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Effect of abiotic factors on progression of Alternaria blight of brinjal

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Abstract
Vegetables are the important component of the human diet because of their nutritional health benefits. In terms of vegetable production and consumption, India is right next to China being the second-highest producer and consumer in the world. In India brinjal is the 5th most important solanecious crop in term of production. Being a warm season crop its production is exposed to biotic stresses due to prevalence of congenial warm and wet weather conditions during the entire growing season. Amongst the biotic stresses, Alternaria blight of brinjal is one of the major disease which become severe under the weather conditions prevailing during the summer season. The study indicated that different biotic factors have a considerable impact on the initiation and progression of disease. The temperature ranging between 25-30 ºC, in combination with relative humidity >90% and leaf wetness of more than 20h were found favourable epidemiological parameters for initiation and progression of Alternaria blight on detached leaves, covering the major proportion of leaves after 144h of incubation period with maximum apparent rate of infection.

Keywords: Production, stresses, epidemiology, incubation, progression, apparent

Introduction
India is an agriculture-based country that produces a lot of fruit and vegetables apart from staple food wheat and rice. Fresh vegetables are very much important for diet mainly for vitamins, minerals, and antioxidants (Ayaz *et al.*, 2015) [2]. Amongst different vegetables, brinjal is a major cash crop in the commercial vegetable growing areas and almost every rural household has few brinjal plants in the kitchen garden. Eggplant or brinjal is the fifth most important solanaceous crop after potato, tomato, pepper, and tobacco (Choudhary and Kalda, 1968) [4]. India is considered as the center of origin and is the second-largest producer of brinjal after china. In India brinjal is grown on about 669 thousand hectares of area with production of 12400 thousand metric tons giving productivity of 18.54 metric tons per hectare. In Himachal Pradesh, it is grown during the warm season over an area of 1.22 thousand hectares with an annual production of 27.80 thousand metric tons and the productivity is 22.79 metric tons per hectare (Anonymous, 2018). Major brinjal producing states are Orissa, Bihar, Karnataka, West Bengal, Andhra Pradesh, Maharastra, and Uttar Pradesh (NHB, 2019).
Being a warm-season crop and its demand of temperature and humidity for full yield potential is always subjected to biotic stresses, results in high yield losses. Various workers across the world have reported the rapid development of Alteraria blight of brinjal under warm and humid conditions resulting in serious yield losses ((Neegards, 1945; Kapoor and Hingorani 1958; Rangaswami and Sambadam,1960; Gupta and Paul, 2001; Raja *et al.*, 2006; Kumar, 2017; Raina *et al.*, 2018). Bochalya *et al.* (2012) while studying the effect of different physical parameters on growth and sporulation of *Alternaria alternata* causing leaf spot and fruit rot of brinjal reported a temperature of 25ºC and 90 percent relative humidity as most suitable for growth and sporulation. Airspora of Alternaria has been reported over the brinjal field by different workers (Dingar and Singh, 1985; Pandey and Pandey, 2001; Pandey, 2010) [5, 8, 9]. Warm and humid (24-29 °C/ 75-84 °F) environmental conditions are conducive to infection. In the presence of free moisture and at an optimum of 28-30 °C (82-86°F), conidia will germinate in approximately 40 min (Dinger and Singh, 1985 [5]; Singh and Shukla, 1986; Buffet *et al.*, 1988; Vijaya, 2004) [5, 15, 12]. Fungal airospora of Alternaria is one of the most important factors in the occurrence of leaf spot and mostly weather dependent (Premila and Sophiarani, 2016) [10]. As Alternaria blight development on brinjal is significantly influenced by the metrological factors, thus the present study is being undertaken to study the impact of

epidemiological factors on the disease development and progression of Alternaria blight of brinjal.

Material and Methods

To find out the optimum temperature, relative humidity, and duration of leaf wetness for development and progression of Alternaria leaf blight on brinjal, fully expanded leaves of variety Pusa Purple Cluster were taken from 45-day old seedlings for inoculation. Healthy leaves were removed from the plants, washed with sterilized distilled water, and placed in sterilized Petri plates. Detached leaves were moistened with the help of sterile distilled water and were pin-pricked at the two places on the abaxial leaf surface along the horizontal axis of the main vein. The incisions were inoculated with 20µl of spore suspension (10^5 spores) of the pathogen. While the sterilized distilled water was used for inoculation in control and leaves were placed in Petri plates (14 cm) lined on both sides with double-layered moist filter paper. Different temperature levels (15, 20, 25, 30 and 35 ºC), humidity levels (75, 85, 90, 95 and 100 percent) and duration of leaf wetness (4, 8, 12, 16, 20 and 24 hr) were maintained in separate sets in Relative Humidity cum Temperature Control Cabinet. The standard temperature, relative humidity, and leaf wetness were kept as 25±2 ºC, 95±5 percent, and 24 hr, respectively. Ten leaves were taken in each replication and each treatment was replicated three-time to minimize the experimental error. The incubation period for inoculated leaves at different epidemiological factors and percent leaf area covered by a lesion at a particular factor was recorded after 48, 96, and 144 h of the incubation period. Leaf area covered by lesion was calculated using formula (Fontem *et al.*, 2004) [6] as given below:

$$S = \pi \left(\frac{L+I}{4}\right)^2$$

Where,
S = Lesion size (cm^2)
L = Length of lesion (cm)
I = Width of lesion (cm)

The total leaf area covered by lesion is given by sum of the area covered by the two lesions on the two sides of the leaves. The disease progression at different temperature regimes was measured by calculating the apparent rate of infection (r) based on the area covered by the lesion as per Van der Plank (1963) [14] using the logistic equation as given below :

$$r = \frac{2.303}{t_2\text{-}t_1} - \log_{10} \frac{X_2(1\text{-}X_1)}{X_1(1\text{-}X_2)}$$

Where,
r = apparent infection rate per unit per hour
t_2-t_1 = time interval between first and last observation
X_1 & X_2 = proportion of leaf area covered by lesion at t_1 and t_2 time intervals, respectively
(1-X_1) & (1-X_2) = proportion of healthy leaf area at t_1 and t_2 time intervals, respectively

Result and Discussion

The study indicated that all the abiotic factors have significant impact on initiation, development, and progression of Alternaria leaf blight of brinjal. Different temperature levels revealed variable responses for the disease initiation, development, and progression. A temperature level of 25 ºC was found the most suitable manifesting appearance of the disease with minimum incubation period (62.10 hours) and lesion progressed with a maximum apparent rate of infection (0.034 mm/hr), covering the 90.44 percent of leaf area after 144 hours of the incubation period, followed by that at 30ºC. The disease progression being minimum at 35ºC with an incubation period of 108.33 hours and covered nearly half the proportion of healthy leaf after 144 hours of incubation at a slower apparent rate of infection (0.021 mm/hr). At lowest temperature i.e. of 15 ºC, the pathogen failed to develop any symptoms. The higher disease intensity of Alternaria leaf spot of brinjal has been reported high between 25-30 ºC by different workers (Allen *et al*., 1982; Dinger and Singh, 1985 [5]; Singh and Shukla, 1985; Vijaya, 2004; Gaine *et al*., 2015 and Premila, and Sophiarani, 2016) [15, 10, 12].

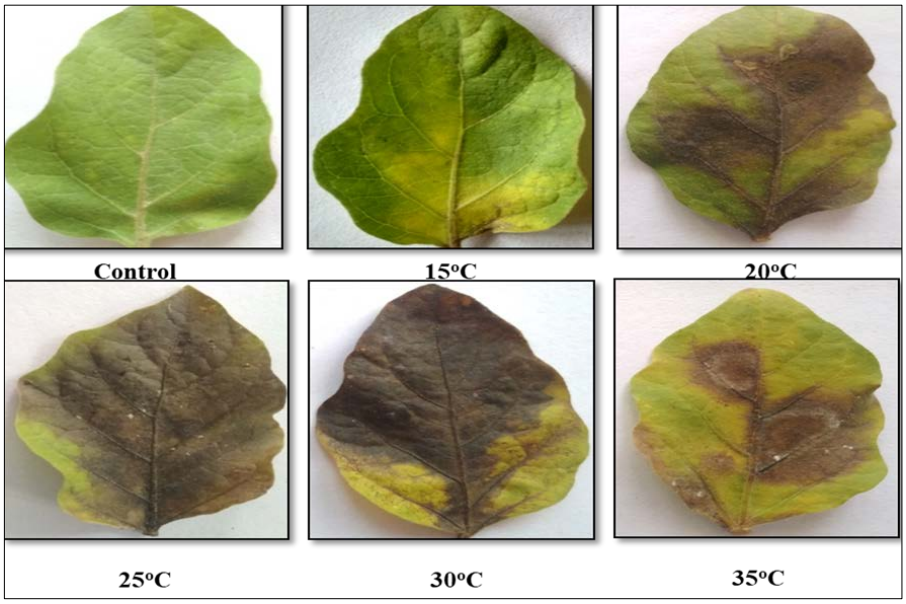


Fig 1: Alternaria leaf blight progression at different temperature levels under *in vivo* conditions

Table 1: Effect of different temperature regimes on disease progression of Alternaria leaf blight of brinjal under *in vivo* conditions

Temperature ºC	Incubation period (h)	(%) infected area after hours of incubation period				Apparent rate of infection mm /hr
		48	96	144	Mean	
15	-	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	-
20	87.56	13.24(21.32)	43.43(41.42)	62.09(51.98)	39.59(38.17)	0.025
25	62.11	25.81(30.51)	64.13(53.20)	90.44(72.50)	60.12(52.07)	0.034
30	68.22	23.50(28.99)	62.07(51.96)	83.16(65.77)	56.24(48.91)	0.029
35	108.33	12.55(20.72)	28.22(32.06)	50.91(45.50)	30.56(32.76)	0.021
		15.04(20.63)	39.59(36.01)	57.34(47.47)		

$CD_{0.05}$ Incubation period = 2.18, Temperaturre= 1.74, Interval= 1.35, Temperature×interval= 3.01

Similarly, different relative humidity levels exhibited significantly varied responses for the incubation period and disease progression. Relative humidity of 100 percent was found optimum for disease development and progression with a minimum incubation period (60.40 hours) followed by 95 percent relative humidity (68.70 hours). The further perusal of results on disease progression studies revealed that 100 percent relative humidity proved to be most favourable for disease development in a significant-high proportion (90.20%) along with the highest apparent rate of infection (0.036 mm/hr) after 144 hours of the incubation period.

Table 2: Effect of different relative humidity levels on disease progression of Alternaria leaf spot of brinjal under *in vivo* conditions

Relative Humidity (%)	Incubation period (h)	(%) infected area after hours of incubation period				Apparent rate of infection/ h
		48	96	144	Mean	
75	117.44	12.24(20.46)	26.46(30.94)	47.48(43.54)	28.73(31.65)	0.019
85	104.89	17.97(25.06)	40.51(39.51)	61.32(51.52)	39.93(38.70)	0.021
90	85.33	19.46(26.16)	47.41(43.50)	70.96(57.39)	45.94(42.35)	0.024
95	68.67	20.27(26.74)	51.80(46.01)	81.53(64.53)	51.20(45.76)	0.030
100	60.44	23.18(28.77)	56.46(48.70)	90.16(71.75)	56.60(49.74)	0.036
Mean		18.62(25.44)	44.53(41.73)	70.29(57.74)		

$CD_{0.05}$ Incubation period = 2.91, Relative Humidity = 1.04, Interval = 0.80, Relative Humidity × Interval = 1.79

The area covered by lesion and disease progression rate decreased with decreasing order of relative humidity. Late appearance and poor development of Alternaria leaf spot of brinjal were observed at 75 percent relative humidity. The significance of higher relative humidity in the rainy season with maximum disease intensity has been reported by Tubaki and Nishihara, 1969; Singh and Shukla, 1985 [5, 12]; Buffet *et al.*,1988; Dragomir, 1995; Basollote-Ureba *et al.*, 1999; Vloutoglou and Kalogerakis, 2000 [16]; Vijaya, 2004 [15]; Gaine *et al.*, 2015.

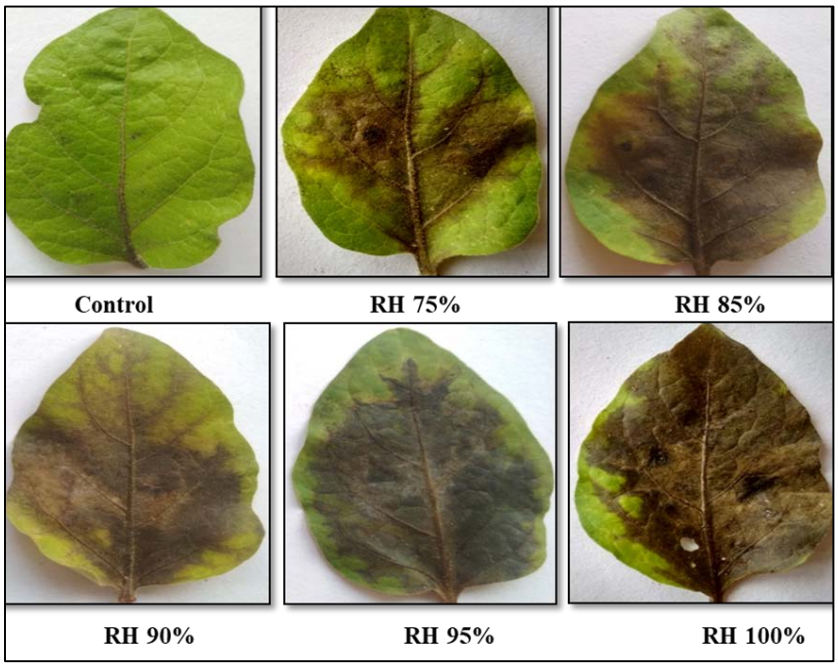


Fig 2: Alternaria leaf blight progression at different relative humidity levels under *in vivo* conditions

Leaf wetness period of 24 hours was found optimum with the lowest incubation period (63.70 hours) followed by a leaf wetness period of 20 hours (68.50 hours) and 16 hours (89.40 hours). The longest incubation period (120.60 hours) was recorded at the wetness period of 8 hours. At 4 hours of wetness period, the pathogen fails to develop any disease symptom in inoculated leaves of brinjal. The infected area covered by the lesion (88.50 %) and the apparent rate of infection (0.034 mm/hr) was found highest at 24 hours of leaf wetness.

Table 3: Effect of leaf wetness periods on disease progression of Alternaria leaf spot of brinjal under *in vivo* conditions

Leaf Wetness period (h)	Incubation period (h)	(%) infected area after hours of incubation				Apparent rate of infection/h
		48	96	144	Mean	
4	0	0.00(0.00)	0.00(0.00)	0.00()0.00	0.00(0.00)	-
8	127.56	5.15(13.09)	9.65(18.07)	24.91(29.92)	13.24(20.36)	0.019
12	113.67	9.92(18.32)	21.88(27.88)	50.26(45.13)	27.35(30.44)	0.023
16	89.44	17.63(24.82)	44.05(41.56)	70.13(56.86)	43.94(41.08)	0.025
20	68.52	19.57(26.24)	51.50(45.84)	81.16(64.28)	50.74(45.45)	0.030
24	63.66	22.80(28.50)	57.87(49.51)	88.53(70.20)	56.40(49.41)	0.034
Mean		12.52(18.76)	30.84(30.75)	52.51(44.67)		

$CD_{0.05}$ Incubation period = 2.82, Leaf wetness= 1.04, Interval= 0.40, Laef wetness ×Interval= 1.81

Therefore the results of the present study inferred that the disease progressed in increasing proportions with the increase in leaf wetness period and required a minimum of 8 hours of leaf wetness for Alternaria leaf spot infection to take place. The similar observations in relation to *Alternaria spp.* infecting different hosts at high wetness period have been made by different workers (Allen *et al*., 1982; Basallote Uber *et al*., 1999; Suheri and Price, 2000; Vollutoglou and Kalogerakis, 2000) [16]. It is also clear that, a significant duration of leaf wetness is required for the initiation of diseases in plants and free water is essential for the progression and development of disease.

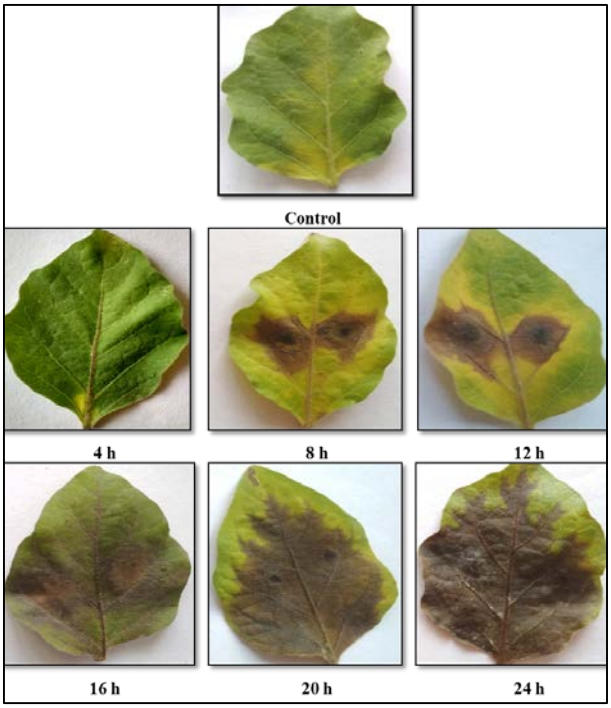
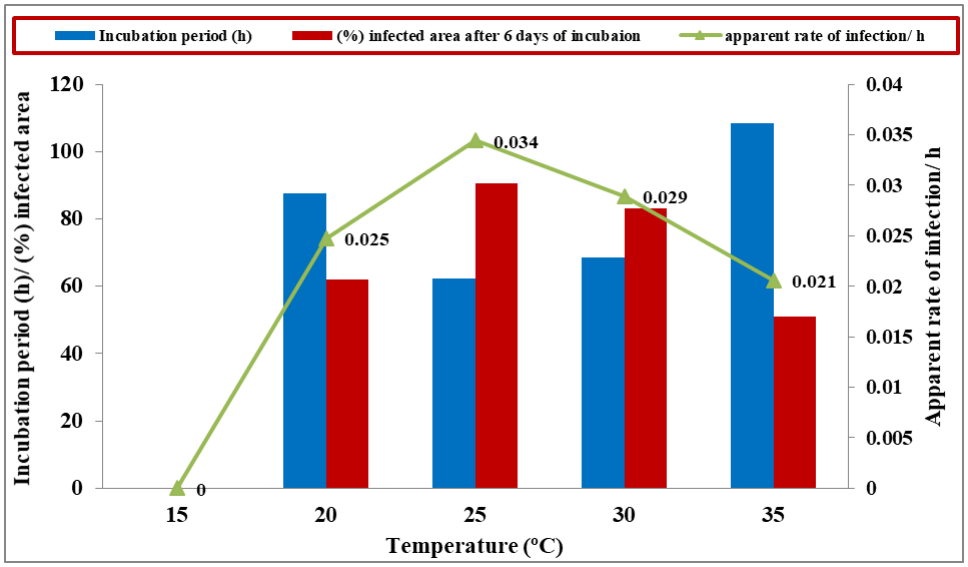


Fig 3: Alternaria leaf blight progressions at different levels of leaf wellness period under *in vivo* conditions



Graph 1: Effect of different temperature regimes on disease progression of Alternaria leaf spot of brinjal under *in vivo* conditions

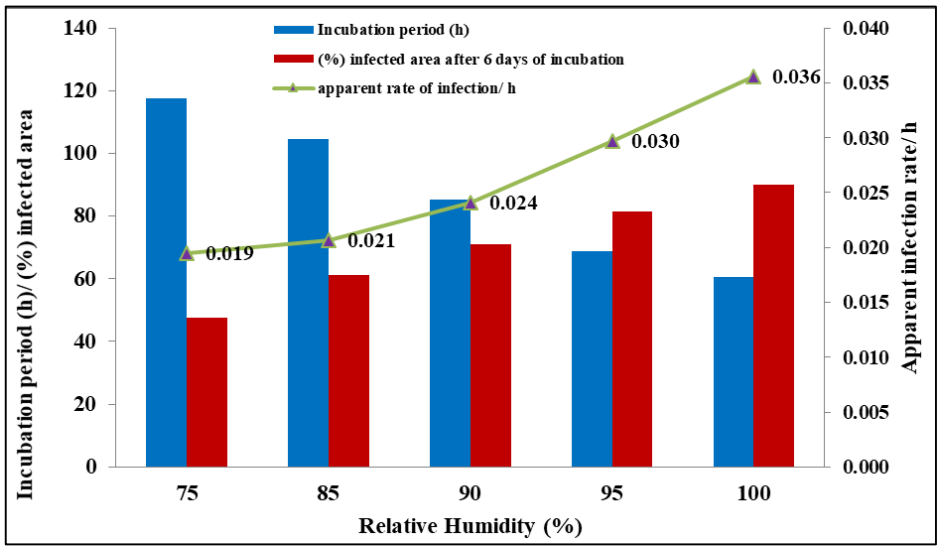
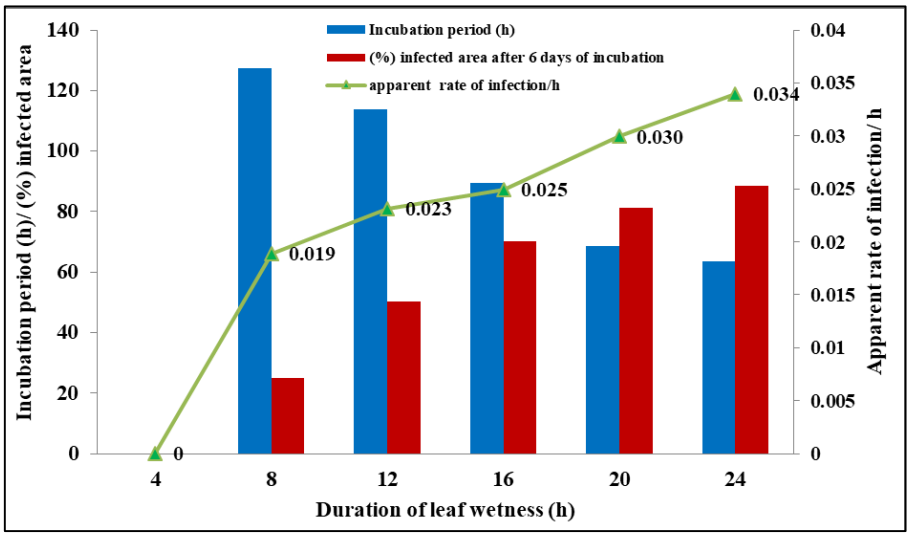


Fig 2: Effect of different levels of relative humidity on disease progression of Alternaria leaf spot of brinjal under *in vivo* conditions



Graph 3: Effect of leaf wetness periods on disease progression of Alternaria leaf spot of brinjal under *in vivo* conditions

Conclusion

Environmental factors always have an impact on disease development and progression. Although initiation of the disease depends upon the many factors like primary inoculums, survival rate of the pathogen. But among all the factors, temperature, relative humidity, and leaf wetness duration are considered the most important for the development and progression of the disease. The optimum concentration of different levels of environmental factors helps the pathogen to perpetuate and to initiate the disease in the next growing season. Considering the results of present *in-vitro* experiments the optimum levels can be correlated with the environmental conditions of the growing area and disease can be effectively managed by timely application of fungicides to reduce the cost of production and achieve a higher yield.

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