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Influence of Edaphic Factors on Fusarium wilt of Bell Pepper

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Abstract

Fusarium wilt of bell pepper (*Capsicum annuum* L.) caused by *Fusarium oxysporum* f. sp. *capsici* is a damaging disease and causes huge losses to the crop. To study the effect of temperature and pH on mycelial growth of *Fusarium oxysporum* f. sp. *capsici,* an experiment was conducted under *in vitro* conditions. The results revealed that pathogen grew well at temperature range 15-35 °C and pH range of 4.0-9.0. However, optimum temperature for mycelial growth was recorded at 25 °C (10.65 mm day^{-1}) followed by 30 °C (9.65 mm day^{-1}). The most suitable pH level for growth of fungus was 7.0 (12.75 mm day^{-1}) followed by 6.0 (10.70 mm day^{-1}). Growth of fungus reduced drastically below 15 and above 35 °C. Similarly very low and high pH levels were not suitable for mycelial growth. To study the effect of soil temperature and soil moisture on the development of Fusarium wilt of bell pepper, an experiment was conducted in sick pots. Bell pepper seedlings were transplanted in sick pots and different soil temperature and soil moisture were maintained. It was observed that incidence of Fusarium wilt disease was maximum (100%) at soil temperature of 25 °C followed by 30 °C (75.0%) and 20 °C (37.5%) while 40% soil moisture resulted in maximum disease incidence of 66.66% followed by 50% (58.33%) and 60% (50.00%). Hence, optimum temperature for the development of Fusarium wilt of bell pepper was 25 °C whereas optimum soil moisture was 40%.

Keywords: pH, soil temperature, soil moisture, wilt, Fusarium wilt incidence

1. Introduction

Soil-borne diseases are major constraints in the production of many economically important crops, especially vegetables and ornamentals. Fusarium wilt of bell pepper, caused by *Fusarium oxysporum* f. sp. *capsici* is one of the important soil-borne vascular wilt pathogen (Gupta and Thind, 2006). The disease is a common disease in tropical and subtropical and reduces overall yield of crop. The disease was first reported in New Mexico (Leonian, 1919). Slight yellowing of lower leaves and wilting of upper leaves followed by permanent wilting of entire plant and browning of the vascular tissue are the characteristic symptoms of the disease (Smith *et al*., 1988; Black and Rivelli, 1990). In India, occurrence of Fusarium wilt in bell pepper and chilli has been reported from various parts of country including Jammu and Kashmir, Karnataka and Himachal Pradesh and causes up to 25% losses with disease incidence up to 75% (Singh et al., 1998; Madhukar and Naik, 2004; Anonymous, 2005). Temperature and pH play important role on the growth and development of *Fusarium*. Different species and *forme specialis* of *Fusarium* grow at the temperature range of 15-30 °C and at pH 5.0 and 6.0 (Landa et al., 2001; Gangadhara et al., 2004; Jaruhar and Prasad, 2011; Kumar et al., 2012). The temperature and moisture are two important parameters which greatly influence the development of Fusarium wilts in different crops (Landa et al., 2001; Mina and Dubey, 2010; Prasad and Saifulla, 2012). Chen et al. (2013) showed that *F. oxysporum* was able to grow at wide temperature range, and the highest growth rate was observed at 23–24 °C. Scarce reports on the influence of soil temetrature and soil moisture on the development of Fusarium wilt of bell pepper are available in literature. Hence, the present investigation is concentrated on the role of temperature, pH and moisture on the growth, infection and development of Fusarium wilt of bell pepper. The effect of different temperature and pH levels on the mecelial growth of *Fusarium oxysporum* f. sp. *capsici* was studied *in vitro*. In addition, the effect of edaphic factors viz. soil temperature and soil moisture on the development of Fusarium wilt disease of bell pepper was also investigated.

2. Materials and Methods

An experiment was conducted under *in vitro* in Completely Randomized Design (CRD) to evaluate the effect of temperature and pH on mycelial growth of *F. oxysporum* f. sp. *capsici*. The

effect of different temperature treatments i.e. 15, 20, 25, 30, 35 °C on mycelial growth of fungus was evaluated to PDA medium. Sterilized Petri plates (90 mm) containing equal amount of potato dextrose agar medium were inoculated with mycelial discs of 5 mm diameter taken from actively growing culture of the fungus and were incubated at different temperatures. The experiment was replicated four times.

Similarly, the effect of different pH treatments i.e. 4, 5, 6, 7, 8, 9 on mycelial growth of *F. oxysporum* f. sp. *capsici* was evaluated to PDA medium in a Completely Randomized Design (CRD) with four replications. The pH of PDA medium was adjusted with the help of N/10 HCl or N/10 NaOH. The pH of the medium was checked after autoclaving and adjusted, if required. Inoculated Petri plates were incubated at 25±2 °C. Observations on the diametric growth of the colonies were taken at 24 h interval up to five days and the growth rate (rg) mm day^{-1} at each temperature and pH level were calculated as: Growth rate=mycelia growth/number of days

Further, effect of soil temperature and moisture on development of Fusarium wilt of bell pepper was studied in pots under polyhouse conditions. Mass culture of *F. oxysporum* f. sp. *capsici* was prepared on corn:sand meal medium (Dohroo, 1988) and sick pots, at inoculum dose of 10 g pot^{-1}, were used to conduct this experiment. Four seedlings (40 days old) of bell pepper cv. 'Solan Bharpur' were transplanted and sick pots were maintained at different temperature viz. 20, 25, 30, 35, 40 °C and soil moisture viz. 20, 30, 40, 50, 60 and 70%. The experiment was conducted in Completely Randomized Design (CRD) and each treatment was replicated four times. The numbers of wilted plants at each treatment were recorded after 10 days and per cent disease incidence was calculated.

3. Results and Discussion

Temperature had significant effect on the growth of *Fusarium* spp. In the present study, the most favourable temperature for growth of *F. oxysporum* f. sp. *capsici* was 25 °C (10.65 mm day^{-1}) followed by 30 °C (9.65 mm day^{-1}) and 20 °C (5.5 mm day^{-1}) (Table 1). However, diameter of colony was statistically at par at 15 °C and 35 °C. Growth rate of fungus started to decline above 30 °C. Differences in the growth of fungus at different temperature levels were recorded (Figure 1). Highest growth of fungus was recorded at 25 °C however, below 15 °C and above 35 °C growth was reduced drastically. Results of our studies are in conformity with the findings of Sharma et al. (2011) who also reported maximum growth of *F. oxysporum* f. sp. *lycopersici* at 25 °C followed by 30 °C while minimum average radial growth of fungus was recorded at 15 and 35 °C. Similar observations were also recorded by other workers (Gangadhara et al., 2004, Kimberly et al., 2015). They concluded that the growth of *F. oxysporum* was maximum at 25 °C after seven days of inoculation, which reduced drastically below 15 °C and showed zero growth at 40 °C.

Table 1: Effect of different temperature regimes on the mycelial growth of *F. oxysporum* f. sp *capsici*

Temperature (°C)	Colony diameter (mm)	Mycelial growth rate (mm day^{-1})
15	17.75[d]	3.55
20	27.50[c]	5.50
25	53.25[a]	10.65
30	48.25[b]	9.65
35	21.5[d]	4.30
CD (*p*=0.05)	4.94	

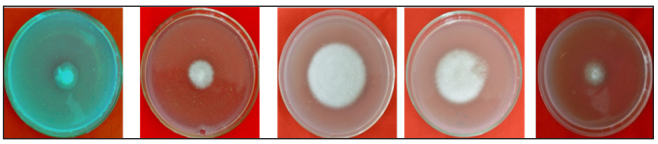

Figure 1: Effect of different temperature levels on growth of *F. oxysporum* f .sp. *capsici*

Behaviour of *F. oxysporum* f. sp. *capsici* at six pH ranging from 4 to 9 was studied with respect to their radial growth. Maximum radial growth rate of fungus was recorded at pH 7.0 (12.75 mm day^{-1}) followed by pH 6.0 (10.70 mm day^{-1}) (Table 2). Data also revealed that growth rate was increasing in ascending order (6.90, 8.75, 10.70, 12.75 mm day^{-1}) from pH 4.0 to 7.0 and started to decline above pH level of 7.0 (Figure 2). Optimum pH for growth of fungus was recorded at pH 7.0. The studies conducted on *F. oxysporum* f. sp. *capsici* during present investigation indicated that, as the pH decreases or increases from the optimum, the rate of growth gradually decreased. Gangadhara et al. (2004), Kishore et al. (2009), Gupta et al. (2010) and Jaruhar and Prasad (2011) reported

Table 2: Effect of different pH levels on mycelial growth of *F. oxysporum* f. sp. *capsici*

Temperature (°C)	Colony diameter (mm)	Mycelial growth rate (mm day^{-1})
4	34.50[d]	6.90
5	43.70[c]	8.75
6	53.50[b]	10.70
7	63.75[a]	12.75
8	49.50[b]	9.90
9	43.00[c]	8.60
CD (*p*=0.05)	4.53	

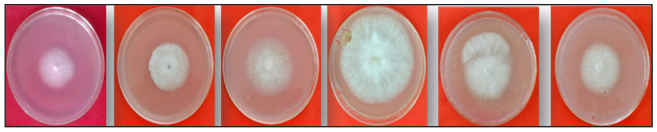

Figure 2: Effect of different pH levels on growth of *F. oxysporum* f .sp. *capsici*

optimum pH range for growth and sporulation of *Fusarium* were in between 5.0–7.0. Present findings of pH are also in consonance with the findings of Kumar et al. (2012). The results of studies conducted by Hossain et al. (2015) also revealed that mycelial growth of *F. moniliforme* was maximum at pH range of 6.0–7.0. These reports are in agreement with present findings on *F. oxysporum* f. sp. *capsici*, those highly acidic and alkaline mediums are not suitable for growth and sporulation of the fungus.

Incidence of Fusarium wilt of bell pepper was studied on different soil temperature levels ranging between 15-40 °C (Table 3). The effect of soil temperature was found maximum at temperature level of 25 °C with maximum incidence of disease. However, it was found that temperature range from 20-30 °C was suitable for development of disease. The disease incidence was minimum at 35 °C whereas no disease development was occurred at 15 and 40 °C (Figure 3). This explanation is in general agreement with those obtained for disease incidence in wilt of pea caused by *F. oxysporum* f. sp. *pisi* (Tu, 1994), who observed that disease incidence were maximum at 25-30 °C. Similar results were also obtained by Peng *et al*. (1999), Landa et al. (2001) and Sekhon and Singh (2007) who reported that range of soil temperature for Fusarium wilt disease development in different crops was 23-27 °C with optimum at 25 °C. Soil temperature range of 25-30 °C was recorded best for multiplication of *Fusarium udum* which favours wilt disease development (Prasad and Saifulla, 2012). Results obtained from present studies indicated that optimum soil temperature for Fusarium wilt development in bell pepper was 25-30 °C. This shows that extremely low and high soil temperatures are not favourable for disease development. However, information on this aspect in bell pepper is lacking and hence cannot be compared with.

Table 3: Effect of different temperature regimes on Fusarium wilt disease development of bell pepper

Temperature (°C)	Disease incidence (%)
15	0.00 (0.00)[e]
20	37.50 (37.48)[c]
25	100.00 (90.00)[a]
30	75.00 (63.73)[b]
35	12.50 (14.99)[d]
40	0.00 (0.00)[e]
CD (*p*=0.05)	(16.53)

Figures in the parenthesis are arc sine transformed value

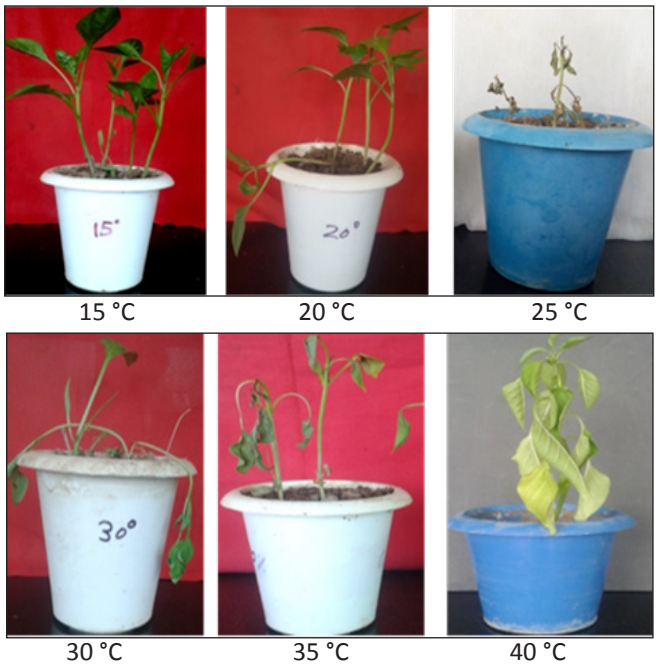

Figure 3: Effect of different temperature regimes on diseases development

Fusarium wilt of bell pepper was affected markedly by soil moisture. It had significant influence on the disease incidence when seedlings transplanted in sick soil exposed to various moisture regimes. Data (Table 4) revealed that disease incidence varied according to different moisture regimes and maximum disease incidence of 66.66% was recorded at 40% soil moisture level followed by 50% (58.33%) and 60% (50.00%) soil moisture level (Figure 4). The disease incidence at 40 and 50% soil moisture level were statistically at par with each other and there was no significant difference. The results of present studies clearly indicated that beyond 60% of soil moisture level, disease incidence started to decline whereas disease incidence was very low (25%) at 30% soil moisture level and no disease incidence was recorded at 20% soil moisture level. Results of present investigations are in conformity with Fahmy and Tewfik (1928) and Fikry (1932), who observed that relatively high percentages of soil moisture were correlated with increased disease incidence. Incidence and disease severity of wilt disease of cotton *(F. oxysporum)* was favoured by wet soil conditions. Very low soil moisture and very high soil moisture were not favourable for Fusarium wilt development.

Table 4: Effect of different soil moisture regimes on Fusarium wilt disease development of bell pepper

Moisture Level (%)	Disease incidence (%)
20	0.00 (0.00)d
30	25.00 (29.98)c
40	66.66 (54.97)a
50	58.33 (49.98)a
60	50.00 (44.98)b
70	16.66 (19.99)c
CD (*p*=0.05)	(15.571)

Figures in the parenthesis are arc sine transformed value

Figure 4: Effect of different soil moisture levels on diseases development

4. Conclusion

In order to study the thermal, moisture and pH requirement of *Fusarium oxysporum* f. sp. *capsici,* studies were conducted under *in vitro* and *in vivo* conditions**.** Optimum temperature for mycelial growth was at 25 °C. Optimum pH level for growth of fungus was 7.0 under *in vitro*. Environmental conditions play a vital role in development of diseases on a particular host with pathogen. The present study revealed that maximum incidence of Fusarium wilt of bell pepper was at soil temperature of 25 °C and soil moisture of 40% in pot conditions.

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