

Effect of environmental variables on development of *Fusarium* wilt in chickpea (*Cicer arietinum*) cultivars

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ABSTRACT

An experiment was conducted during winter (*rabi*) season of 2005–07 in laboratory and field to assess influence of environmental parameters on wilt caused by *Fusarium oxysporum* f. sp. *ciceris* in ‘Pusa 212’ and ‘BGD 1005’ chickpea (*Cicer arietinum*) cultivars at IARI, New Delhi. Under controlled laboratory experiments the growth and sporulation of *F. oxysporum* f. sp. *ciceris* was observed at different temperatures. The ‘Pusa 212’ showed larger incubation period, less wilt incidence and higher yield in comparison ‘BGD 1005’. Early sowing minimizes wilt incidence in both the cultivars. Lowest mean wilt incidence (22.6–25.5%) and maximum mean grain yield (13.5–14.3 tonnes/ha) were recorded in the crop sown on 10 and 20 November. Similar trend was observed in ‘BGD 1005’ whereas 20 November sown ‘Pusa 212’ crop showed lowest wilt incidence (15.3 and 20.1%) and highest grain yield (16.2 tonnes/ha) during both the years. Maximum and minimum ambient temperature and soil temperature were positively and significantly correlated with wilt incidence in ‘Pusa 212’.

Key words: Chickpea, *Fusarium* wilt, Environmental variables, Temperature

Chickpea (*Cicer arietinum* L.) is an important pulse crop. Low yield of chickpea is attributed to its susceptibility to several fungal, bacterial and viral diseases. Among the diseases, affecting chickpea, wilt caused by *Fusarium oxysporum* f. sp. *ciceris* (Padwick) Matuo and K. Sato is the most important and causes annual loss of 10% in yield (Dubey *et al.* 2007).

It has been predicted by fourth assessment report of Intergovernmental Panel on Climate Change (Meehl *et al.* 2007) that due to 21st century emissions, concentration of atmospheric CO₂ will increase from current 368 ppm to 600 ppm and the temperature would rise between 0.9 to 3.5°C leading the world towards global climate change. Climate change is cause of concern for agriculture. Climate not only affect plants but also affects the pathogens, insect pests and weeds that reduces crop yield (Anderson *et al.* 2004). The classic disease triangle recognizes the role of climate in disease development on crops, as no virulent pathogen can induce disease on a highly susceptible host if climatic conditions are not favourable (Agrios 2005; Ziska and Runion 2007). Wilt incidence in chickpea also depends on climatic conditions of the region. Information on influence of Indian

tropical climatic conditions on wilt incidence in chickpea is very limited. To generate baseline data and to fill the existing information gaps this study has been carried out.

MATERIALS AND METHODS

An experiment was carried out during winter (*rabi*) 2005–07 to observe growth and sporulation of *F. oxysporum* f. sp. *ciceris* causing wilt in chickpea at different temperature from 20 to 37°C. *F. oxysporum* f. sp. *ciceris* was cultured on Petri-plates of 90 mm diameter containing solidified 15 ml Potato Dextrose Agar medium. Each plate was inoculated in the centre with 3 mm diameter disc of 15-day-old culture of *F. oxysporum* f. sp. *ciceris*. Five Petri-plates were maintained for each temperature and the inoculated plates were incubated at different temperatures in incubator for 7 days. Regularly, all the plates kept at different temperatures were observed for colony diameter and sporulation till 7 days incubation period. Sporulation in *F. oxysporum* f. sp. *ciceris* on Petri-plates kept at different temperature was observed by serial dilution method.

Randomized block design was followed for field experiments in plots of 4 m × 15 m. ‘BGD 1005’ and ‘Pusa 212’ chickpea were sown at 6 different dates (10 days interval) starting from 10 November to 30 December during 2005–06 and 2006–07. Each date of sowing was replicated 4 times. Recommended agronomical and cultural practices

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were followed. Incubation period, wilt incidence at weekly interval and grain yield at crop harvest were recorded. The environmental factors, viz maximum, minimum and mean ambient temperature, mean soil temperature for 0–30 cm depth and soil moisture were recorded during the experimental period. The observations recorded were statistically analyzed (via. ANOVA) using SPSS 10.0 software for windows.

RESULTS AND DISCUSSION

The pathogen *F. oxysporum* f. sp. *ciceris* was able to grow at all temperature range (20–37°C) tested *in vitro* conditions. Sporulation was observed only from 25 to 30°C. Maximum colony diameter (85 mm) was observed at 28°C, followed by 30 and 35°C. This temperature range also favoured for maximum sporulation of the pathogen in culture. It was highest at 28 and 30°C (1.5×10^8 – 2.5×10^8 /ml), followed by 25 and 35°C (0.5×10^8 – 1×10^8 /ml). Thus, the optimum temperature range for growth and sporulation of the pathogen was 28–30°C (Fig 1). The present findings are in accordance with earlier observations of Landa *et al.* (2001) that optimum growth of *F. oxysporum* f. sp. *ciceris* was at 24.5–28.5°C.

During the field experiments in 2005–06 and 2006–07 considerable variations were observed in the mean of environmental variables such as maximum and minimum

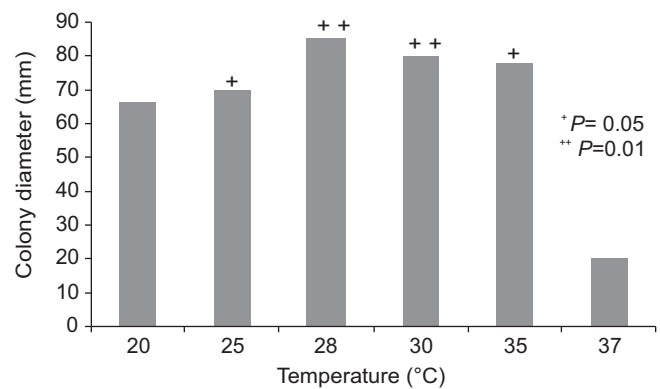


Fig 1. Growth trend of *Fusarium oxysporum* f. sp. *ciceris* at different temperatures

ambient temperature, soil temperature and soil moisture. The mean maximum ambient temperature during 2005–06 was in the range of 24.7–25.4°C and in 2006–07 it was 23.3–24°C, whereas mean minimum ambient temperature was in the range of 6.6–7.6°C in 2005–06 and in 2006–07 it was 9.2–9.7°C. The mean ambient temperature during the experimental period was high during 2006–07 (16.4°C) than 2005–06 (15.9°C). Whereas mean soil temperature was low (20.5°C) and mean soil moisture (9.4%) was high in year 2005–06 compared 2006–07 which was 23.5°C and 8.7% respectively.

Table 1 Effect of sowing dates on incubation time, wilt incidence and grain yield caused by *F. oxysporum* f.sp.*ciceris* in chickpea cultivars

Date of sowing	Incubation time (days)		Mean	Wilt incidence (%)		Mean	Yield (kg/ha)		Mean
	'Pusa 212'	'BGD1005'		'Pusa 212'	'BGD1005'		'Pusa 212'	'BGD1005'	
<i>2005–06</i>									
10 November 2005	42.0	20.0	31.0	21.3	24.0	22.6	1 440	1 410	1 425
20 November 2005	49.0	32.5	40.7	15.3	33.2	24.2	1 620	1 190	1 405
30 November 2005	46.5	30.0	38.2	21.0	38.6	29.8	1 490	1 140	1 315
10 December 2005	49.0	22.0	35.5	29.9	42.8	36.3	1 350	1 060	1 205
20 December 2005	40.0	28.0	34.0	30.1	55.6	42.8	1 290	560	925
30 December 2005	23.0	15.0	19.0	38.6	57.2	47.9	1 150	300	725
Mean	41.5	24.5	33.1	26.0	41.9	33.9	1 390	943	1 166
CD (<i>P</i> =0.05)			2.8 (1.2)			2.8 (1.2)			83.7 (10.9)
Date of sowing									
Variety			2.3 (0.7)			2.3 (0.9)			68.3 (11.2)
Date of sowing × variety			3.9 (1.6)			3.9 (1.6)			118.3 (11.2)
<i>2006–07</i>									
10 November 2006	45.0	22.0	33.5	25.0	26.0	25.5	1 390	1 310	1 350
20 November 2006	54.0	38.0	46.0	20.1	32.0	26.1	1 470	1 150	1 310
30 November 2006	50.0	35.0	42.5	21.3	38.0	29.7	1 480	1 090	1 285
10 December 2006	41.0	26.0	33.5	27.9	41.0	32.3	1 310	980	1 145
20 December 2006	38.0	25.0	31.5	28.0	42.0	39.4	1 360	940	1 150
30 December 2006	26.0	18.0	22.0	30.7	49.0	45.7	1 280	850	1 065
Mean	42.3	27.3	34.8	25.5	38.0	33.1	1 381	1 053.3	1 217
CD (<i>P</i> =0.05)			2.5 (1.1)			2.5 (1.1)			78.4 (11.1)
Date of sowing									
Variety			2.0 (0.6)			2.1(0.5)			58.2 (10.7)
Date of sowing × variety			3.5 (1.5)			3.8 (1.4)			101.2 (21.1)
SEM ± are given in parentheses									

Table 2 Correlation between environmental factors and disease incidence in chickpea cultivars

Weather factors	Disease incidence (r)	
	'Pusa 212'	'BGD 1005'
	2005–06	
Maximum temperature	0.827*	0.194 ns
Minimum temperature	0.758*	0.115 ns
Mean temperature	0.166 ns	0.805*
Soil temperature	0.813*	0.317 ns
Soil moisture	0.53 ns	0.955*
	2006–07	
Maximum temperature	0.779*	0.531 ns
Minimum temperature	0.554 ns	0.314 ns
Mean temperature	0.711*	0.449 ns
Soil temperature	0.595*	0.409 ns
Soil moisture	0.432 ns	0.482 ns

* $P= 0.05$; ns, Non-significant

Wilt incidence was observed at all the date of sowings in both the chickpea cultivars. Incubation time taken by *F. oxysporum* f. sp. *ciceris* for inducing wilt symptoms was found minimum in crop sown on 30 December during both the years in both the varieties. Of the 2 cultivars, mean incubation time for inducing wilt symptoms was less in 'BGD 1005' than 'Pusa 212' (Table 1). During both the years the incubation period in case of both the varieties at early-sown dates (November) was more and gradually it was declined during the subsequent sowing dates. Results show that delaying chickpea sowing from early winter (November) to late winter (December) suppressed disease development in spite of lower incubation period. However, the usefulness of this effect depended on the level of disease resistance in chickpea cultivars (Landa *et al.* 2004, Navas-Cortés *et al.* 2000). The influence of temperature on the resistance of chickpea cultivars to Fusarium wilt has important implications on the efficient use of choice of sowing dates and chickpea genotypes in infested soils with pathogen for which the cultivars may show a temperature-sensitive reaction.

Wilt incidence was lowest in Pusa 212' sown on 20 November of 2005–06 and 2006–07, whereas in 'BGD 1005' it was lowest in 10 November. The incidence in both the cultivars increased gradually during subsequent dates of sowing and reached maximum at 30 December sown crops. The wilt incidence was more in 'BGD1005' than the 'Pusa 212'.

In 'BGD1005' grain yield in 10 November sowing was highest during both the years. Whereas in 'Pusa 212' highest grain yield was recorded in crop sown on 20 November in 2005–06 and on 30 November sown crop in 2006–07. Mean yield between 2 cultivars for all sowing dates was high in 'Pusa 212' compared to 'BGD 1005' and between different

date of sowing grain yield was highest on 10 November sown crop during both the years (Table 1). Landa *et al.* (2006) reported that 'Ayala' chickpea cultivar was moderately resistant to *F. oxysporum* f. sp. *ciceris* when grown in temperature regime of 24–21°C, but highly susceptible at a temperature regime of 27–25°C. The underlying mechanism of the effect of temperature on increased susceptibility of resistant cultivars to diseases is not clear. Several studies have described cellular and biochemical changes induced by high temperatures in plants, which suggested that high temperatures (22–30°C) could alter products of a virulence or resistance genes, their interactions, later steps in the resistance response, or the ability of the pathogen to overcome certain types of host resistance (Prabhavati and Rajam 2007). Results of the present study, confirmed that the choice of sowing date influences development of the Fusarium wilt, as reported previously by Chand and Khirbai (2009) that winter sowing of chickpea contributes to control of Fusarium wilt and consequently to increased yield. However, the efficacy of winter sowing as a management practice for Fusarium wilt is influenced by several factors in the pathosystem, and may be significantly reduced under changing climatic scenario (Navas-Cortés *et al.* 2000).

The correlation was established in between wilt incidence recorded in both the cultivars and environmental variables. Maximum ambient and soil temperature were found to be positively and significantly correlated with wilt incidence of 'Pusa 212' during both the years. Minimum temperature was positively and significantly correlated with wilt incidence only in 2005–06. During 2005–06 in 'BGD1005' mean ambient temperature and soil moisture were positively and significantly correlated with wilt incidence. This suggests maximum and minimum ambient temperature and soil temperature can influence the development of wilt in chickpea. In present experiment impact of soil temperature was significant on disease incidence in 'Pusa 212'. Jalali and Chand (1992) also observed that understanding of influence of temperature on Fusarium wilt of chickpea is important for management of wilt disease. Chand and Khirbat (2009) in India and Westerland *et al.* (1974) in California also attributed variation in the Fusarium wilt severity to differences in temperature in soil. The amount of wilt incidence recorded in two years varied considerably, possibly because of differences in weather conditions and the increase of the pathogen population in soil as a result of disease in successive chickpea sowings.

In present experiment, delay in the date of sowing from early November to late December favoured the development of Fusarium wilt may be because of increase in soil temperature. High wilt incidence was observed in both the cultivars sown on 30 December as Fusarium took less time in expression of symptoms. Navas-Cortés *et al.* (2007) through modeling also reported positive correlation between wilt severity and soil temperature. It was established that

temperature can affect the relative resistance response of certain chickpea cultivars against *F. oxysporum* f. sp. *ciceris* under field conditions. This demonstrates the importance of temperature in identifying not only resistant genotypes but also choosing sowing dates for the management of Fusarium wilt of chickpea.

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