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EFFECT OF DATES OF SOWING AND WEATHER FACTORS ON EARLY BLIGHT OF TOMATO (*Alternaria solani*)

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Abstract: *A study was carried out to find out the effect of sowing dates and weather factors on the severity of early blight of tomato. Seeds were sown on nine dates of sowing (November 11, 18, 25 and December 2, 9, 16, 23, 30, January 6), the crop sown on November 11 recorded lowest percent disease severity of 19.3 per cent. The crop sown on the above date also recorded highest fruit yield (233.5 q/ha). Whereas, highest disease severity of 34.7% was recorded in the crop sown January 6 and lowest fruit yield of 182.4 q/ha. As evident from the data, late sowing favoured disease development. The temperature ranged from 6.8 to 22.9^{o}C, relative humidity ranged from 60.6 to 82.3% sunshine hours ranged from 8.2 to 8.7 hr and rainfall ranged from 0.2 to 0.5 mm apparently favoured disease development during Rabi season, 2013-14. PDI were nonsignificantly positively correlated with maximum temperature, minimum temperature and mean temperature and significantly positively correlated with morning relative humidity (r = 0.551), evening relative humidity (r = 0.650), mean relative humidity (r = 0.653) and rainfall (r = 0.678), significantly negative correlated with sunshine hours (r= -0.734) during 2013-14. Simple regression in out of eight weather parameters selected for the study, only sunshine was found to be contributing significantly negative impact. Mean temperature, morning relative humidity, evening relative humidity, mean relative humidity, rainfall, and sunshine was found to be contributing significantly positive impact on PDI, multiple linear regressionin only sunshine was found to be contributing significantly positive impact on PDI, Fruit yield were nonsignificantly positively correlated with maximum temperature, minimum temperature and mean temperature and significantly positively correlated with sunshine hours (r = 0.636), significantly negative correlated with morning relative humidity (r = -0.574), evening relative humidity (r = -0.493), mean relative humidity (r = -0.614) and rainfall (r = - 0.632). Simple regression in out of eight weather parameters selected for the study, only sunshine was found to be contributing significantly positive impact and morning relative humidity, evening relative humidity, mean relative humidity and rainfall was found to be contributing significantly negative impact on fruit yield, while all other variables like maximum temperature, minimum temperature and mean temperature showed nonsignificant.*

Key words: *Lycopersiconesculentum, sowing dates, weather factors, early blight, Yield.*

Introduction

Tomato is theone of 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 leaf, stem, petiole, flower and fruit (Pandey *et al.* 2002). The disease severity was recorded up to 90 per cent in Indo-Gangetic region of the country which causes tomato yield loss of up to 78 percent (Datar and Mayee, 1981; Pandey *et al.*, 2002).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.Many workers have studied various weather factors for disease development of *A. solani* (Gupta and Paul, 2001; Dragomir 1995; Tong *et al.* 1994). 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

Effect of date of sowing on incidence of the disease

To determine the effect of dates of sowing on early blight of tomato a field trial was conducted at Reseach Farm, Birsa Agricultural University, Ranchi-6 during *Rabi* season, 2013-14 in RBD with three replications. Tomato seeds (Var.S-22) were sown in nursery at seven days interval *viz.*, 11, 18, 25 November, 2, 9, 16, 23, 30 December, 2013 and 6 January, 2014 in nursery. Twenty days old seedlings were transplanted in main field with spacing of 60 cm X 45 cm. The plot size was 3.6 m X 3.15 m each. The crop was fertilized with 100: 60: 60 kg NPK/ha. The plots were irrigated as per need of crop to maintained sufficient moisture condition. Plants were inoculated after seven days of last date of transplanting by using eight days old mycelia-cum-spore suspension of the pathogen ($1X10^6$ spore/ml). The mycelium cum spore suspension was sprayed in evening under humid condition for early establishment of the pathogen. The disease severity was recorded after fifteen days of inoculation by taking forty leaves randomly from each plot. All the recommended package of practices were followed to raise tomato crop.After harvest, the yield of tomato was also calculated (q/ha). The per cent disease index (PDI) was calculated by using 0-5 scale as given by Mayee and Datar, 1986.

Effect of weather factors on disease development of early blight

The effect of weather factors like temperature (maximum, minimum and mean), relative humidity (morning, evening and mean), rain fall (mm),Sunshine (hr) on development of early blight of tomato was studied at Research plot, Department of Plant Pathology, Birsa Agricultural University, Kanke, Ranchi, during *Rabi*, 2013-14. The disease severity of early blight and fruit yield of tomato were recorded. They were correlatedwith weather parameters, Coefficient of determination (R^2) and simple regression equation amongst weather parameters with PDI and yield were also worked out. Multiple regression equation were also worked out by adopting statistical analysis procedures (Gomez and Gomez, 1984). Per cent disease index (PDI) was calculated by using following formula as proposed by Wheeler (1969).

$$\text{PDI} = \frac{\text{Sum of the individual disease ratings}}{\text{Number of fruits/leaves observed X Maximum disease grade}} \text{ X } 100$$

Results and Discussion

Crop sown on November 11 recorded lowest disease severity of 19.3%. The crop sown on the above date also recorded highest fruit yield of 233.5 q/ha. A relative lower PDI (20.7%) was recorded in the crop sown on November 18. Whereas, highest disease severity of 34.7% was recorded in the crop sown January 6 and lowest fruit yield of 182.4 q/ha. As evident from the data, late sowing favoured disease development. The temperature ranged from 6.8 to 22.9°C, relative humidity ranged from 60.6 to 82.3% sunshine hours ranged from 8.2 to 8.7 hr and rainfall ranged from 0.2 to 0.5 mm apparently favoured disease development during 2013-14 (Table 1).

PDI were nonsignificantly positively correlated with maximum temperature, minimum temperatureand meantemperature and significantly positively correlated with morning relative humidity (r = 0.551), evening relative humidity (r = 0.650), meanrelative humidity (r = 0.653) and rainfall (r=0.678), significantly negative correlated with sunshine hours (r= -0.734) during 2013-14. (Table 2) The data are again subjected to simple and multiple linear regression analysis.

The simple regression equations of PDI (%)

$Y= -61.2 + 3.89X_1$; $Y= 1.82 + 3.55X_2$;
$Y= -7.16 + 1.99 X_3$; $Y= -23.8 + 0.66 X_4$

$Y= -74.7 + 1.63 X_5$; $Y= -55.8 +1.19 X_6$;
$Y= 11.5 + 50.4 X_7$; $Y= 306.2 – 33.0 X_8$

Where,

Y= PDI(%), X_1 =Maximum temperature (^{0}C), X_2 = Minimum temperature (^{0}C), X_3 = Mean temperature (^{0}C), X_4 = Morningrelative humidity (%), X_5 = Evening relative humidity (%), X_6 = Mean relative humidity (%), X_7= Rainfall (mm), X_8= Sunshine (hr)

Out of eight weather parameters selected for the study, only sunshine was found to be contributing significantly negative impact. Mean temperature, morning relative humidity, evening relative humidity, mean relative humidity, rainfall, and sunshine was found to be contributing significantly positive impact on PDI, while all other variables like maximum temperature and minimum temperature showed nonsignificant.

The multiple regression equation is

$$Y= 699.4 – 12.241 X_1 – 1.876 X_2+1.984 X_3 - 0.103 X_4 + 0.731 X_5+1.183X_6– 39.272 X_7 – 48.199 X_8$$

With R^2 =0.554

Where,

Y= PDI (%), X_1 =Maximum temperature (^{0}C), X_2 = Minimum temperature (^{0}C), X_3 = Mean temperature (^{0}C), X_4 = Morningrelative humidity (%), X_5 = Evening relative humidity (%), X_6 = Mean relative humidity (%), X_7= Rainfall (mm), X_8= Sunshine (hr)

The multiple regression fit was found highly significant for the data with R^2=0.554 for the PDI. Out of eight weather parameters selected for the study, only rainfall was found to be contributing significantly negative impact on PDI, while all other variables showed nonsignificant.

Fruit yield were nonsignificantly positively correlated with maximum temperature, minimum temperature and meantemperature andsignificantly positively correlated with sunshine hours (r = 0.636), significantly negative correlated with morningrelative humidity (r = -0.574), evening relative humidity (r = -0.493), mean relative humidity (r = -0.614) and rainfall (r = - 0.632). (Table. 3)

The data are again subjected to simple and multiple linear regression analysis.

The simple regression equations of fruit yield (q/ha)

$Y= - 787.2 + 43.7 X_1$; $Y= -60.8 + 37.3 X_2$;

$Y= -593.3+ 53.5 X_3$; $Y= 356.9 – 1.96 X_4$;

$Y= 425.8 – 3.53 X_5$; $Y= 427.4 – 3.17 X_6$;

$Y= 247.3 – 133.6 X_7$; $Y= -481.6 + 81.4 X_8$

Where,

Y= Fruit yield (q/ha), X_1 =Maximum temperature (^{0}C), X_2 = Minimum temperature (^{0}C), X_3 = Mean temperature (^{0}C), X_4 = Morningrelative humidity (%), X_5 = Evening relative humidity (%), X_6 = Mean relative humidity (%), X_7= Rainfall (mm) andX_8= Sunshine (hr)

Out of eight weather parameters selected for the study, only sunshine was found to be contributing significantly positive impact and morning relative humidity, evening relative humidity, mean relative humidity and rainfall was found to be contributing significantly negative impact on fruit yield, while all other variables like maximum temperature, minimum temperature and mean temperature showed nonsignificant.

The multiple regression equation is

$$Y= -2,186.8 + 43.569 X_1+ 52.511 X_2+58.521 X_3 + 0.307 X_4- 2.897 X_5-3.264 X_6+ 138.341 X_7 + 135.313 X_8$$

With R^2 =0.584

Where,

Y= Fruit yield (q/ha), X_1 =Maximum temperature (^{0}C), X_2 = Minimum temperature (^{0}C), X_3 = Mean temperature (^{0}C), X_4 = Morningrelative humidity (%), X_5 = Evening relative humidity (%), X_6 = Mean relative humidity (%), X_7= Rainfall (mm), X_8= Sunshine (hr)

The multiple regression fit was found highly significant for the data with R^2=0.584 for the fruit yield. Out of eight weather parameters selected for the study, while all other variables*viz*., maximum temperature, minimum temperature, mean temperature, morning relative humidity, evening relative humidity, mean relative humidity, sunshine, rainfall showed nonsignificant.

Lakra. (2005) conducted field trial *i.e.*, effect of date of sowing (1 Oct., 16 Oct., 1 Nov., 16 Nov. and 1 Dec.) for monitoring early blight (*Alternaria solani*) of potato. Planted crops from 2001-02 to

2004-05. In October sown crops, yield loss was highest due to occurrence of high incidence of early blight. November sown crops exhibited moderate level of disease incurring only 15.0-20.0% yield loss. In December planted crops, early blight, acquired serious proportions causing higher yield loss (30.0%).

Peralta *et al*. (2005) reported that high disease severity of early blight disease can lead to complete defoliation, is most damaging on tomato in regions with heavy rainfall, high humidity and fairly high temperatures 24-29^{0}C.

Singh *et al*. (2007) conducted trial on epidemiological study of tomato. They reported per cent disease index (PDI) was recorded at 45 days of disease appearance, which clearly indicates a significant increase in disease severity due to delay in transplanting during both the years. Maximum PDI (37.86 and 38.71) was recorded in 9th July followed by 23rd June (27.26 and 35.45) and 7th June (23.56 and 29.60) during the growing seasons of 2005 and 2006, respectively. Similarly delayed transplanting of tomato had significant impact on area under disease progress curve (AUDPC) and it was highest (436.85 and 474.77) in 9th July followed by 23rd June and lowest (314.82 and 393.02) in 7th June.

Yanar*et al*. (2010) studied the effects of different planting dates (1st, 10th, and 20th of May)of different varieties of early blight (*A.solani*)of potato.Average early blight severities of cultivar Agata were 2.7%, 1.0%, and 0.4% at first, second and third planting dates, respectively. Disease indexes of the same cultivar were 67.5%, 25.0%, and 10% at the three different planting dates, respectively. On the other hand, early blight severities of cultivar Marabel were 1.4, 0.3, and 0.0 at first, second and third planting dates, respectively, while disease indexes were 35.0%, 7.5%, and 0.0%, respectively. The semi-late maturing cultivar Agria had no early blight symptoms at any of these three planting dates.

Pandey (2011) conducted epidemiological trials on tomato during 2002, 2003 and 2004. On the basis of three years data it was concluded that early blight initiates in November from *Kharif* sown tomato and continued up to April-May in *Rabi* sown tomato in Gangetic plains. *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.^{O}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% in early blight development.

Rani *et al*. (2015) worked on effect of weather on early blight of tomato. They reported that weather factors (temperature, humidity and rainfall) were found to play a significant role in the development of early blight of tomato. Disease showed a progressive increase and maximum disease intensity was observed in the 21th standard week in the variety Pusa ruby and minimum severity in Co3 during the same week.The per cent disease intensity exhibited significant and positive simple correlation with minimum and maximum temperature and significant and negative correlation with maximum relative humidity. However, rainfall and minimum relative humidity showed nonsignificant positive and negative correlation respectively.

Table 1: Incidence of early blight of tomato at different sowing dates in relation to meteorological factors

Date of sowing	Days	Temperature (°C)			RH (%)			Sun Shine (hr)	Rainfall (mm)	*PDI (%)	*Fruit Yield (q/ha)
		Maximum	Minimum	Mean	Morning	Evening	Mean				
11-11-2013	93	22.7	7.3	15.0	60.6	60.6	60.6	8.7	0.2	19.3 (25.9)	233.5
18-11-2013	86	22.8	7.3	15.1	76.7	68.2	68.2	8.6	0.2	20.7 (26.7)	232.4
25-11-2013	79	22.6	7.0	14.8	76.9	68.3	68.3	8.6	0.2	23.3 (28.8)	206.8
02-12-2013	72	22.5	6.8	14.7	76.8	68.2	68.2	8.5	0.3	26.7 (30.9)	194.0
09-12-2013	65	22.7	7.0	14.9	77.8	69.4	69.4	8.5	0.3	22.7 (28.3)	207.5
16-12-2013	58	22.9	7.3	15.1	79.1	70.9	70.9	8.3	0.3	31.3 (34.0)	200.4
23-12-2013	51	22.7	7.2	14.9	80.5	72.4	72.4	8.3	0.4	33.3 (35.3)	198.5
30-12-2013	44	22.8	7.2	15.0	82.0	74.3	74.3	8.3	0.4	32.7 (34.9)	196.4
06-01-2014	37	22.6	7.2	14.9	82.3	75.3	75.3	8.2	0.5	34.7 (36.0)	182.4
S Em (±)										2.3	9.5
									CD at 5%	6.9	28.8
									CV%	12.8	8.1

*Mean of three replicationsFigures in parentheses are transformed arc sine values

Table 2: Correlation and simple regression between weather parameters and PDI (%)

Description	Correlation coefficient (r) of PDI (%)	Coefficient of determination(R^2)	Regression equations
Temperature (°C)			
Maximum (X_1)	0.061 ^{NS}	0.003 ^{NS}	$Y= -61.2 + 3.89X_1$
Minimum (X_2)	0.079 ^{NS}	0.006 ^{NS}	$Y= 1.82 + 3.55X_2$
Mean (X_3)	0.076 ^{NS}	0.999 *	$Y= -7.16 + 1.99 X_3$
Relative humidity (%)			
Morning (X_4)	0.551 *	0.303 *	$Y= -23.8 + 0.66 X_4$
Evening (X_5)	0.650 *	0.422 *	$Y= -74.7 + 1.63 X_5$
Mean (X_6)	0.653 *	0.427 *	$Y= -55.8 + 1.19 X_6$
Rainfall (mm) (X_7)	0.678 *	0.459 *	$Y= 11.5 + 50.4 X_7$
Sunshine (hr) (X_8)	-0.734 *	0.538 *	$Y= 306.2 – 33.0 X_8$

*Significant at 5% level of significance NS- Nonsignificant

Table 3: Correlation and simple regression between weather parameters and fruit yield (q/ha)

Description	Correlation coefficient (r) of Yield(q/ha)	Coefficient of determination(R^2)	Regression equations
Temperature (°C)			
Maximum (X_1)	0.246 ^{NS}	0.057 ^{NS}	$Y= - 787.2 + 43.7 X_1$
Minimum (X_2)	0.291 ^{NS}	0.085 ^{NS}	$Y= -60.8 + 37.3 X_2$
Mean (X_3)	0.287 ^{NS}	0.102 ^{NS}	$Y= -593.3+ 53.5 X_3$
Relative humidity (%)			
Morning (X_4)	-0.574 *	0.329 *	$Y= 356.9 – 1.96 X_4$
Evening (X_5)	-0.493 *	0.243 *	$Y= 425.8 – 3.53 X_5$
Mean (X_6)	-0.614 *	0.377 *	$Y= 427.4 – 3.17 X_6$
Rainfall (mm) (X_7)	-0.632 *	0.399 *	$Y= 247.3 – 133.6 X_7$
Sunshine (hr) (X_8)	0.636 *	0.404 *	$Y= -481.6 + 81.4 X_8$

*Significant at 5% level of significance NS- Nonsignificant

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