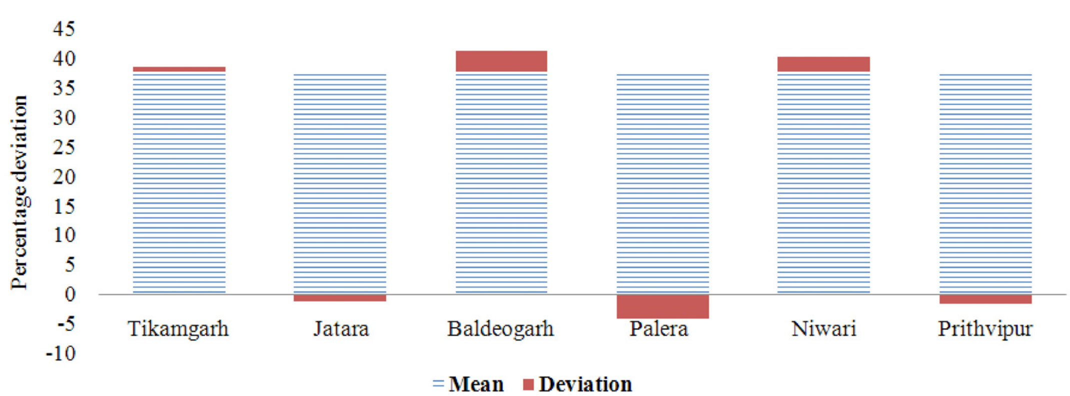

Fig. 2. Deviation of potato early blight intensity at Tikamgarh

33.6 to 41.1 percent (avg. 37.6) in different blocks surveyed. The highest disease incidence (50%) was observed in Baldeogarh block, followed by Niwari (49.8), Jatara (47.8), Palera (46.1) whereas highest disease intensity (41.1%) was in Baldeogarh followed by Niwari (40.1%), Tikamgarh (38.5%), Jatara (36.5%). On the otherhand, disease incidence was found to be minimum in Pritvipur (42.9%) followed by Tikamgarh (44.2%) and that of intensity was lowest in Palera (33.6%) followed by Prithvipur (36.0%). Many workers Vanderwalls *et al*. (2003), Hossain *et al*. (2010), Ganie *et al*. (2013) have been reported about the disease incidence and they recorded 24.5 to 28.2% and 13.8 to 16.0% incidence of early blight on potato during different field survey. Rani *et al*. (2015) reported that the disease incidence varied from 21.7 to 34.1% and intensity 10.5 to 18.6% during 2011-12 at Jammu and Kashmir. The findings indicate thatrelatively higher incidence and intensity of early blight disease was prevalent in several potato-growing blocks of Tikamgarh district during the *rabi* season of 2018-19. The spatial variability of blockwise incidence and intensity of early blight of potato in Tikamgarh district has been given in fig.3.

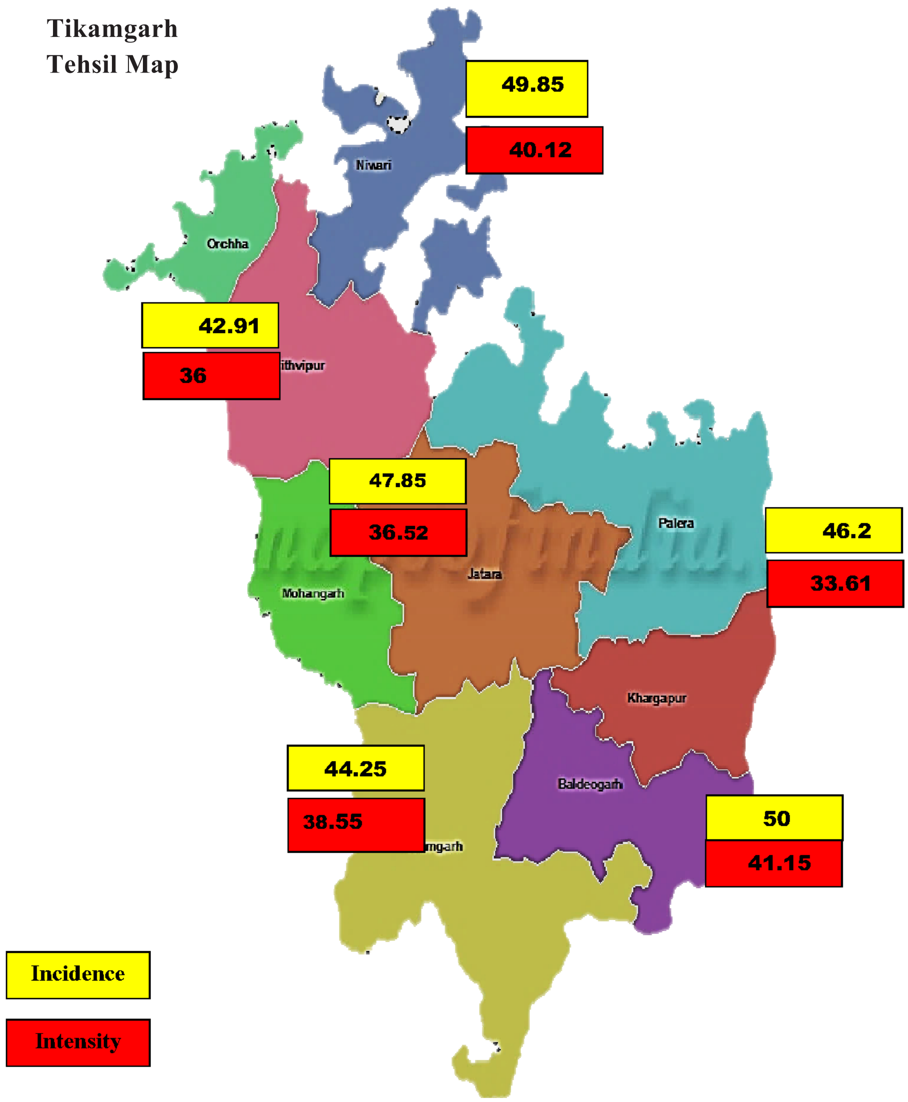

Fig. 3. Administrative block-wise incidence and intensityof early blight of potato in Tikamgarh district

Temporal Variability

From the field experiment, conducted at Tikamgarh, the weekly early blight intensity was recorded 30 days after planting. Weekly values of disease intensity vis-à-vis weather variables are presented in table 3.

The percent disease intensity was lowest (7.06%) during 52 standard meteorological week (SMW) and increased throughout the cropping period (Table 3). The last stage peak disease intensity was recorded during $7^{th}$and 8^{th} SMWs and were 35.03and 42.42 per cent, respectively (Table 3). The data indicated that disease intensity gradually increased from 52 SMW to 8 SMW. In the second and third SMW, the disease increased at faster rate as compared to previous week (3.7% to 6.4%) when the maximum temperature was varied from 20.8 °C and 23.4 °C, minimum temperature was varied from 4.6 °C and 5.2 °C and morning relative humidity was varied from 90 to 94 per cent. Gemawat and Ghosh (1980) observed *Alternaria solani* development in the range of 5-35 °C. Mehboob *et al*. (2013) recorded maximum disease severity at 17 to 20 °C maximum temperature and 6 to 9 °C of minimum temperature.

Association between disease intensity and weather variables

To find out the association between disease intensity and weather variables, correlation coefficients were worked out and presented in table 3. The early blight disease developmentis affected by weather variables and the growth-phase of the potato crop. The result revealed that minimum and mean temperatures and rainfall were positively correlated (r = 0.87, 0.85 & 0.41) with disease intensity. The correlation between PDI and mean relative humidity was found to be insignificant. From the correlation between the disease intensity and weather variables it can be inferred that minimum and mean temperatures were highly and positively correlated with disease intensity whereas mean relative humidity showed statistically non-significant correlation.The result obtained is in conformity with the result obtained by Verma (1970).

Weekly changes in weather variables and disease intensity

To examine the weekly changes in mean values of temperature and humidity in relation to disease intensity, departure from previous week's values of these variables were worked out and presented in table 4. It can be noted that positive and negative departures from previous week temperatures has not much been related directly with the changes in disease intensity (Table 4). For example, when change in mean temperature from previous week were positive in some weeks (52 to 1, 3 to 4 & 6 to 7 SMW) and above 1 °C corresponding changes in disease intensity was negative. It is observed that increase in mean

Table 3. Correlation between disease intensity and weather variables

Standard meteorological weeks	Mean Relative Humidity (%)	Rainfall (in mm)	Mean Temperature (°C)	Max. Temp. (°C)	Min. Temp. (°C)	Disease intensity (PDI) (%)
52	68	0.0	12.5	21.6	3.5	7.06
1	68	0.0	15.2	24.0	6.4	10.90
2	73	0.0	13.0	20.8	5.2	14.59
3	72	0.0	14.0	23.4	4.6	21.01
4	78	2.2	15.4	21.5	9.4	26.21
5	68	0.0	14.5	22.4	6.6	29.17
6	68	1.0	16.2	24.1	8.4	32.55
7	70	3.2	17.3	24.8	9.9	35.03
8	59	0.0	20.4	28.2	12.6	42.42
Correlation (r)	-0.39	0.41	0.85	0.69	0.87	

Table 4. Weekly change of weather variables vis-à-vis change in disease intensity

Standard meteorological weeks	Departure in mean temperature from the previous week	Departure in mean relative humidity (%) from the previous week	Departure in disease intensity (%)from the previous week
51-52	-0.7°C	4	7.06
52-1	2.7°C	0	3.84
1-2	-2.2°C	5	3.66
2-3	1.0°C	1	6.42
3-4	1.4°C	6	5.21
4-5	-0.9°C	-10	2.96
5-6	1.7°C	0	3.38
6-7	1.1°C	2	2.48
7-8	3.1°C	-11	3.4

relative humidity increased the disease intensity during 51-52, 2-3 & 3-4 SMW, while increase in mean relative humidityby 2 per cent from 6-7 SMW decreased the disease intensity. The above results indicate that positive or negative departures from previous week's mean temperature and mean relative humidity have been less meaningful to draw any conclusion. Therefore, a threshold or critical limit of temperature and humidity were screened out.

Critical weather limit and disease development

Statistically significant correlations were observed between weather variables, viz., mean temperature andmean relative humidity with disease development. During 2nd SMW and 8th SMW the disease increased quite fast (14.59% to 42.42%), when the maximum temperature ranged between 20.8 and 28.2°C, minimum temperature between 5.2 to 12.6°C and mean relative humidity ranged from 59 to 73 per cent. The result obtained is in conformity with the result obtained by earlier workers. Tiwari *et al*. (2004) found that the inoculation made at early crop growth stage resulted in higher per cent disease index (83.8%). Correlation coefficient obtained between different weather variables andpercent disease severity indicated that maximum temperature (r = 0.72) and relative humidity (r = 0.70) has significant effect on early blight severity (Tiwari *et al.,* 2004). Rashid *et al*. (2011) investigated the effect of climatic factors on the development of Alternaria disease under field conditions. They reported that maximum (23.5°C) and minimum (11.1°C) temperatures and sunshine hours (5.0 h) had significant positive correlation, while relative humidity (78%) and fog hours (4.4 h.) has significant negative correlation with conidia landing and number of spots per leaf on 50 days old transplanted plants.

To screen out the critical weather limit for positive changes in disease intensity, the weekly mean, minimum and maximum temperature and disease intensity were plotted and shown in figure 4. From the figure it is clear that the positive changes in disease intensity is mostly observed when the minimum temperature above 6°C and mean temperature above 15°C. The weekly mean relative humidity, weekly rainfall and disease intensity were plotted and were shown in figure 5. It was notedthat the occurrence of rainfall has much more impact in positive increase in disease intensity than mean relative humidity changes. From the above results, it can be inferred that weekly values of mean&minimum temperatures above 15 and 6°C, respectivelyaccompanied with rainy days are critical limit for the disease development in Bundelkh and Agro-climatic zone of Madhya Pradesh. Jonson *et al*. (2015) reported the optimum climatic requirement for early blight of tomato are temperature ranged from 13.5 to 24°C and rainy weather with high humidity (>90%).Sandhu *et al*. (2018) reported the early blight disease of potato is influenced by temperature and humidity but precipitation may favour the disease development. The earlier

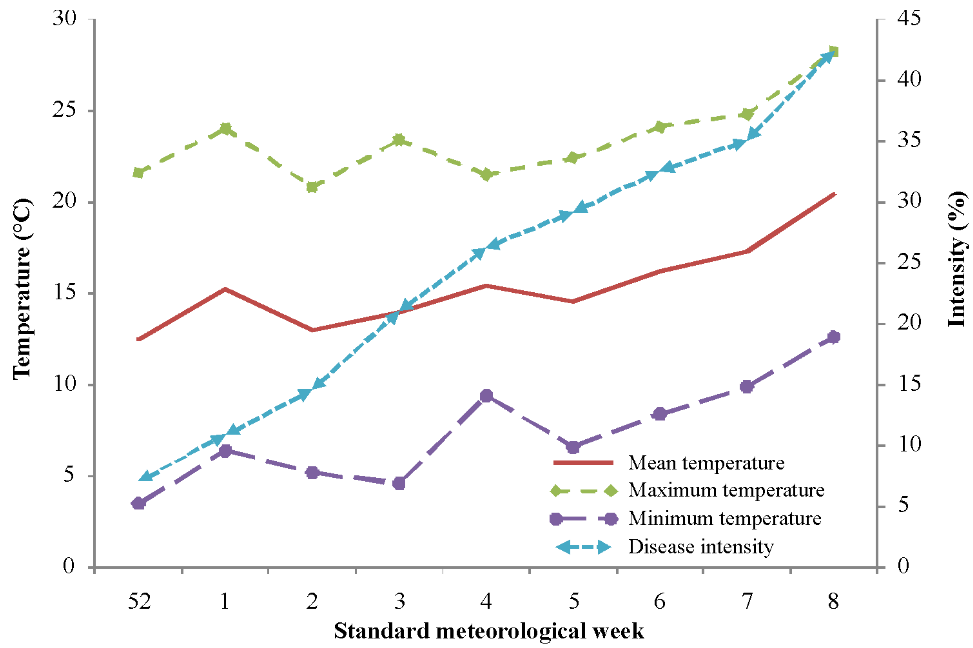

Fig. 4. Weekly pattern of disease intensity and temperature at Tikamgarh

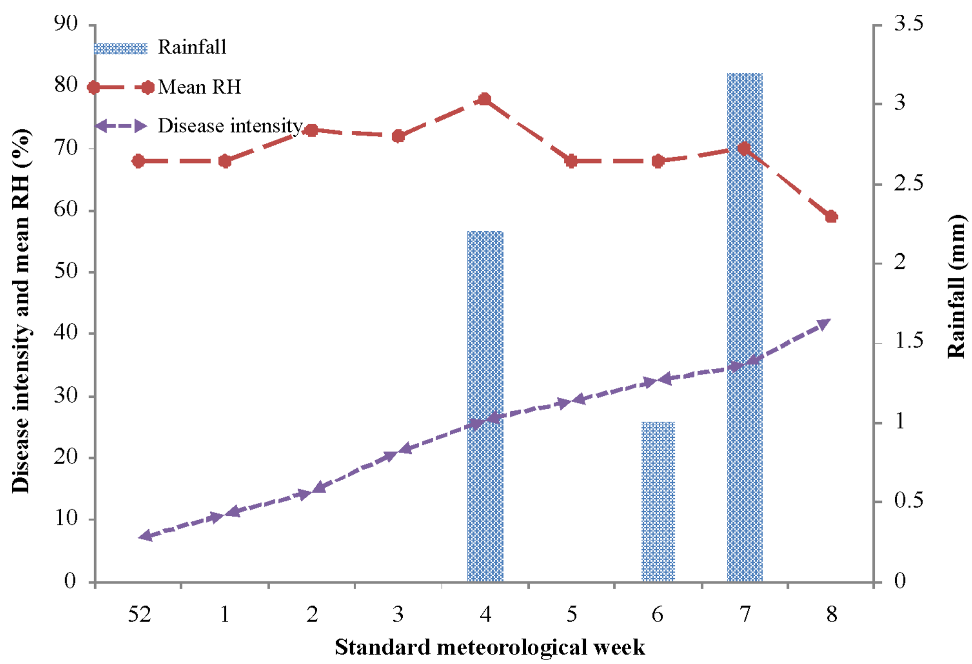

Fig. 5. Weekly pattern of disease intensity, mean humidity and rainfall at Tikamgarh

reported results are in conformity of the present result but differ in their limiting weather values. The above finding is based upon one season data, hence further investigation may be carried out for its validation or refinement.

Conclusions

The administrative block-wise incidence and intensity variability of early blight of potato was studied in Tikamgarh district. The lowest incidence and intensity were recorded at

Prithvipur and Palera blocks, respectively and that of highest was at Baldeogarh block. The disease incidence scatterness were higher at Prithvipur and Baldeogarh as compared to other blocks. Whereas, the disease intensity scatterness were higher at Palera and Baldeogarh and lower at Jatara and Tikamgarh. The disease intensity was observed after 6 weeks of sowing and increased upto 8th SMW. The disease intensity is significantly and positively correlated with minimum and mean temperature. Mean and minimum temperatures above 15 and 6°C accompanied with rainy days are congenial weather conditions for increase in intensity of the disease. Further investigation is required to validate the critical weather limit for increase in disease intensity.

Acknowledgments

First author acknowledges the facilities provided by the college of agriculture, JNKVV, Tikamgarh for carrying out this work as a part of his M.Sc.(Ag.) thesis. Authors thanks the Dean, CoA, JNKVV, Tikamgarh for extending facility support for this work.

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Received: January 9, 2019; Accepted: May 12, 2019