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STUDY ON WEATHER PARAMETERS IN RELATION TO PERPETUATION OF ALTERNARIA LEAF BLIGHT DISEASE IN TOMATO (*LYCOPERSICON ESCULENTUM L.*)

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ABSTRACT
The relationship of meteorological parameters on the natural incidence of early blight disease and its severity in tomato was studied through an intensive survey during Rabi 2010-11, 2011-12 and 2012-13, as *Alternaria* blight is a major constraint in Odisha for tomato production. The disease severity increased with increase in temperature from 13.0^{0}C to 37.7^{0}C and RH minimum 34% to maximum 93%. The pooled result revealed that the maximum temperature (r= +8.498), maximum RH (r= +0.578), number of rainy days (r= +2.656), wind velocity (r= +4.239) had positive significant correlation and minimum temperature (r= -4.623), relative humidity during evening (r= -1.046), evaporation (r= -2.485) and bright sunshine hour (r= -7.053) had strong negative and significant correlation with per cent disease index. The weather factors viz. max and min temperature, day and night RH, rainfall, number of rainy days, evaporation, wind velocity and BSH as a whole contributed about 93.9% towards disease development.

INTRODUCTION

Tomato (*Lycopersicon esculentum L.*) is an important vegetable crop and cultivated almost year-round in tropical and subtropical regions of the world. In India, it is cultivated during kharif, rabi and summer seasons and occupies an area of 865.0 thousand hectares with production of 16.82 thousand million tonnes from an average productivity of 19.5 metric tonnes per hectare (Anonymous, 2011). The low productivity of tomato is attributed to different biotic and abiotic stresses. There are several diseases on tomato caused by biotic stress like fungi, bacteria, viruses, nematodes and other biotic factors (Balanchard, 1992). Among the fungal diseases the early blight or target spot disease incited by *Alternaria solani* (Eliss and Martin) Jones and Grout is one of the world's most catastrophic diseases. The disease appears on leaves, stems, petioles, twigs and fruits under favourable climatic condition resulting in defoliation, drying off of twigs and premature fruit drop, thus causing loss from 50-86 per cent in fruit yield (Mathur and Sekhawat, 1986). The disease if favoured by high temperature and humidity, the crowded plantation, high rainfall and extended period of leaf wetness from dew, the plants are more susceptible to the blight infection during fruiting period (Momel and Pemezny, 2006). *Alternaria solani* has the capacity to grow over a temperature of 4-36ºC (Pound, 1951). Epidemics can also take place in semi-arid climate where frequent and prolonged night dews occur (Rotem and Richert, 1964). The symptoms associated with the disease are collar rot (basal stem lesion in seedling stage) stem lesion in adult plant and fruit rot (Chaerani *et al.*, 2006, Ganie *et al.*, 2013). The leaf blight phase is the most devastating phase which results in complete loss of the crop when the incidence is severe (Jambhulkar *et al.*, 2012). The yield loss as high as 79% has been reported from Canada, India, USA and Nigeria (Gwari and Nahunnaro, 1998).

The management of the disease in tomato crop is important to maximize the crop yield. As the disease occurs in all most all tomato growing areas, it is difficult to manage the pathogen without chemical measures (Kumar and Srivastava, 2013; Sahu *et al.*, 2013[b]). Environment factors play important role in *Alternaria* blight incidence. The conidia remain on the leaves and also on soil surface (Rouselle *et al.*, 1999) and the disease develops rapidly in the environmental condition alternatively between humidity and drought.

The epidemiological models have been developed by different authors for prediction of the disease occurrence (Wiik, 2002). Majority of models are based on study of meteorological parameters, specially temperature, RH and rainfall. The correlation between weather and disease severity has been well studied by many authors (Mesta *et al.*, 2009 and Devi and Chanu, 2012). The airborne conidia of *Alternaria,* temperature and humidity are the major factors which closely correlated with the disease occurrence. The present study aims at the role of various weather factors on infection and development of *Alternaria* blight (early blight) in tomato crop. Also prior to devise a novel IDM approach, the environmental condition conducive and severity of the disease in relation to weather have been studied during the present investigation.

MATERIALS AND METHODS

In order to study the relationship of meteorological parameters on the natural occurrence of the early blight disease and its severity in tomato, an intensive roving survey was conducted during Rabi 2010-11, 2011-12 and 2012-13 under field condition at the farmer's field, Ghatikia area, Bhubaneswar. Three villages were surveyed comprising five fields in each village. In each field ten plants were selected randomly and disease severity was assessed by using 0 – 5 scale (Mayee and Datar, 1986) Table-1

Per cent Disease Index (PDI) was worked out by using formula given by Wheeler (1969).

$$\text{PDI}(\%) = \frac{\text{Sum of individual ratings} \times 100}{\text{No. of leaves examined} \times \text{Maximum disease scale}}$$

The tomato variety Utkal kumari was used in the experiment. The trial was sown at a spacing of 60cm row to row and 40cm plant to plant. The experiment was conducted under natural field condition; therefore no protection measure was adopted against any disease. The weather parameters such as max and min temperature (ºC), max and min RH (%), rainfall (mm), no of rainy days, wind velocity (km/hr), evaporation (mm) and bright sunshine hour (hr) were obtained from the Meteorological Observatory, Orissa University of Agriculture and Technology, Bhubaneswar (Table-2). The weather parameter were correlated to weekly disease incidence by calculating the karl pearson's correlation coefficient (r). Correlation coefficient values were tested for their significance at 5% probability level using the formula.

$$t = \frac{r\sqrt{(n-2)}}{\sqrt{1-r}}$$

Where,

t = test of significance

r = correlation coefficient

n = number of observations

Further the data were subjected to multiple linear regression to find out the linearity of the independent variable for prediction of disease and the correlation coefficient r.

The prediction equation was used as follows.

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9$$

Where Y = Percent disease incidence, a is the intercept, b_1 to b_9 are the partial regression coefficient, x_1 is the max. temperature (ºC), x_2 is the min. temperature (ºC), x_3 is max. RH (%), x_4 is min. RH (%), x_5 is the rainfall (mm), x_6 is the number of rainy days, x_7 is the wind velocity, x_8 is the evaporation (mm), and x_9 is the bright sunshine hours (hr).

RESULTS AND DISCUSSION

Gradual disease development

The early blight disease development was taken place under natural field condition, found to be influenced by environmental factors. The data from three crop seasons revealed that 25days old tomato seedlings transplanted on 15.12.2010, 23.12.2011 and 27.12.2012 during the Rabi season of 2010-11, 2011-12 and 2012-13 respectively. The first appearance of early blight was noticed at 28 days after planting (DAP) in 2010-11, 30 DAP (2011-12) AND 29 DAP (2012-13) which progressed thereafter gradually (Table-2 and fig 1, 2, 3). The progress of the disease was initially slow (2.1% at SMW 47) but reached to maximum at SMW 13 (62.7%) which happened in the month of March. During the cropping period mean max. temperature ranged from 27.0 to 37.7 ºC , min. temperature (12.6-24.2 ºC), max. RH (85-93%), min. RH (31-56%), rainfall (0.0-21.5 mm), number of rainy days (0-2), wind velocity (2.7-8.8 km/hr), evaporation (3.3- 6.3 mm) and BSH (5.8-8.3 hrs).

The disease severity increased with increase in temperature from a minimum of 12.6 ºC to maximum at 37.7ºC and also the increase in incidence was found in the same trend of Bright Sunshine Hour (5.8 to 8.3 hrs). This suggested a direct bearing of temperature and light period on the early blight incidence. The role of humidity at flowering and fruit formation stage also determines the disease severity. This finding is in

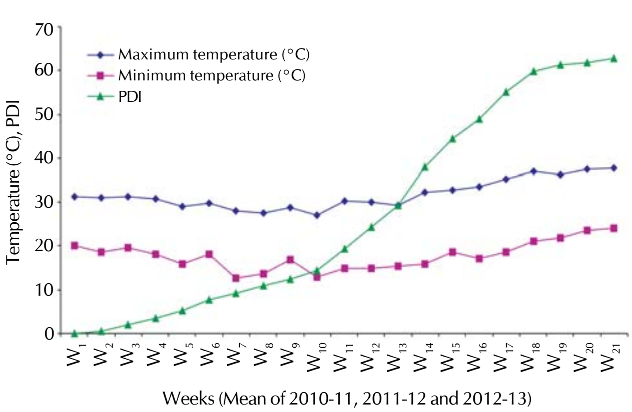

Figure 1: Effect of maximum & minimum temperature on disease incidence

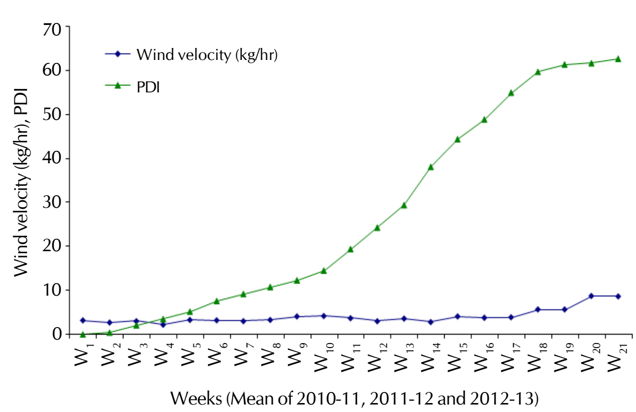

Figure 2: Effect of wind velocity (km/hr) on disease incidence

Table 1: Description of disease scale (0-5).

Scale	Description
0	No symptoms on the leaf
1	0 – 5 per cent leaf area infected and covered by spot.
2	6-20 per cent leaf area infected and covered by spot, some spots on petiole
3	21-40 per cent leaf area infected and covered by spots, spots also seen on petiole and branches.
4	41-70 per cent leaf area infected and covered by spot, spots alsoseen on petiole, branches and stem
5	>71 per cent leaf area infected and covered by spot, spots also seen on petiole, branch, stem and fruits.

Table2: Effect of Meteorological parameters (Mean of 3 seasons) on the incidence of *Alternaria* blight in tomato.

No. of Weeks	Standard Meteoro-logical week	Temperature(⁰C)		RH (%)		Rain fall (mm)	No. of rainy days	Wind velocity (km/hr)	Evapo ration (mm)	BSH	PDI
		Max	Min	Max	Min						
W_1	45	31.3	20.1	92	56	21.5	2	3.2	3.3	6.1	0.0
W_2	46	31.1	18.5	94	49	0.0	0	2.7	3.5	7.3	0.4
W_3	47	31.4	19.7	88	52	0.0	0	3.0	3.4	6.6	2.1
W_4	48	30.7	18.1	90	50	0.0	0	2.2	3.4	6.6	3.5
W_5	49	29.0	16.0	92	53	11.9	1	3.3	3.3	5.8	5.2
W_6	50	29.8	18.2	91	50	2.0	1	3.2	3.4	5.5	7.6
W_7	51	28.0	12.6	86	34	0.0	0	3.0	3.6	7.7	9.2
W_8	52	27.5	13.7	85	41	0.0	0	3.3	3.7	6.2	10.8
W_9	1	28.9	17.0	88	53	1.5	1	4.1	3.6	4.9	12.3
W_{10}	2	27.0	13.0	87	41	13.3	1	4.2	3.4	6.4	14.5
W_{11}	3	30.3	14.9	92	41	0.0	0	3.7	3.6	8.3	19.4
W_{12}	4	30.0	15.0	92	41	0.0	0	3.0	3.6	6.4	24.3
W_{13}	5	29.2	15.5	90	40	0.0	0	3.6	3.6	5.8	29.4
W_{14}	6	32.3	15.9	88	34	0.0	0	2.8	4.1	7.5	38.1
W_{15}	7	32.7	18.6	93	41	0.0	0	4.1	4.2	6.7	44.4
W_{16}	8	33.6	17.2	91	38	8.2	1	3.8	4.1	5.8	48.9
W_{17}	9	35.2	18.5	90	37	0.0	0	3.9	4.4	8.2	55.0
W_{18}	10	37.1	21.0	91	31	0.0	0	5.7	5.4	8.3	59.7
W_{19}	11	36.2	21.8	92	37	0.6	1	5.7	5.8	6.8	61.4
W_{20}	12	37.5	23.7	91	39	0.0	0	8.8	6.1	7.7	61.7
W_{21}	13	37.7	24.2	91	40	0.0	0	8.7	6.3	6.5	62.7
		X1	X2	X3	X4	X5	X6	X7	X8	X9	Y

Table 3: Correlation and regression studies between PDI and Climatic factors(Pooled mean of 3 years)

	X1	X2	X3	X4	X5	X6	X7	X8	X9	Y1
X1	1.000									
X2	0.868	1.000								
X3	0.441	0.495	1.000							
X4	-0.402	0.047	0.176	1.000						
X5	-0.244	-0.098	0.087	0.438	1.000					
X6	-0.174	0.032	0.125	0.493	0.838	1.000				
X7	0.735	0.703	0.165	-0.348	-0.147	-0.099	1.000			
X8	0.886	0.747	0.208	-0.543	-0.321	-0.219	0.909	1.000		
X9	0.436	0.132	0.089	-0.603	-0.366	-0.563	0.196	0.363	1.000	
Y1	0.841	0.547	0.224	-0.720	-0.319	-0.244	0.741	0.883	0.378	1.000

agreement with findings of Das *et al.* (1998), Kemmitt (2002) and Ruth *et al.* (2016).

Correlation study

The correlation analysis between disease incidence recorded at different growth stage of the crop were correlated with weather parameters prevailed during the corresponding stage. The mean prediction equation of three years indicated significant positive correlation with max. temperature (+ 8.498), max. RH (+ 0.578), number of rainy days (+2.656), wind velocity (+4.239) and significantly negatively correlated with min. temperature (-4.623), min. RH (-1.046), rainfall (-0.391), evaporation (-2.485) and bright sunshine hour (-7.053) (Table-3). Our findings in respect of correlation of disease incidence with different weather parameters are in agreement with the earlier findings of Sunita Rani *et al.* (2015), who reported that in Rabi season there was maximum increase in early blight in month of March where the minimum and maximum temperature 15.5°C and 29.8°C, min. and max. RH 41.9 and 70.4 % respectively and rain fall 9.6mm were found to be most favourable for disease development. Sahu *et al.* (2014), stated the increase in disease severity index (DSI) comparatively higher in the temperature range 26.3 to 28.3°C (maximum), 10.5 to 14.5°C (minimum) with average RH of 65% in month of January to be the most congenial for disease development. But the present investigation envisages the trend

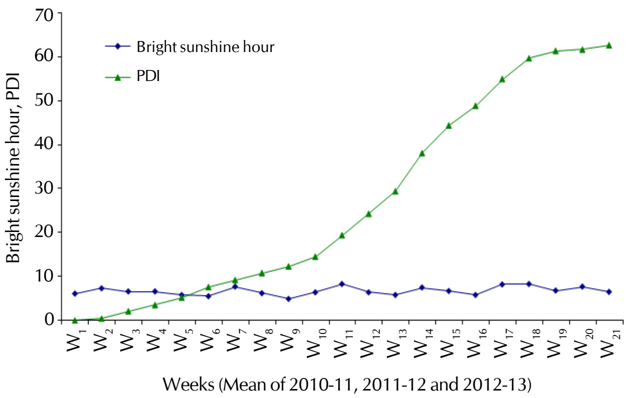

Figure 3: Effect of bright sunshine hour on disease incidence

of increasing temperature with higher range of 29.2 to 37.7°C (maximum) and 15.4 to 24.2°C (minimum) in the month of February and March found to be more congenial in increasing the leaf blight incidence from 29.4 to 62.7% which contradict the findings of Sahu *et al*. (2014).

The mean prediction equation was developed. The multiple linear regression of PDI in relation to weather parameters indicated.

Prediction equation of PDI (Y) = -127.568 + 8.498**x1 – 4.623*x 2 + 0.578x3 – 1.046x 4 –

0.391x 5 + 2.656x6 + 4.239x7 –2.485x8 – 7.053**x 9

Where Coefficient of determination (R-Square) = 0.966, Adjusted R-Square = 0.939,Multiple R = 0.983

The adjusted R^2 value indicated that the association of weather factors with disease severity showed 93.9% in tomato crop infected with *Alternaria solani*. It may be presumed that some unknown factor might be involved in early blight development which needs to be studied.

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