The Bioscan 9(3): 1345-1350, 2014 (Supplement on Plant Pathology)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EPIDEMIOLOGICAL STUDIES ON EARLY BLIGHT DISEASE OF TOMATO

D. K. SAHU*, C. P. KHARE, H. K. SINGH, R. PATEL AND M. P. THAKUR
Department of Plant Pathology,
Indira Gandhi Krishi Vishwavidyalaya, Raipur - 492 006, INDIA
e-mail: dsahu696@gmail.com

KEYWORDS
Alternaria solani
Correlation
Epidemiology
Weather parameters
Tomato

Received on :
23.02.2014

Accepted on :
10.07.2014

***Corresponding author**

ABSTRACT

Alternaria leaf blight caused by *Alternaria solani* is a severe constraint in tomato production. The severity of this disease has been increasing day by day for last few years in India due to changes in environment. The field experiment was carried out to understand the development of early blight on tomato with respect to weather conditions during Rabi 2011-12 and 2012-13 at IGKV Raipur. Results showed that maximum temperature (r= -0.801 in 2011-12 and -0.564 in 2012-13), minimum temperature (r=-0.755 in 2011-12 and -0.682 in 2012-13), relative humidity during morning (r=-0.550 in 2011-12 and -0.541 in 2012-13), relative humidity during evening (r=-0.593 in 2012-13) and rainfall (r=-0.531 in 2012-13) had strong negative and significant correlation with disease severity index (DSI) while relative humidity during evening (r=0.342 in 2011-12) and rainfall (r=0.409 in 2011-12) had positive correlation with DSI. Disease severity was found comparatively higher in the temperature range from 25.6-28.3°C (maximum) and 13.6-16.4°C (minimum) and average relative humidity 65% in the month of January 2011-12 and 2012-13.

INTRODUCTION

Tomato (*Solanum lycopersicum* 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 tonns per hectare (Anonymous, 2011). Tomato production is severely affected by several diseases at all growing stages from seedling to maturity causing considerable reduction in yield (Balanchard 1992). Of these, early blight caused by the necrotrophic fungus *Alternaria solani* (Ellis and Martin) Jones and Grout, is one of the most common foliar diseases of tomato occurring over a wide range of climatic conditions. It is found prominently in areas with dew, rainfall and high relative humidity. The plants are most susceptible at 8-10 week's age. This disease, under severe condition may lead to complete defoliation, can occur in areas with high rainfall high humidity and high temperature (24-29°C) as well as in semiarid climates where frequent and prolonged night dews occur (Rotem and Reichert, 1964; Agrios, 1988). The other symptoms associated with the disease includes collar rot (basal stem lesions at the seedling stage), stem lesions in the adult plant stage and fruit rot (Chaerani *et al.*, 2006; Nash and gardner, 1988; Ganie *et al.*, 2013). The leaf blight phase, commonly referred to as early blight, is the most important phase of the disease and can result in complete loss of the crop when incidence is severe (Kallo and Banerjee, 1993; Jambhulkar *et al.*, 2012). Early blight of tomato is important in reducing crop yields (Sahu *et al.*, 2013a). Yield losses up to 79% due to early blight damage were reported from Canada, India, USA, and Nigeria (Basu 1974; Datar and Mayee, 1981; Sherf and MacNab, 1986; Mathur and Shekhawat, 1986; Gwary and Nahunnaro, 1998). Collar rot can cause seedling losses in the field from 20 to 40 percent (Sherf and MacNab, 1986).

This disease causes chlorotic and necrotic spots (Mirkarimi *et al.*, 2013a). Important hosts for *Alternaria* include tomatoes, potatoes and eggplant (Pschedit, 1985). Other hosts, including nettle, red peppers and other vegetables like cabbage, cucumbers and flowers like Zinnia (Qusta, 2004). The management of tomato crops against this pathogen is important to maximize the crops' yield. The disease occurs throughout the major tomato production areas and it is difficult to produce both the crops during the main rainy season without chemical protection measures (Sahu *et al.*, 2013b; Kumar and Shrivastava, 2013).

Environmental factors play a key role in the development of the disease. The spores remain on the soil surface and on the leaves (Rouselle *et al.*, 1999). Early blight develops more rapidly during periods when environmental conditions alternate between humidity and drought.

In recent years, many studies have been carried out to examine the presence and dispersion of pathogenic fungal spores in crops (Olga *et al.*, 2010; Burt *et al.*, 1998; Davis and Main, 1986). Many authors have developed epidemiological models, in order to predict when the disease will occur and to improve the use of control measures (Díaz *et al.*, 1998; Wiik, 2002). Almost all these models are based on the use of meteorological parameters, especially relative humidity, temperature and rainfall. Anaccurate forecast of the spore concentrations in a geographical area allows for reductions in the use of fungicide treatments, preventing pollution of the atmosphere, crops and fields (Frenguelli, 1998).

The correlation between weather and disease severity has been recognised by many authors in different parts of the world (Raghavendra, 2006; Sangeetha and Siddaramaiah, 2007; Mesta *et al.*, 2009 and Devi and Chanu, 2012). Atmospheric A*lternaria* spores, temperature and humidity are the factors that most closely correlate with the occurrence of this disease. The aim of present study is to find out the role of various weather factors on infection and development of early blight in tomato.

MATERIALS AND METHODS

Field experiments were conducted during *Rabi* season 2011-12 and 2012-13 at the Horticulture Research Farm, Indira Gandhi Krishi Vishwavidyalaya Raipur. Pusa Ruby was used in the experiments. The standard method was used for other cultural practices. The experiment was carried out in randomized block design with three replications sown at 60 × 45 cm. In each plot (10 ×10 m) ten plants were selected at randomly, labeled and severity of early blight was recorded at seven days interval starting from the date of planting on leaves using 0-5 grade scale as given by Horsefall and Barett, 1945 (Table1).

The Disease Severity Index (DSI) was calculated using the formula (Wheeler, 1969).

$$DSI = \frac{\text{Sum of individual rating}}{\text{No. of leaves examined} \times \text{Maximum disease scale}} \times 100$$

The experiments were conducted under natural field conditions. No protection was given against any disease. Weather parameters were relative humidity (%), maximum/ minimum temperature (°C), rainfall (mm), and rainy days. Weather data with respect to maximum and minimum temperature, relative humidity during morning (M), RH evening (E) and rainfall were obtained were recorded with the assistance from the Department of Meteorology, IGKV Raipur and averaged for seven days (Table 2 and 3). The weather parameters were correlated to weekly disease severity index by calculating the Karl Pearson's correlation coefficient (r). Correlation coefficient values were tested individually for their significance at 5% probability level using following formula:

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

Where, t: test of significance, r: correlation coefficient and n = number of observations

Further, the data were subjected to multiple linear regression analysis to find out the linearity of the independent variables for prediction of disease and the correlation coefficient r and regression coefficient b between the number of disease severity and weather factors were calculated. The following prediction equation was used:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$$

Where, Y is the predicted number of conidia or number of spots, a is the intercept, b_1 to b_5 are the partial regression coefficients, X_1 is the maximum temperature (°C), X_2 is the minimum temperature (°C), X_3 is the relative humidity morning(%), X_4 is the relative humidity evening(%), and X_5 is the total rainfall (mm).

RESULTS AND DISCUSSION

Progressive disease development

Disease development under natural conditions was found to be influenced by environmental factors. The data from 2 crop seasons revealed that 20 days old plant transplanted on 41st standard meteorological week (SMW) during 2011-12 and 2012-13. Observations were recorded from 45th SMW at weekly interval. The first appearance of early blight was noticed 28 days after planting (DAP) in 2011-12 and 30 DAP (2012-13) which progressed thereafter (Table 2 and Fig.1 and 2). The development of the disease was initially slow but it reached to maximum during the 7th SMW of 2012 (78.28%) and also in 2013 (76.70%) which happened in the month of February.

During the cropping period maximum temperature ranged from 22.8°C (5th SMW 2012) to 32.6°C (45th SMW 2011), minimum temperature from 9.1°C (2nd SMW 2012) to 20.8°C (45th SMW 2011), relative humidity during morning ranged from 81% (7th SMW 2012) to 95% (46th SMW 2011) and relative humidity during evening ranged from 25% (2nd SMW 2012) to 72% (4th SMW 2012). However, rainfall ranged from 0 mm (45th SMW 2011) to 34.1 mm (4th SMW 2012) in 2011-12 and in 2012-13 maximum temperature ranged from 25.6^{0}C (4th SMW 2013) to 31.9°C (46th SMW 2012), minimum temperature from 8.3°C (6th SMW 2013) to 20.2°C (45th SMW 2012) relative humidity during morning ranged from 77% (7th SMW 2013) to 96% (52nd SMW 2012) and relative humidity during evening ranged from 37% (50th SMW 2013) to 74 (45th SMW 2013).

Increase in disease severity index was comparatively higher in the temperature ranged from 26.3- 28.3°C (maximum), 10.5-14.5°C (minimum) and average relative humidity of 65% in the month of January in 2011-12 and also in 2012-13 were most congenial for disease development. These findings are in agreement with the earlier findings (Sarkar and Sengupta, 1978; Humpherson- Jones and Ainsworth, 1983; Maude *et al.*, 1986; Hiremath *et al.*, 1990; Sinha *et al.*, 1992; Broker and Patil, 1995; Rajiv Kumar and Singh, 1996; Das *et al.*, 1998 and Kemmitt, 2002).

Correlation study

The correlation analysis between DSI obtained at different

Table 1: Scale/description of the symptoms for early blight

Scale	Description of the symptoms
0	Leaves free from infection
1	Small irregular spots covering <5% leaf area
2	Small irregular brown spots with concentric rings covering 5.1-10% leaf area
3	Lesions enlarging, irregular brown with concentric rings covering 10.1-25% leaf area
4	Lesions coalease to form irregular and appears as a typical blight symptom covering 25.1-50% leaf area
5	Lesions coalease to form irregular and appears as a typical blight symptom covering >50% leaf area

Table 2: Effect of weather parameters on disease development and severity of early blight of tomato during *Rabi* 2011-12 and 2012-13 at IGKV Raipur

SMW	Max T (°C)	Min T (°C)	RH M (%)	RH E (%)	Rainfall (mm)		DSI (%)	Increase in DSI (%)					
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
45	32.6	31	20.8	20.2	93	88	37	74	0	42.6	0.67	0.61	0.67	0.61
46	31.8	31.9	17.7	19.5	95	87	35	73	0	84.4	4.33	1.83	3.66	1.22
47	30.8	31.6	15.2	18.4	90	92	27	54	0	2.8	9.67	4.61	5.34	2.78
48	32.2	28.9	15.8	18.4	91	89	28	56	0	9.2	13.67	10.21	4	5.6
49	31.2	28.5	15.7	17.3	89	92	30	45	0	0	18.33	15.52	4.66	5.31
50	30.2	28.4	15.2	12.7	88	87	33	37	0	0	25.71	21.4	7.38	5.88
51	29.9	29.6	14.7	16.4	85	85	35	38	0	0	31.2	26.52	5.49	5.12
52	29.8	30.1	13.4	14.3	92	96	33	59	0	27.3	36.33	32.3	5.13	5.78
1	27.5	28.3	14.5	13.6	84	94	36	45	0	5.6	46.21	38.74	9.88	6.44
2	32.7	30	9.1	18.1	90	86	25	33	0	0	52.32	46.3	6.11	7.56
3	29.3	28.6	11.9	11	95	86	29	43	0	0	58.6	51.38	6.28	5.08
4	26.3	25.6	16.4	14.2	89	87	72	35	34.1	0	64.67	59.2	6.07	7.82
5	22.8	28	11	16	86	78	39	57	20.6	1.2	71.21	65.9	6.54	6.7
6	26.9	26.3	10.5	8.3	86	85	31	39	0	0	76.23	71.38	5.02	5.48
7	25.7	30.7	12.5	14.6	81	77	42	39	0	0	78.28	76.7	2.05	5.32

SMW- Standard meteorological week, Max T = Maximum temperature, Min T = Minimum Temperature, RH M = Relative humidity during morning; RH E = Relative humidity during evening; DSI = Disease severity index

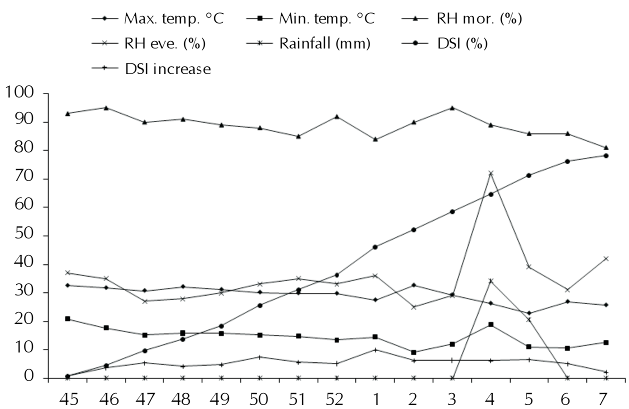

Figure 1: Progress of early blight of tomato in relation to weather parameters during 2011-12

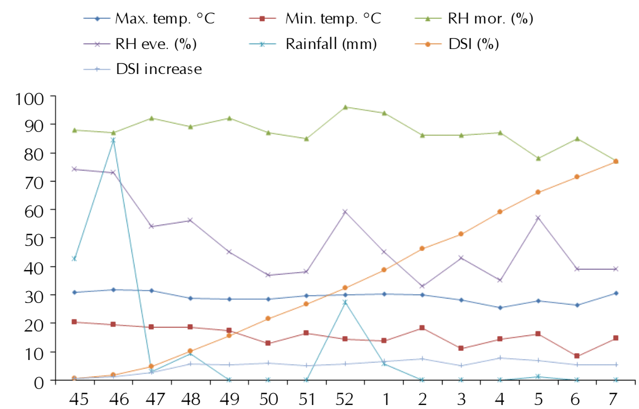

Figure 2: Progress of early blight of tomato in relation to weather parameters during 2012-13

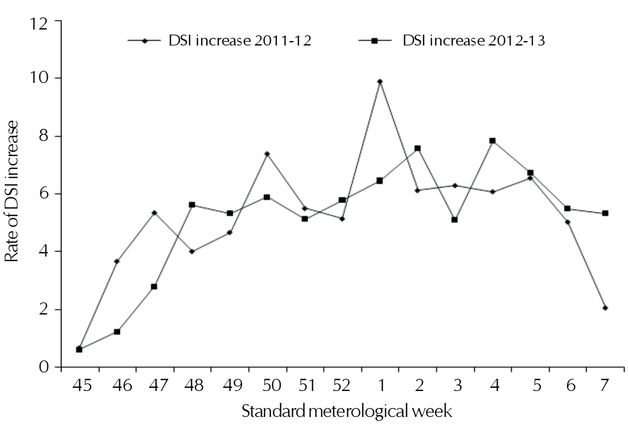

Figure 3: Rate of increase in severity of early blight of tomato during 2011-12 and 2012-13

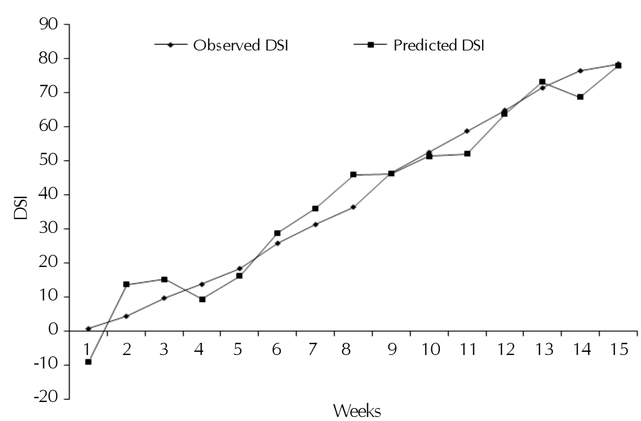

Figure 4: Observed and predicted DSI of early blight of tomato during progression of disease for Rabi 2011-12

growth stage were correlated with weather parameters prevailed during the respective stage (Table 3). The results in Table 3 indicated significant negative correlation with maximum temperature (-0.801), minimum temperature (-0.755) and relative humidity during morning (-0.550). DSI was positively correlated with relative humidity during evening (0.342) and rainfall (0.409) during 2011-12. Similarly, during 2012-13, DSI was significant and negatively correlated with maximum temperature (-0.564) minimum temperature (-0.682) and relative humidity during morning (-0.541) and evening (-0.593) and rainfall (-0.531). Our findings of correlations of DSI with different weather parameters are in agreement with earlier findings (Raghavendra, 2006; Sangeetha and Siddaramaiah, 2007; Mesta *et al*., 2009 and Devi and Chanu

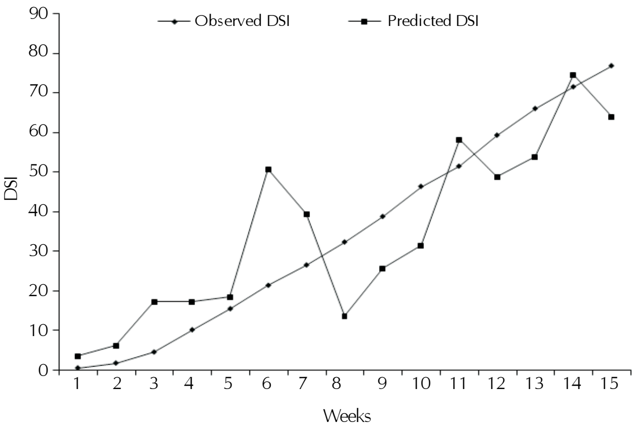

Figure 5: Observed and predicted DSI of early blight of tomato during progression of disease for Rabi 2012-13

2012). From the results presented, it is very clear that the severity of early blight of tomato declined with increase in temperature (maximum and minimum) and relative humidity during morning. However, there was no influence of rainfall and RH during evening on the severity of early blight of tomato.

The prediction equations were developed. The multiple linear regression of DSI in relation to weather parameters indicated that the regression coefficients for maximum temperature, minimum temperature, morning relative humidity, evening relative humidity and rainfall were found to be-2.98, -7.55, 0.60, 2.16 and -1.13 in *Rabi* 2011-12 and -1.19, - 3.88, -2.37, -0.29 and -0.04, respectively in *Rabi* 2012-13 (Table5).

For *Rabi* 2011-12 the regression equation when all the parameters are included was,

$Y = 109.65-2.99X_1-7.55X_2+0.60X_3\ 2.16X_4-1.03X_5$

with $R^2 = 0.95$

For *Rabi* 2012-13, the regression equation is

$Y = 350.97-1.19X_1-3.88X_2-2.37X_3-0.29X_4-0.04X_5$

with $R^2 = 0.73$

Where, Y=PDI, X_1 = maximum temperature (ºC), X_2 = minimum temperature (ºC), X_3 = RH (%) morning, X_4 = RH (%) evening and X_5 = rainfall (mm).

The R^2 values indicated that the association of weather factors with disease severity showed 95% (2011-12) and 73% (2012-13) in tomato crop infected with *A. solani*. This indicated that some unknown factors might be involved in early blight development. According to these models, the observed and predicted disease severities of early blight of tomato during *Rabi* 2012-13 are given in Table 6.

Table 3: Correlation coefficient between weather factors and early blight severity index

Weather parameters	Correlation Coefficient 'r' value	
	2011-12	2012-13
Maximum temperature (°C)	-0.801**	-0.564*
Minimum temperature (°C)	-0.755**	-0.682**
Relative humidity morning (%)	-0.550*	-0.541
Relative humidity evening (%)	0.342	-0.593
Rainfall (mm)	0.409	-0.531

*Significant (p = 0.05) level (R value 0.514), **Significant (p = 0.01) level (R value 0.641)

Table 4: Multiple regression equation for prediction of *Alternaria* blight in tomato crop

Year	Parameters	Constant (A)	X1	X2	X3	X4	X5	R2
2011-12	All weather parameters	109.65	-2.99*	-7.55	0.60*	2.16*	-1.03	0.95
2012-13	All weather parameters	350.97**	-1.19	-3.88	2.37*	-0.29	-0.04	0.73

X1 = Maximum temperature (°C), X2 = Minimum temperature (°C), X3 = Rainfall (mm), X4 = Relative humidity (morning) (%), X5 = Relative humidity (evening) (%)

Table 6: Observed and predicted DSI of early blight of tomato caused by *A. solani* during the progression of disease for *Rabi* 2011-12 and 2012-13

Time interval (week)	Disease severity index (DSI)					
	Rabi 2011-12			*Rabi* 2012-13		
	Observed PDI	Predicted PDI	Deviation	Observed PDI	Predicted PDI	Deviation
1	0.67	-9.12	9.79	0.61	3.60	-2.99
2	4.33	13.56	-9.23	1.83	6.22	-4.39
3	9.67	15.14	-5.47	4.61	17.34	-12.73
4	13.67	9.18	4.49	10.21	17.32	-7.11
5	18.33	16.05	2.28	15.52	18.53	-3.01
6	25.71	28.70	-2.99	21.4	50.69	-29.29
7	31.2	35.90	-4.70	26.52	39.38	-12.86
8	36.33	45.89	-9.56	32.3	13.56	18.74
9	46.21	46.14	0.07	38.74	25.76	12.98
10	52.32	51.21	1.11	46.3	31.40	14.90
11	58.6	51.86	6.74	51.38	58.02	-6.64
12	64.67	63.58	1.09	59.2	48.78	10.42
13	71.21	73.02	-1.81	65.9	53.84	12.06
14	76.23	68.54	7.69	71.38	74.41	-3.03
15	78.28	77.79	0.49	76.7	63.75	12.95

ACKNOWLEDGEMENT

The author is highly grateful to the Professor and Head Department of Plant Pathology Dr. A. S. Kotasthane for providing necessary facilities.

REFERENCES

Anonymous 2011. Indian horticulture database. National Horticulture Board, Department of Agriculture Cooperation, Ministry of Agriculture. pp.

Balanchard, D. 1992. A colour atlas of tomato diseases. Wolfe Publication Limited, Book House, London. p. 298.

Basu, P. K. 1974. Measuring early blight, its progress and influence on fruit losses in nine tomato cultivars. *Can. Plant Dis. Surv.* **54(2):** 45-51.

Borkar, S. G. and Patil, B. S. 1995. Epidemiology of *Alternaria* leaf spot disease of sunflower. *Indian Pytopath*. **48:** 84-85.

Burt, P. J. A., Rutter, J., Ramírez, F .1998. Airborne spore loads and mesoscale dispersal of the fungal pathogens causing Sigatoka diseases in banana and plantain. *Aerobiologia*. **14:** 209-214.

Chaerani, R., Voorrips, R. E. and Roeland, E. 2006. Tomato early blight (*Alternaria solani*): the pathogen, genetics and breeding for resistance. *J. Gen. Plant Pathol.* **13:** 335-347.

Das, N. D., Sankar, G. R. M. and Srivastav, N. N. 1998. Studies on progression of *Alternaria* blight disease *Alternaria helianthi* (Hansf.) Tubaki and Nishihara of sunflower. *Ann. Plant Prot. Sci.* **6:** 209-211.

Datar, V. V. and Mayee, C. D. 1981. Assessment of losses in tomato yield due to early blight. *Indian Phytopath.* **34(2):** 191-195.

Davis, J. M. and Main, C. E. 1986. Applying atmospheric trajectory to problems in epidemiology. *Plant Disl.* **70(6):** 490-497.

Diaz, M. R., Iglesias, I., and Jato, V. 1998. Seasonal variation of airborne fungal spore concentrations in a vineyard of North-West Spain. *Aerobiologia.* **14:** 221-227.

Devi, A. P. and Chanu, L. B. 2012. Airspora and epidemiology of early blight of tomato caused by *Altemaria solani* (Ell and Mart) Jones and Grant in Manipur. *Journal of Mycopathological Research.* **50(1):** 81-84.

Ganie, S. A., Ghani1, M. Y., Nissar, Q., Jabeen, N., Anjum, Q., Ahanger, F. A. and Ayaz A. 2013. Status and symptomatology of early blight (*Alternaria solani*) of potato (*Solanum tuberosum* L.) in Kashmir valley. *African Journal of Agricultural Research.* **8(41):** 5104-5115.

Gwary, D. M. and Nahunnaro, H. 1998. Epiphytotics of early blight of tomatoes in North eastern Nigeria. *Crop Prot.* **17:** 619-624.

Hiremath, P. C., Kulkarni, M. S. and Lokesh, M. S. 1990. An epiphytotic of *Alternaria* blight of sunflower in Karnataka. *Karnataka Journal of Agricultural Sciences.* **3:** 277-278.

Horsefall, J. G. and Barret, R. W. 1945. An improved system for measuring plant disease. *Phytopatho.* **35:** 655.

Humpherson-Jones, F. M .and Ainsworth, L. F. 1983. Canker of brassicas. 33rd Annual report for 1982, National Vegetable Research Station, Wellsbourne, Warwick, UK. pp. 63-64.

Jambhulkar, P. P., Meghwal, M. L. and Kalyan, R. K. 2012. Efficacy of plastic mulching, marigold intercropping and fungicidal spray against early blight of tomato caused by *Alternaria solani*. *The Bioscan.* **7(2):** 365-368.

Kallo, G., Banerjee, M. K. 1993. Early blight resistance in *Lycopersicon esculentum* Mill. transferred from *L. pimpinellifolium* (L.) Mill. and *L. hirsutum f.* glabratum Mull. *Gartenbauwiss.* **58:** 238-240.

Kemmitt, G. 2002. Early blight of potato and tomato. The Plant Health Instructor. DOI: 10.1094/PHI-I-2002-0809-01.

Kumar, S. and Srivastava, K. 2013. Screening of tomato genotypes against early blight (*Alternaria solani*) under field conditions. *The Bioscan.* **8(1):** 189-193.

Mathur, K. and Shekhawat, K. S. 1986. Chemical control of early blight in *Kharif* sown tomato. *Indian J. Mycol. Pl. Pathol.* **16:** 235-238.

Maude, R. B., Bambridge, J. M., Spencer, A., Suett, D. L., Drew, R. L. K., Humpherson-Jones., F. M., O' brien, M. J., Crute, I. R. and Gordon, P. L. 1986. Fungus diseases of brassicas-biology, resistance and control. 36th Annual report for 1985, National Vegetable Research Station, Wellsbourne, Warwick, UK. pp. 63-64.

Mirkarimi, H. R., Abasi moghadam, A. and mozafari, J. 2013a. Evaluation of disease resistance potential of seven potato genotypes against early blight caused by *Alternaria tenuissima* under greenhouse conditions. *Journal of Experimental Biology and Agricultural Sciences.* **1(3):** 191-196.

Mirkarimi, H. R., Abasi moghadam, A. and mozafari, J. 2013b. In vitro evaluation of Atlantic genotype to early blight of potato caused by the fungus isolates of *Alternaria solani* H. *Scholarly Journal of Agricultural Science.* **3(8):** 308-312.

Nash, A. F., Gardner, R. G. 1988. Tomato early blight resistance in a breeding line derived from *Lycopersicon hirsutum* PI 126445. *Plant Dis.* **72:** 206-209.

Olga, E., Seijo, M. C., Fernández-González, M. and Iglesias, I. 2010. Effects of meteorological factors on the levels of *Alternaria* spores on a potato crop. *Int. J. Biometeorol.* DOI 10.1007/s00484-010-0330-4.

Pscheidt, J. W. 1985. Epidemiology and control of potato early blight, caused by *Alternaria solani*. Ph. D. thesis, Van der Waals *et al.* Review of early blight of potato 101 University of Wisconsin-Madison. pp.

Qusta, Y. 2004. The studying *Alternaria* isolate in Iran. Tabiat Modares University.

Raghvendra, K. M. 2006. Epidemiology and management of *Alternaria* blight of sunflower caused by *Alternaria helianthi* (Hansf.) Tubaki and Nishihara: University of Agricultural Sciences, Dharwad Ph. D. thesis. pp.

Rajivkumar and Singh, S. B. 1996. Influence of weather factors on *Alternaria* leaf spot development in sunflower. *Indian J. Mycol. Pl. Pathol.* **26:** 196-198.

Rotem, J. and Reichert. I. 1964. Dew - A principal moisture factor enabling early blight epidemics in a semiarid region of Israel. *Plant Dis. Rep.* **48:** 211-215.

Rouselle, P., Robert, Y., and Crosnier, J. C. 1999. La patata: Producción, mejora, plagas yenfermedades, utilización. Mundi-Prensa, Barcelona. pp.

Sangeetha, C. G. and Siddaramaiah, A. L. 2007. Epidemiological studies of white rust, downy mildew and *Alternaria* blight of Indian mustard (*Brassica juncea* (Linn.) Czern. and Coss.). *Afr. J. Agric. Res.* **2(7):** 305-308.

Sarkar, B. and Sengupta, P. K. 1978. Studies on some aspects of the epidemiology. of *Alternaria* leaf blight of mustard (*Brassica sp.)* Bentrage zur *Tropischen landwirt-schaft and Veterinarmedizen.* **16(1):** 91-96.

Sahu, D. K., Khare, C. P., and Patel, R. 2013a. Seasonal occurrence of tomato diseases and survey of early blight in major tomato growing regions of Raipur district. *The Ecoscan.* **4:** 153-157.

Sahu, D. K., Khare, C. P., Singh, H. K. and Thakur, M. P. 2013b. Evaluation of newer molecules for management of early blight of tomato in Chhattisgarh. *The Bioscan.* **8(4):** 1255-1259.

Sherf, A. F. and Macnab, A. A. 1986. Vegetable diseases and their control. John Wiley and Sons, New York. pp. 634-640.

Sinha, R. K. P., Rai, B., and Sinha, B. B. P. 1992. Epidemiology. of leaf spot of rapeseed mustard caused by *Alternaria brassicae*. *J. Appl. Botany*. **2**(**1-2**): 70-73.

Vander plank, J. E. 1963. Plant disease epidemics and control. Academic Press, New York, USA 349. p. 3.

Wiik, L. 2002. Fungicide strategies against late blight in Sweden. GILB'02 conference: late blight managing the global threat. 11-13 July. Hamburg, Germany. pp.