Influence of environmental factors on the progress of root rot and web blight (Rhizoctonia solani) of French bean

SACHIN UPMANYU and S.K. GUPTA
Department of Mycology and Plant Pathology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan 173 230

ABSTRACT: Root rot and web blight (Rhizoctonia solani Kuhn), an important disease of French bean, appears in the field with the onset of monsoon rains in Himachal Pradesh. A high soil moisture (80 %) and 25° C temperature were the most favourable for root rot development while web blight was best favoured at >85 percent relative humidity coupled with 25° C temperature. Continuous leaf wetness for at least 6h was essential for disease initiation, while increase in leaf wetness duration for 6-12h showed a corresponding decrease in incubation period from 36-26h, no effect on incubation period was observed with further increase in leaf wetness. Intermittent leaf wetness up to 4 cycles (12h wet! dry) resulted in high web blight severity. Simple correlation coefficient between web blight severity and mean soil moisture (r = 0.81), average relative humidity (r = 0.76) and cumulative rainfall (r = 0.73) were found to be significant and positive while partial correlation coefficients between disease severity and average relative humidity (r = 0.68) was significant and positive. Regression equation between web blight severity and environmental factors explain 86.67 percent change in the disease due to these factors. The present studies suggest that high cumulative rainfall and soil moisture, mean soil temperature ranging between 24-25° C coupled with high relative humidity (>80 %) favour the out break of web blight.

Key words: Root rot, web blight, Rhizoctonia solani, Phaseolus vulgaris

French bean (Phaseolus vulgaris L.) is an important vegetable crop of Himachal Pradesh, India. With the onset of monsoon rains, the crop is severely affected by root rot and web blight (Rhizoctonia solani Kuhn) which has become a major problem of French bean growing areas of the State (Mathew and Gupta, 1996). Almost all commercially grown cultivars were found susceptible (Upmanyu et al., 2004) and yield losses of green pods may vary from 8.45 to 64.68 percent (Sharma and Sohi, 1980). Various environmental factors like temperature, relative humidity, soil moisture and rainfall play an important role in the development of this disease (Sartorato, 1988) but in India information on this aspect is very limited (Mathew and Gupta, 1996). Hence quantification of critical environmental factors responsible for initiation and subsequent spread of the disease are crucial for the development of need-based spray programmes through effective prediction and warning systems. The present studies were, therefore, conducted through a series of in vitro, greenhouse and field experiments over three consecutive crop seasons.

MATERIALS AND METHODS

The mass culture of R. solani was prepared on sand corn meal medium. Two-week-old cultures were used for inoculating the soil. Mass culture of R. solani was mixed in steam sterilized soil @ 10g/pot contained in pots up to 5 cm depth. After inoculation, the soil was sprayed with sterilized water and the R. solani inoculum was allowed to establish under polythene cover for 2 days. For spray inoculation the mycelial mats harvested from a 4 day old culture raised in Petri plates were suspended in sterilized distilled water and homogenized in a warring blender for one minute and strained through double layered muslin cloth to get a clear suspension, which was serially diluted with sterile distilled water to contain 15-20 mycelial bits per microscopic field (150 X) and used as
inoculum. The percent root rot incidence and disease severity were calculated by using a 0-5 scale as adopted by Mathew and Gupta (1996).

To study the effect of different temperature regimes on the incidence of root rot, steam sterilized soil contained in pots (10 cm dia.) was inoculated with *R. solani* culture. Three seeds of French bean were sown in each pot and each treatment was replicated 6 times. These pots were kept in different incubators provided with light and maintained at 15, 20, 25, 30 and 35°C for 20 days. The data on incidence of root rot were recorded 10 and 20 days after sowing (DAS). To study the effect of temperature regimes on web blight severity, twenty-five days old bean seedlings were inoculated with mycelial suspension and transferred to the moist chamber for 12 h for providing sufficient leaf wetness required for infection and subsequently placed in incubators maintaining 15, 20, 25, 30 and 35°C temperatures. Each treatment was replicated six times. The data on web blight severity were recorded after 48 h of incubation.

In order to study the effect of different soil moisture regimes on the incidence of root rot, sterilized soil contained in pots (10 cm dia) was inoculated with *R. solani* culture and three seeds were sown in each pot. Different moisture levels (%) viz., 20, 30, 40, 50, 60, 70 and 80 were maintained and each moisture level was replicated 10 times. Moisture levels were achieved by calculating moisture percentage through thermo gravimetric method as given by Misra and Ahmed (1987). The pots were kept in the greenhouse and daily moisture level was maintained by adding requisite quantity of water for 20 days. The number of infected plants at each moisture level was recorded 10 and 20 DAS for pre- and post-emergence root rot, respectively, and disease incidence (%) was calculated.

To find out the most optimum relative humidity levels for the development of web blight, ten day old potted French bean seedlings were inoculated with mycelial suspension, placed in desiccators (25 cm dia.) kept at 25 ± 1°C for 48 h and maintaining different humidity levels viz., 100.0, 98.2, 95.6, 89.9, 85.7 and 80.5 percent. Data on web blight severity were recorded after 48h. Spray inoculated potted 10 days old French bean seedlings were immediately transferred to a moist chamber. Distilled water sprays were given frequently so that leaves remained completely wet. After, 3, 6, 9, 12, 18, 24 and 48 h of wetness, the plants were removed from the moist chambers and leaves were air-dried in front of a fan and the plants transferred to a net house bench for development of symptoms. Data on web blight severity and incubation period was calculated.

The severity of web blight was recorded in a replicated field trial at weekly intervals commencing from 10th July and were continued upto 4th September in 2000 and 2001. Simultaneously, meteorological data on temperature, relative humidity, cumulative rainfall, soil temperature and soil moisture were also recorded for the intervening period between two consecutive disease severity data recordings and simple, partial and multiple correlations were worked out separately for both years and then data were pooled to establish the relative contribution of these factors in the spread of the disease. The disease progress was also measured by calculating area under disease progress curve (AUDPC) as described by Shanner and Finney (1977).

**RESULTS AND DISCUSSION**

Effect of different temperature regimes showed that web blight was not observed at 15°C but with increase in temperature, it increased and reached maximum at 25°C, after which it decreased (Fig. 1A). These results to a greater extent corroborate the findings of (Sartorato, 1988). Similarly, high incidence of root rot was recorded when weekly atmospheric and soil temperature were above 25 and 23°C, respectively (Sharma, 1988). Incidence of root rot was minimum but constant at lower soil moisture regimes (20-40%), increased up to 50 percent moisture level and reached maximum at 70 percent moisture level (Fig. 1B). However, subsequently increase in root rot incidence was not observed. In contrast, Bruggen et al. (1986) observed a positive correlation between lesion size and soil moisture, being largest at 10 percent soil moisture regimes.

Web blight severity was comparatively less at 80.5 percent relative humidity, which increased progressively with an increase in the relative humidity from 80.5 to 100 percent (Fig. 2A). Prevalence of prolonged rainfall and high relative humidity levels favouring disease development has also been
Studies revealed that continuous wetness for 6 h was essential to initiate the infection of *R. solani* (Fig. 2B). Increase in leaf wetness from 6 to 12 h showed a corresponding decrease in incubation period (36-24 h) after which, leaf wetness duration did not have any effect on incubation period. However, there was a progressive increase in disease severity, which was maximum after 24 h of leaf wetness. Studies on the role of intermittent leaf wetness on the disease development (Table 1) showed an increasing trend in the disease severity with interruption of leaf wetness up to 4 cycles each of 12h wet and dry periods being maximum (96.67%) which suggests that the disease is also enhanced by alternate wet and dry periods. These findings corroborate with the observations of Singh (1987), who reported that if weather is just damp enough to permit infection, definite circular to irregular brown spots with distinct borders appeared whereas in the case of frequent drizzle a pronounced leaf scald appeared.

The results on the influence of environmental factors on web blight development under field conditions revealed that the disease was initiated in the third week of July and the severity at the end of study ranged from 0.0 to 63.06 and 0.0 to 55.53 percent in 2000 and 2001, respectively. The prevailing weather conditions during second fortnight of July viz., high cumulative rainfall (433.0 and 70.6 mm), high soil moisture (23.6 and 13.7 %), mean soil temperature ranging between 24-25°C coupled with high relative humidity (92.5 and 87.5%) during 2000 and 2001 crop seasons, respectively, resulted in the severe outbreak of the disease, indicating thereby the role of these factors on disease development.
Table 1. Effect of intermittent leaf wetness on development of web blight

<table>
<thead>
<tr>
<th>Total wetness period (h)</th>
<th>Wetness/dry period sequence (h)</th>
<th>Disease severity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wet</td>
<td>Dry</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>24</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>36</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>48</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

CD<sub>0.05</sub> (6.20)

Figures in parentheses are arcsine-transformed values

Fig. 3. Relationship between disease progress, meteorological factors, soil moisture and temperature during years 2000 and 2001

Development during July and August (Fig. 3). Prevalence of high cumulative rainfall and soil moisture coupled with higher relative humidity and soil temperature (23-25°C) to be most conducive for severe outbreak of the disease has also been reported by various workers (Singh, 1987; Sartorato, 1988 and Mathew and Gupta, 1996). Correlation between web blight severity and mean soil moisture was found to be highly significant and positive \((r = 0.81)\) while the correlation coefficients between web blight severity and average relative humidity \((r = 0.76)\) and cumulative rainfall \((r = 0.73)\) were found to be significant and positive (Table-2). Web blight severity and mean soil temperature and mean air temperature recorded a non-significant and negative correlation, respectively. The pooled analysis of partial correlation coefficients (Table -2) deduced highly significant and positive correlation with average relative humidity \((r = 0.68)\). Similarly, mean soil temperature also showed a positive but non-significant correlation with web blight severity. Correlation coefficients of mean air temperature and mean soil moisture were found to be positive but non-significant while that of cumulative rainfall was negative and non-significant.

The pooled coefficient of determination (year 2000 and 2001) between web blight severity and group of independent variables was found to be 0.8667, which indicated that 86.67 percent change in web blight severity was caused by mean air temperature, average relative humidity, cumulative
Table 2. Simple and partial correlation between web blight severity and meteorological as well as soil factors

<table>
<thead>
<tr>
<th>Meteorological factor</th>
<th>Simple correlation</th>
<th>Partial correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
<td>2001</td>
</tr>
<tr>
<td>Mean air temperature</td>
<td>0.0739</td>
<td>-0.2384</td>
</tr>
<tr>
<td>Av. Relative humidity</td>
<td>0.9318</td>
<td>0.3814</td>
</tr>
<tr>
<td>Cumulative rainfall</td>
<td>0.7476</td>
<td>0.2450</td>
</tr>
<tr>
<td>Mean soil moisture</td>
<td>0.7540</td>
<td>0.4997</td>
</tr>
<tr>
<td>Mean soil temperature</td>
<td>-0.2223</td>
<td>0.3746</td>
</tr>
</tbody>
</table>

*Significant at 5 per cent level

rainfall, mean soil moisture and temperature, collectively, whereas rest of the variation was due to unexplained (error variation) factors and/or the factors not included in the investigations. The regression equation $Y = -127.09 + 0.5665 X_1 + 0.3859 X_5 + \cdot 0.0053 X_5 + 0.4037 X_6 + 3.3016 X_s$ showed that a unit change in average relative humidity could influence the disease severity up to an extent of 0.3859 units, followed by soil temperature, soil moisture, air temperature and cumulative rainfall.

REFERENCES


Received for publication July 7, 2004