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## Short Communication

# Inheritance of resistance to fusarium wilt in chickpea

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*With 2 tables*

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## Abstract

This preliminary study indicated that the resistance to race 2 of fusarium wilt is controlled by two genes, the first of which must be present in the homozygous recessive form, and the other in the dominant form, whether homozygous or heterozygous for complete resistance. Early wilting results if the other gene is homozygous recessive. Late wilting occurs if both loci are dominant. The existence of differences among chickpea cultivars in the time taken to express the initial symptoms of fusarium wilt were observed.

**Key words:** *Cicer arietinum* — *Fusarium oxysporum* — wilting time

Wilt of chickpea (*Cicer arietinum* L.) caused by *Fusarium oxysporum* f.sp. *ciceri* was first described by Padwick (1940) in India, and has since been reported in several other countries (Nene 1980). It is a typical vascular disease causing xylem browning or blackening, affecting the crop at all stages. A highly susceptible cultivar, under favourable conditions, may be killed within 10 days of sowing in a wilt-infested field. The freshly wilted plants show foliage droop but retain their green colour. In tolerant cultivars (e.g. 'K850'), the disease causes general yellowing and drying of the lower leaves, and late wilting. The root systems of wilted plants do not show any apparent symptoms. At least seven races of *Fusarium oxysporum* f.sp. *ciceri* have been reported in India, Spain and the United States, out of which four races (1–4) are prevalent in India (Haware and Nene 1982, Phillips 1988, Jimenez-Diaz et al. 1989). Race 2 of *Fusarium oxysporum* was reported by Haware and Nene (1982). A number of reports on the inheritance of resistance to fusarium wilt race 1 (ICRISAT isolate) in chickpea are available (Haware et al. 1980, Kumar and Haware 1982, Sidhu et al. 1983, Smithson et al. 1983, Upadhyaya et al. 1983a,b). Very little or no information is available regarding race 2 (Kanpur isolate, India,) and other races of fusarium wilt. Pathak et al. (1975) reported that, under field conditions, the resistance to race 2 is controlled by a single recessive gene. This present study was undertaken to investigate the number of genes involved in the inheritance of resistance to race 2 of *Fusarium oxysporum* f.sp. *ciceri* in chickpea under controlled conditions, and to find out whrether different chickpea cultivars differ in the time taken to express initial wilt symptoms. The implications of the results with regard to breeding for wilt resistance are discussed.

The material studied in this experiment consisted of the parents and $F_2$ and $F_3$ progenies of the cross 'P165' × 'C104'. The cultivars 'P165' and 'C104' were classified as resistant and susceptible, respectively, to race 2 of fusarium wilt (Haware and Nene 1980). In addition, the cultivars 'CPS1' (early wilter) and 'K850' (late wilter to race 2) were also included as controls. The study was conducted at ICRISAT, Andhra Pradesh, India, in a glasshouse, using plastic pots of 15-cm diameter, according to the method described by Nene and Haware (1980). The temperature throughout the study was maintained at 25—30°C. The fungus culture was derived from a single spore multiplied in 100 g of sand-chickpea meal in a 250 ml flask, incubated for 10 days at 25°C. A total of 100 g of the inoculum was mixed thoroughly with 2 kg of a mixture of equal parts of autoclaved soil (vertisol) and riverbed sand. The pots were washed in running water, treated with a 5% $CuSO_4$ solution, and air-dried before filling with the medium. For the four cultivars 'CPS1', 'K850', 'C104' and 'P165', 10 seeds of each were sown separately in each of the four pots. The $F_2$ seeds were planted in 26 pots, each with seven test seeds and one of each of the three control seeds, i.e. 'CPS1', 'K850', and 'C104'. Each of the 85 $F_3$ progenies was grown in two pots with seven seeds of the test variety and three seeds of each of the three controls, as in $F_2$. The number of days from sowing to the initial symptoms of wilting were recorded for each plant, and the number of early- and late-wilting and healthy plants were recorded.

The mean number of days taken by different cultivars ('CPS1', 'K850', and 'C104') and generations ($F_2$ and $F_3$ of the cross 'P165' × 'C104'), together with their standard errors and variances for the initial appearance of wilt symptoms, are given in Table 1. All plants of the cultivars 'C104', 'CPS1' and 'K850' wilted, whereas those of 'P165' were resistant. Control 'K850' took more days from sowing to the appearance of the initial symptoms of fusarium wilt than the controls 'CPS1' and parent 'C104', indicating that these two cultivars differ from 'K850' in their wilting time. This variance in time to initial wilting symptoms was also high in the late-wilting parent 'K850', as compared to the early wilting check 'CPS1' and the parent 'C104'. $F_2$ plants showed a large variation in the time to wilting, varying from 12 to 50 days. The variation in the time to wilting in $F_2$ was also higher than that of all the cultivars. The time of appearance of initial wilting in the $F_3$ progenies varied from 12 to 55 days. The number of days to initial wilting in the $F_3$ progenies fell between that of the $F_2$ mean and the mean of the late-wilting control 'K850'.

The $F_2$ plants and $F_3$ progenies were grouped as early or late wilting, or as resistant or segregating, and individual plants in the segregating $F_3$ progenies were classified as early or late wilting relative to the time to wilting in 'CPS1', 'C104', and

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Table 1: Number of plants and days to initial wilting of three cultivars and the $F_2$ and $F_3$ generations of the cross 'P165' × 'C104' in a screening test against race 2 of *Fusarium oxysporum* f.sp. *ciceri*

| Cultivar/ generation | Days to wilting Min. | Max. | Mean | SE(mean) | Variance | No. of plants |
|---|---|---|---|---|---|---|
| 'CPS1' | 12.0 | 18.0 | 15.4 | 0.12 | 1.35 | 95 |
| 'C104' | 12.0 | 22.0 | 17.6 | 0.20 | 3.02 | 76 |
| 'K850' | 20.0 | 54.0 | 27.8 | 0.49 | 43.20 | 181 |
| $F_2$ | 12.0 | 50.0 | 31.3 | 1.12 | 131.63 | 147 |
| $F_3$ | 12.0 | 55.0 | 28.3 | 0.28 | 101.05 | 1041 |

Table 2: The segregation of $F_3$ progenies into different categories expected from the segregation of two genes for resistance to *Fusarium oxysporum* f.sp. *ciceri*; $\chi^2$ values and probabilities for goodness of fit to the expected ratio in the cross 'P165' × 'C104'

| Class of wilting or resistance | Gene symbols | No. of $F_3$ progenies Observed | Expected | $\chi^2$ | Probability |
|---|---|---|---|---|---|
| Uniform early wilting (4/16) | A-bb<br>aabb | 17 | 21.3 | 0.87 | 0.25–0.50 |
| Uniform late wilting (1/16) | AABB | 3 | 5.3 | 0.99 | 0.25–0.50 |
| Segregating for early and late wilting (2/16) | AABb | 10 | 10.6 | 0.03 | 0.70–0.80 |
| Segregating for early and resistant plants (2/16) | aaBb | 12 | 10.6 | 0.18 | 0.95–0.99 |
| Segregating for late-wilting and resistant plants (2/16) | AaBB | 12 | 10.6 | 0.18 | 0.95–0.99 |
| Segregating for early and late-wilting and resistant plants (4/16) | AaBb | 25 | 21.3 | 0.64 | 0.50–0.70 |
| Uniformly resistant (1/16) | aaBB | 6 | 5.3 | 0.09 | 0.70–0.80 |
| Overall | | | | 2.98 | |

'K850'. All plants of the early wilting check 'CPS1' and parent 'C104' wilted in less than 23 days. All $F_2$ plants or $F_3$ progenies wilting up to 23 days were classified as early wilting and those after 23 days as late-wilting. This study shows that resistance to race 2 of fusarium wilt is controlled by two genes. The proposed gene symbols for the two loci are A and b; bb always causes early wilting, regardless of A. AB gives late wilting while, aa-B is responsible for resistance. Gene A can only be expressed for B. The number of $F_2$ plants fits well to the ratio 13 : 3 (13 early and late-wilting : 3 resistant) or to the ratio 4 : 9 : 3 (4 early wilters : 9 late wilters : 3 resistant) expected from the segregation of these two non-allelic genes. The $F_3$ data supported these ratios. The detailed segregation of $F_3$ progenies into different categories based on the segregation of these two genes is given in Table 2.

This preliminary study indicates that, as well as the one recessive gene for resistance to race 2 (aa) already found by Pathak et al. (1975), a second gene controls wilting time and aabb causes early wilting. Alternatively, aabb could be resistant. The $F_2$ results do not fit, but the $F_3$ results support this proposal. Therefore, additional experiments to discriminate between these two hypotheses are necessary. This study also confirms the existence of differences among chickpea genotypes in their time to appearance of initial symptoms of fusarium wilt, as reported by Haware and Nene (1980) and Upadhyaya et al. (1983a) for race 1 in chickpea cultivars 'JG62' (early wilter) and 'C104' (late wilter). In this study on race-2 fusarium wilt in chickpea, 'C104' wilted as early as 'JG62' in race 1, whereas 'K850' wilted much later than 'CPS1' and 'C104'. Singh et al. (1987) also gave evidence of late wilting of 'K850' for race 1 of this pathogen. The presence of significant variation in time to initial symptoms of wilt in the late-wilting parent 'K850', as compared to the early wilting parent 'CPS1' (Table 1), may be due to large environmental effects on the wilting time of late-wilting genotypes. Similar observations have been recorded for race-1 fusarium wilt in chickpea (Upadhyaya et al. 1983a).

Late-wilting chickpea cultivars have great significance in breeding for resistance to fusarium wilt because late-wilting genotypes can survive up to maturity and produce some seeds, whereas early wilting genotypes die before they reach flowering or pod formation. Therefore, there is no complete loss of seed yield in late-wilting cultivars as there is with early wilting cultivars. Late wilters are generally good agronomic cultivars and crosses among them usually produce better segregants. Moreover, Singh et al. (1987) obtained resistant plants in a cross of two late-wilting cultivars, i.e. 'K850' and 'C104'; due to the additive action of the recessive genes of both cultivars in the breeding programme. However, there is a need to study the complementation of recessive genes in late-wilting parents for race-2 fusarium wilt in chickpea.

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