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Weather based relations on different component of epiphytotic for early blight of tomato

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Abstract On the basis of three years data it was concluded that early blight initiates in November from kharif sown tomato and continued upto April-May in rabi sown tomato in Gangetic plains. The disease and its inoculums remain active on different plant parts of tomato starting from seedling and slowly progressed on leaves, stem, flower parts and fruits for nearly nine months in field itself. Kharif and rabi season tomato crop affected by early blight but maximum disease severity was recorded (91.3 per cent) in rabi season crop during March-April. Early blight persists in wide range of temperature and relative humidity. The maximum temperature range was 14.0 to 38.0^{0}C and minimum temperature 6.0 to 21.0.^{0}C while maximum relative humidity 54-93 percent and minimum relative humidity 20-68 percent prevailed during the disease development. Multiple regression equation and coefficient of determination value indicate that the temperature and relative humidity reflected during the above mentioned period contribute 84 to 100 per cent in early blight development. AUDPC of early blight vary from 1095.7 to 3650.7 and apparent infection rate from 0.005 to 0.118 in a susceptible variety during epiphytotic period.

Keywords: Tomato, earlyblight, epiphytolic

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Introduction

Tomato is the most important vegetable crop of India. The crop is severely affected by early blight predominantly caused by *Alternaria solani*. Disease appeared on all above ground parts of plants particularly stem, petiole, flowers and fruits (Pandey *et al.* 2002). The disease severity was recorded up to 90 per cent in Indo-Gangetic region of the country (Pandey *et al.*, 2002). The yield loss of tomato fruit was 78 percent was recorded at 72 percent disease intensity of *A. solani* (Datar and Mayee, 1985). The yield loss in experimental field was recorded as high as 86 percent in the fungicide treated crop of tomato (Pandey & Pandey 2003). Lodha (1977) recorded upto 50 percent losses caused by *A. solani* in tomato. Inspite of a lot of work done on the chemical management of this disease, invariably it was found ineffective in its economic management. One of the reasons would be insufficient information in the epidemiological aspects of the disease. Keinath *et al.* (1996) emphasized that TOM-CAST schedule reduced the number of spray application to 6 compared with 10 at weekly interval and the AUDPC of early blight was lowest with TOM-CAST schedule while highest with no fungicide. Some of the workers have studied various weather factors for disease development of *A. solani* (Gupta & Paul 2001, Dragomir 1995, Tong *et al.* 1994). However, the quantum of work on this aspect is scanty on tomato in comparison to potato. The disease progress curve, referred to as the signature of an epidemic, represents the integration of all the host, pathogen and environmental effects during the epidemic (Campbell and Madden 1990). The natural epidemics of tomato early blight are strongly influenced by environmental conditions and severe disease appears every year in India. Hence, the present study was confined on the epidemiological aspects of early blight of tomato was undertaken.

Materials and Methods

Tomato crop was raised during kharif and rabi season with applying all standard agronomic practices. However, no fungicidal spray was given in whole cropping period except need based spray of insecticide to manage *Helicoverpa* fruit borer and serpentine leaf minor. The experiment was carried out in comparatively large plot size of 200 m^2 area. Ten plants at each sampling site were demarcated with three such randomly selected sites in the field for recording data. Periodical observation on disease progress of early blight was recorded every year during disease prevailing period using five-point rating scale as described by Pandey *et al.* (2003). Percent disease index was correlated with major weather factors viz., maximum temperature, minimum temperature, mean temperature, maximum RH, mean RH and minimum RH. Multiple regression equation, correlation coefficient and coefficient of multiple determination ($R^{2)}$ were calculated as per the standard statistical formula $Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$ where Y = Percent disease index, a is intercept/ constant value, $b_1 \ldots b_5$ are regression coefficient of corresponding independent weather variables, $X_1 \ldots X_5$ are independent weathers variables. Area under disease progress curve (AUDPC) was calculated as described by Campbell and Madden (1990).

Where, X_i = Disease index expressed as a proportion at the *i*th observation, t_i = Time (days after planting) at the *i*th observations, *n* = Total number of observations. Apparent infection rate (*r*) was calculated as described by Vander Plank (1963).

where t_1 = Time (days) during the 1st observation, t_2 = Time during the 2nd observation, t_2-t_1 = Time interval between two observations and subsequently so on, x_1 = Disease index value at t_1 time, x_2 = Disease index at t_2 time. The tagged plants also were observed for site of infection on stem and fruits which most devastating phases of early blight in tomato.

Results and Discussion

The tomato grown in kharif season indicated that early blight incidence started in the month of November. The severity of early blight was 27.0 per cent to 54 per cent during November to December. The weather condition particularly diurnal temperature variation from 9.3 to 29.4^{0}C and relative humidity (RH) from 35 to 88 per cent was favourable for early blight development in November-December (46-50 SMW). The disease severity did not exceed 54per cent (Table1). However, the disease prevalent in this period was not a usual feature of every year. The early blight occurrence is because of warm winter where minimum temperature was 9.3-14.7^{0}C and did not go very low as it usually happens every year. Tong *et al.* (1994) reported that *A. solani* can grow *in vitro* at temperature between 23-25^{0}C at optimal pH of 6-8. The AUDPC value of early blight in kharif was 1095.5 while apparent infection rate (r value) varies from 0.1106 to 0.0307. The multiple regression equation was $Y = -274.21 - 6.64X_1 + 0.39X_2 + 133.76\ X3_4 - 78.17\ X_4 - 237.59\ X_{5,}$ and coefficient of multiple determination ($R^{2),}$ 1.0 mean 100 per cent these five independent weather variables are contributing for disease development.

The second year observations on grown in winter season reveled that early blight initiated in 8 SMW and increased rapidly in subsequent weeks. The disease progress was continued upto13 SMW (82.7%) and reduced slightly to 78.7 per cent and increased 91.3 per cent in subsequent days. The most critical period for early blight epiphytotic was observed from 9th to 14th SMW (Table 2). The AUDPC value was calculated 2402.1 during this season which indicates high level of disease for long period. Maximum 'r' was 0.1182 during 8-9 SMW while lowest 0.0049 in 11-12 SMW. The reduction in disease severity from 82.7 per cent in 13 SMW to 78.7 per cent in 14 SMW and later on, increased to 91.3 per cent in 16 SMW was observed. The negative infection rate (-0.028) indicated decline of disease severity in that particular period due to defoliation. In favourable weather, early blight develops very quickly in natural epidemics and infected leaves quickly defoliate. The defoliation led to fewer intact leaves on plant for recording observation. Subsequently new leaves are emerging after leaf losses. In this case, many new leaves lower down the disease scoring as compared to previous observations resulting lower PDI value. This phenomenon is resulting negative infection rate as well as two pecks in disease progress curve. Double sigmoid disease progress curve of early blight in whole cropping season of tomato was reported by Pandey *et al.* (2003). The diurnal temperature variation was quite high and recorded 10.4 to 34.7^{0}C. Similarly the extreme variation in RH was also recorded from 20-80 per cent. However, 18-25^{0}C diurnal temperature and 95-100 per cent RH for 48 h is required to get infection in artificial inoculation condition (Pandey *et al.,* 2003). Present findings clearly indicate that early blight disease progress persists in wide range of temperature and RH. Wide range of adaptability by the pathogen may be due to existence of several variants/races as significant variability was observed in cultural, morphological and pathogenic characters of different isolates of *A. solani*. Multiple regression equation of early blight for rabi season tomato during 2003 developed as $Y = -139.24 + 11.53\ X_1 - 10.39\ X_2 +$

Table1: Periodical disease progress of early blight in relation to different weather factors during kharif 2002

Factors	Cor. Cof.	46 SMW	47 SMW	48 SMW	49 SMW	50 SMW
Max.temp.	0.80	28.3	29.4	27.2	26.2	25.3
Min.temp.	-0.68	14.7	13.3	10.6	10.0	9.3
Mean temp.	-0.40	21.5	21.4	18.9	18.1	17.3
Max. RH*	-0.90	86.0	84.0	85.0	88.0	88.0
Min. RH*	-0.91	47.0	38.0	35.0	35.0	36.0
Mean RH*	-0.93	66.5	61.0	60.0	61.5	62.0
Sunshine (hr.)	-0.44	7.5	8.6	8.2	7.7	7.4
PDI	-	27.0	32.0	36.0	48.0	54.0
Infection rate (*r*)	-	-	0.0149	0.0110	0.0307	0.0149

Table 2: Periodical disease progress of early blight in relation to different weather factors during winter 2003

Factors	Cor. Coef.	8 SMW	8 SMW	9 SMW	10 SMW	11 SMW	12 SMW	13 SMW	14 SMW	16 SMW
Max. temp.	0.79*	25.2	30.4	24.8	29.7	31.8	31.8	31.8	34.7	37.5
Min. temp.	0.60	13.8	17.0	10.4	15.6	16.8	16.8	16.8	20.2	20.7
Mean temp.	0.71*	19.5	23.7	17.6	22.6	24.1	24.1	24.1	27.5	29.1
Max. RH	0.10	88.7	80.0	60.0	82.0	77.0	77.0	77.0	61.0	54.0
Min. RH	-0.71*	58.0	47.0	29.0	52.0	37.0	37.0	37.0	24.0	20.0
Mean RH	-0.66	72.5	63.5	44.5	67.0	55.5	55.5	55.5	42.5	37.0
PDI	-	21.33	44.0	56.0	72.7	74.7	76.7	82.7	78.7	91.3
Inf. rate (*r*)	-	-	0.118	0.021	0.080	0.005	0.024	0.0810	-0.028	0.021

Table 3: Disease progress of early blight in relation to weather factors in early rabi during 2004

Factors	Cor. Coef.	48 SMW	50 SMW	52 SMW	2 SMW	4 SMW	4 SMW	7 SMW	8 SMW	9 SMW	10 SMW	11 SMW
Max. temp.	0.47	27.3	26.2	21.9	13.8	20.0	20.6	23.7	27.6	29.9	29.6	29.6
Min. temp.	0.73*	9.5	11.6	9.8	7.7	5.7	7.1	12.3	13.8	17.4	15.9	14.8
Mean temp.	0.61	18.4	18.9	15.8	10.7	12.8	13.8	18.0	20.7	23.6	22.7	22.2
Max. RH	-0.70	93.0	87.5	88.5	93.0	87.5	93.0	85.0	88.0	86.0	80.5	75.0
Min. RH	-0.46	58.5	44.0	54.5	78.0	67.5	75.0	54.0	46.0	38.0	42.0	39.0
Mean RH	-0.51	75.7	64.2	71.5	85.5	77.5	84.0	69.5	67.0	62.0	61.3	57.0
PDI	-	4.16	12.5	14.5	17.5	21.8	37.3	55.5	71.6	79.3	89.3	85.6
r-value	-	-	0.039	0.074	0.009	0.011	0.066	0.016	0.034	0.026	0.084	-0.032

0.40 X_3 - 0.19 $X_{4\ and}$ coefficient of determination ($R^{2)}$, 0.90 value implies that 90 per cent variation in the disease development was due to all these four weather factors. Multiple regressions revealed that independent variable such as minimum temperature and minimum RH contributed significantly for disease.

The third year meteorological data and early blight relation during rabi sown tomato revealed that the disease initiated in 48 SMW with 4.16per cent disease severity and slowly progressed to 32.3 per cent by the end of 4 SMW but abruptly increased to 55.5 per cent in 7 SMW followed by 89.3 per cent in the 10th SMW (Table 3). During this period, maximum temperature varied from 20.6 to 29.9^{0}C and minimum temperature 7.5 to 17.4^{0}C while maximum RH varied from 75 to 93 per cent. The occurrence and development of disease are favoured by 20-25^{0}C, RH 90 per cent and the presence of water droplets on plants for >2 h/d (Dragomir 1995). It was also clear from table-2 & 3 that fruit rot a most destructive phase of early blight was very high during the prevailing weathers of March-April. Gupta and Paul (2001) reported availability of abundant moisture during

the growth period followed by warm and dry weather conditions are most conducive for early blight development of potato. Apart from the congenial weather factors, maturity of the crop during this period is another reason for maximum disease severity. Degree of susceptibility to *A. solani* infection under artificial inoculation conditions increases with the age of tomato plant (Pandey *et al.* 2003). The AUDPC value of early blight was high in this season (3650.7). The 'r' value varies from 0.0097 to 0.0845 and the negative 'r' was observed in the end of cropping season. Once the pathogen reaches its maximum infection level, the *r*-value may decrease or remain constant as disease progresses because green leaf area is not available for spread of the pathogen (Pandey *et al.* 2003). High value of AUDPC depends on the long time taken from disease initiation to reach maximum disease severity as indicated in tabale-3. Multiple regression equation of early blight for rabi season tomato during 2003 was as $Y = 101.70 + 2.79 X_1 + 9.81 X_2 - 4.64 X_3 + 3.07 X_{4 \text{ and}}$ coefficient of determination ($R^{2)}$ value 0.84 implies that 84 per cent variation in the early blight development was significantly explained by the four variables. The seed borne infection of Alternaria was recorded 20 to100 per cent in harvested seeds from infected fruits. Early blight of tomato survives in seed as seed borne and in the soil as fallen fruits and buried crop debris.

सारांश

तीन वर्षों के आकड़ो के आधार पर यह निष्कर्ष निकला कि गंगा के मैदानी भागों में टमाटर में खरीफ ऋतु में नवम्बर एवं रवी ऋतु में अप्रैल–मई के समय अगेती झुलसा आरम्भ होता हैं रोग और उसके कारक खेत में स्वय 9 महीने के लिए टमाटर के सीड लिंग के समय ही पौधे के विभिन्न भागों में और पत्ती, तना, फूल और फल पर धीरे विकास करता रहता है। अगेती झुलसा द्वारा खरीफ एवं रवी ऋतु की टमाटर फसल प्रभावित होती है परन्तु अधितम रोग का विकास मार्च–अप्रैल के दौरान रवी ऋतु की फसल में प्रभावित (91.3) प्रतिशत हुआ। अगेती झुलसा वृहद श्रेणी की ताप एवं सम्बन्धित नमी में भी विकास करता है। रोग विकास के दौरान अधिकतम ताप श्रेणी 14.0 से 38.0 डिग्री से सेल्सियस और निम्नतम ताप श्रेणी 6.0 से 21.0 डिग्री सेल्सियस था जबकि अधिकतम सम्बन्धित नमी 54–93 प्रतिशत और न्यूनतम सम्बन्धित नमी 20–68 प्रतिशत प्रबलता थी। बहुल दौरान समीकरण और गुणांक की निश्चित मूल्य प्रदर्शित करता है कि ताप और सम्बन्धित नमी में परावर्तित अगेती झुलसा विकास में 84 से 100 प्रतिशत योगदान के दौरान करता है। AUDPC के अगेती झुलसा 1095.7 से 3650.7 के बीच एवं स्पष्ट रूप से संक्रमण दर 0.005 से 0.118 तक अति संवेदनशील किस्म में था।

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