Prevalence of *Fusarium oxysporum* f. sp. *ciceris* Causing Wilt in Chickpea and Its Pathogenic, Cultural and Morphological Characterization

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**Abstract**

Chickpea (*Cicer arietinum* L.) contributes 18% of the global production of grain legume and provides as an important source of dietary protein for living things. The area and production of chickpea has been reduced due to several abiotic and biotic factors. Among them soil borne pathogen of *F. oxysporum* f. sp. *ciceris* causing severe yield loss now a days. In this study conducted for a prevalence of wilt incidence percentage varied from 34.00 to 57.33 per cent in chickpea due to *F. oxysporum* f. sp. *ciceris* in Tamil Nadu. Continuously the pathogenic ability, cultural and morphological characterization was carried out. Among the fifteen isolates Foc4 (Gomangalampudur) is highly pathogenic when compared to other and causing early wilt in JAKI-9218. Grouping of isolates based on their virulence potential isolates like, Foc4, Foc5, Foc6, Foc8, Foc10, Foc11, Foc12, Foc13 and Foc14 are highly pathogenic nature and other isolates were strongly pathogenic. The cultural variability of these isolates have pale yellowish to dark pinkish (Foc4) in pigmentation with aerial compact mycelial growth within 7–9 DAI. The morphological characterization all the isolates produced micro, macro-conidia and chlamydospores within 20 DAI and the size of the spores varied from (micro conidia) 5.6 x 2.5 μm (Foc2) to 12.7 x 3.1 μm (Foc14) and the isolate (Foc4) maximum size of macro conidia in 29.1 x 4.9 μm and mycelial dry weight of 700 mg at 100 ml.

**Keywords**

Survey, Incidence, Micro conidia, Macro conidia, Pathogenic ability

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**Introduction**

Chickpea (*Cicer arietinum* L.) is a most important grain legume crop of *Cicer* genus and cultivated throughout the world for its easy available form of edible proteins and vitamins. In India it is cultivated at cool winter (Rabi) season in semi arid tropics by irrigated or rain-fed conditions (Nene et al., 1984). India is largest producer of chickpea in world sharing 65.25 per cent in area and 65.49 per cent in production and is grown on 10.23 million ha area with production 9.88 million tonnes and productivity 967 kg/ha (Thaware *et al*., 2017). Despite the production was reduced due to several biotic and abiotic factors. Chickpea is noticed to be more than 52 pathogens at cropping season (Harware and Nene, 1980; Nene *et al*., 1984). Among these pathogens *F. oxysporum* f. sp. *ciceris*
causing a potential yield loss for both in seed yield and seed weight by wilt about 10 to 15 per cent (Navas-Cortes et al., 2000b; Khilare et al., 2009).

*Fusarium oxysporum* f. sp. *ciceris* is ubiquitous soil borne pathogen and providing severe economic losses about 10-40% in worldwide (Kaiser et al., 1994). *Fusarium* genus was highly variable nature in survive, growth and infection in all seasons with crop or without also. Because absence of susceptible host it can survive in soil due to their production of resting spores like, micro, macro conidia and chlamydospores for distribution with diverse niches (Leslie and Summerell, 2006; Nelson et al., 1983). Hence traditionally following methods viz., crop rotation, using resistant cultivars, chemical managements is presence with some limitation factors like, location specific pathogen races and wide geographical distribution (Singh et al., 2006). So, the cultural and morphological variability is primary diagnosis for typical identification of different isolates of *F. oxysporum* f. sp. *ciceris* and classically determining by their virulence ability.

In the present study was carried out for disease prevalence and extensively discriminating the different isolates of *F. oxysporum* f. sp. *ciceris* by cultural, morphological characterization and virulence ability through grouping it.

**Materials and Methods**

**Survey and occurrence**

An extensive survey was conducted in major chickpea growing areas of Tamil Nadu during Rabi, 2015. In each districts locations were selected randomly and a total of fifteen locations were selected from four districts for assessment of wilt incidence by *F. oxysporum* f. sp. *ciceris*. The name of the villages surveyed along with districts given in Table 1. The wilt incidence was calculated by using the following formula and impact of disease incidence grouped into classes like, (0% - Nil, 0.1 - 1.0 % - low, 1.1 – 20.0% - moderately high, 20.1-50.0% - high and >50.0% - very high) (Traperos-Casas, 1983).

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\text{Per cent disease Incidence } = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100
\]

**Fungal isolates**

A large systematic collection of fungal isolates were used in this study, consisting of 15 isolates from infected plant samples. The infected root bits were surface sterilized with 1% sodium hypochlorite for 30 seconds, and subsequently three washings were given with sterile distilled water. Then, they were placed in sterilized Petri dishes containing potato dextrose agar (PDA) medium (Potato 200 g, dextrose 20 g, agar 15 g and water 1L) and incubated at the laboratory conditions at 25 ± 2°C for seven days. Pure culture of the pathogen was obtained by single hyphal tip method (Rangaswami, 2005).

**Pathogenic characterization**

Pathogenic ability was assessed by using local cultivar of JAKI-9218 by the method derived by Harware and Nene (1980). The mixtures of sand and chickpea meal (90 g sand + 10 g chickpea meal) in 250 ml conical flasks were inoculated with 5 plugs (8mm in diameter) from different isolates of *F. oxysporum* f. sp. *ciceris* well grown on PDA medium containing Petri plates at 23 ± 1°C for ten days. Fifteen days after incubation the multiplied fungal mass was well mixed with 2kg of autoclaved soil in 15cm diameter plastic pots. Five seeds were sown in each pot and kept under 25 ± 1°C with relative humidity of 30-50%. In each isolate three...
replications were maintained and the control was maintained by uninoculated healthy. These were kept in glasshouse conditions for 40 days till flowering. Plants were observed for symptom development and the pathogenic variability given in to five groups viz., (0% wilting – Non pathogenic; 1-20% wilting – weakly pathogenic; 21-50% wilting-moderately pathogenic; 51-70% wilting-strongly pathogenic and >70% wilting- highly pathogenic) was described by Rakhonde et al., (2015).

Cultural characterization

Fifteen isolates of *Fusarium oxysporum* f. sp. *ciceris* obtained aseptically and invindually inoculated in PDA contained Petri dishes and incubated at 28 ± 2°C for a week. Observations of cultural characteristics viz., Colony morphology, colony diameter, growth rate, growth habitat, pigmentation and sporulating potential were recorded at two weeks after incubation respectively. The grouping was done in the basis of mycelial growth for Slow (10 mm/day), medium (10-12 mm/day) and fast (>12 mm /day) denoted by Dubey et al., (2010).

Morphological characterization

The morphological characteristics of conidial size (Micro and macro conidia) in respect of each test isolate were studied. The size of conidia was measured using ocular micrometer (calibrated using stage micrometer) under the compound microscope (Labomed Vision 2000) at 400X magnification.

Results and Discussion

Understanding the basic information of pathogen’s viz., pathogenic diversity, cultural and morphological variability was most playing a important role in the development of durable resistance. *F. oxysporum* f. sp. *ciceris* is a highly variable nature on other soil borne pathogens. Because of their survival nature and virulence is known to be a vital role in disease incidence and resistance occurrence in chickpea plants.

Survey and occurrence

Survey was conducted to assess the incidence of wilt disease in major chickpea growing districts of Tamil Nadu viz., Coimbatore, Dindigul, Dharmapuri and Tiruppur during Rabi, 2015 (Table 1; Plate 1). The result revealed that the maximum disease incidence of 57.33 per cent was recorded at Gomangalampudur in Tiruppur district of cultivar JAKI-9218 and a minimum of 34.00 per cent incidence was recorded at Idigarai in Coimbatore district in CO4 cultivar (Table 1, Figure 1). These results revealed that Kumar et al., (2012) he reported that the chickpea was attained highly incidence of *F. oxysporum* f. sp. *ciceris* at 38.79 to 59.23 in Ranchi of Jharkhand state. In 25 to 48 per cent of local cultivars of chickpea in field conditions were influenced by wilt at 9.7% to 13.8% in major central and southern parts of India (Ghosh et al., 2013).

Collection of fungal isolates

An extensive survey was conducted during Rabi, 2015 in major chickpea growing areas of Tamil Nadu. The prevalent incidence of wilt was recorded and the fifteen *Fusarium oxysporum* f. sp. *ciceris* isolates were isolated and confirmed through their production of spores and phenotypic appearance of cultural growth.

Pathogenic characterization

The pathogenic variability test indicates that all the fifteen isolates of *Fusarium oxysporum*
f. sp. *ciceris*, proved to be pathogenic to local cultivar JAKI-9218. The fifteen isolates were grouped under five forms like, (Non pathogenic, weakly pathogenic and moderately pathogenic have no represent isolates). Among the all isolates, there are six isolates viz., Foc1, Foc2, Foc3, Foc7, Foc9 and Foc15 were strongly pathogenic nature and causing wilt incidence ranged from 53.3 % to 66.7 %. Another nine isolates viz., Foc4, Foc5, Foc6, Foc8, Foc10, Foc11, Foc12, Foc13 and Foc14 were recorded incidence at 73.3 % to 93.3 % under highly pathogenic respectively (Table 2 and 5). These results revealed that Sharma et al., (2009) reported forty eight *F. oxysporum* f. sp. *ciceris* isolates from India, among the forty one isolates have been identified as highly pathogenic and remaining seven isolates were non-pathogenic respectively. The existence of pathogenic variability in *F. oxysporum* f. sp. *ciceris* isolates was also reported by Gupta et al., (1986), Paul et al., (2001) and Mandhare et al., (2011) from isolated from different regions of India.
Figure 2. Different isolates of *Fusarium oxysporum* f. sp. *ciceris* from major chickpea growing areas of Tamil Nadu

Foc1- Adivalli
Foc2- Anthiyur
Foc3- Athakkampapu
Foc4- Gomangalampudur
Foc5- Idigarai
Foc6- Konnur
Foc7- Modakkuppatti
Foc8- Mukkonam
Foc9- Pannaikinaru
Foc10- Periyanayakanpalayam
Foc11- Poolankinaru
Foc12- Ragalpavi
Foc13- Ramachandrapuram
Foc14- Thippampatti
Foc15- Valzavadi
Figure 3. Microscopic view of *Fusarium oxysporum* f. sp. *ciceris* isolates
Table 1 Survey and occurrence of *Fusarium* wilt disease incidence of major chickpea (*C. arietinum* L.) growing areas of Tamil Nadu

| S. No. | Districts | Location     | Cultivar | Isolate No | Per cent disease incidence (PDI)* | Impact |
|--------|-----------|--------------|----------|------------|----------------------------------|--------|
| 1      | Coimbatore| Idigarai     | CO4      | Foc5       | 34.67<sup>h</sup>                | High   |
|        |           | Periyanakanpalayam | CO4 | Foc10 | 41.00<sup>def</sup> | High   |
| 2      | Dharmapuri| Athakampapu  | JAKI-9218 | Foc3 | 35.33<sup>h</sup> | High   |
| 3      | Dindigul  | Konnur       | JAKI-9218 | Foc6 | 39.67<sup>defg</sup> | High   |
| 4      | Tiruppur  | Adivalli     | JAKI-9218 | Foc1 | 37.00<sup>eh</sup> | High   |
|        |           | Anthiyur     | JAKI-9218 | Foc2 | 38.33<sup>fg</sup> | High   |
|        |           | Gomangalampudur | JAKI-9218 | Foc4 | 57.33<sup>a</sup> | Very high |
|        |           | Modakkupatti | JAKI-9218 | Foc7 | 42.33<sup>cd</sup> | High   |
|        |           | Mukkonam     | JAKI-9218 | Foc8 | 44.33<sup>bc</sup> | High   |
|        |           | Pannaikinaru | JAKI-9218 | Foc9 | 39.33<sup>defg</sup> | High   |
|        |           | Ragalpavi    | JAKI-9218 | Foc12 | 37.33<sup>eh</sup> | High   |
|        |           | Ramachandrapuram | JAKI-9218 | Foc13 | 41.33<sup>de</sup> | High   |
|        |           | Poolankinaru | JAKI-9218 | Foc11 | 40.67<sup>def</sup> | High   |
|        |           | Thippampatti | JAKI-9218 | Foc14 | 46.33<sup>b</sup> | High   |
|        |           | Valzavadi    | JAKI-9218 | Foc15 | 42.33<sup>cd</sup> | High   |

Means followed by a common letter are not significantly different at the 5% level by the DMRT.
**Table 2** Pathogenic variability for different isolates of *Fusarium oxysporum* f. sp. *ciceris* against with local cultivar JAKI-9218 under *in vitro* conditions

| S. No | Locations       | Isolate Name | Germination (%) | (% Wilting) | Type of pathogenic |
|-------|----------------|--------------|-----------------|-------------|--------------------|
| 1     | Adivalli       | Foc1         | 80.0            | 53.3        | SP                 |
| 2     | Anthiyur       | Foc2         | 86.7            | 53.3        | SP                 |
| 3     | Athakkampapu   | Foc3         | 86.7            | 60.0        | SP                 |
| 4     | Gomangalampudur| Foc4         | 100.0           | 93.3        | HP                 |
| 5     | Idigarai       | Foc5         | 86.7            | 73.3        | HP                 |
| 6     | Konnur         | Foc6         | 93.3            | 80.0        | HP                 |
| 7     | Modakkupatti   | Foc7         | 93.3            | 60.0        | SP                 |
| 8     | Mukkonam       | Foc8         | 100.0           | 73.3        | HP                 |
| 9     | Pannaikinaru   | Foc9         | 80.0            | 66.7        | SP                 |
| 10    | Periyanakanpalayam | Foc10 | 93.3 | 73.3 | HP |
| 11    | Poolankinaru   | Foc11        | 100.0           | 73.3        | HP                 |
| 12    | Ragalpavi      | Foc12        | 100.0           | 80.0        | HP                 |
| 13    | Ramachandrapuram | Foc13     | 100.0           | 80.0        | HP                 |
| 14    | Thippampatti   | Foc14        | 93.3            | 86.7        | HP                 |
| 15    | Valzavadi      | Foc15        | 93.3            | 66.7        | SP                 |
| 16    | Control        | Uninoculated | 100.0           | 0.00        | NIL                |
Table 3: Cultural characteristics for different isolates of *F. oxysporum* f. sp. *ciceris*

| S. No | Isolate No | Colony morphology | Mean mycelial growth (mm) / 7DAI | Growth rate (mm) | Growth habitat | No. of. days taken to cover the plate | Pigmentation | Sporulation |
|-------|------------|-------------------|---------------------------------|-----------------|---------------|----------------------------------------|-------------|------------|
| 1.    | Foc 1      | Circular compact aerial mycelia | 80.00 (63.43) | 11.42<sup>de</sup> | Medium | 8 | Pale pinkish | 1-2 celled sparsely dispersed microconidia |
| 2.    | Foc 2      | Smooth circular compact aerial mycelia | 77.00 (61.34) | 11.00<sup>f</sup> | Medium | 9 | Pale pinkish with white | Sparsely dispersed microconidia with minimum curvature |
| 3.    | Foc 3      | Circular profuse compact aerial mycelia | 74.00 (59.34) | 10.57<sup>g</sup> | Medium | 9 | Pale pinkish with white | Sparsely dispersed microconidia |
| 4.    | Foc 4      | Circular compact 5.aerial mycelia | 90.00 (71.56) | 12.85<sup>a</sup> | Fast | 7 | Deep pinkish | Abundantly dispersed micro and 3-5 septate macroconidia |
| 5.    | Foc 5      | Circular smooth compact aerial mycelia | 77.00 (61.34) | 11.00<sup>f</sup> | Medium | 9 | Pale pinkish | Sparsely dispersed microconidia and macroconidia |
| 6.    | Foc 6      | Circular sparsely dense aerial mycelia | 78.67 (62.48) | 11.23<sup>e</sup> | Medium | 9 | Pale yellowish | 1-2 celled sparsely dispersed microconidia |
| 7.    | Foc 7      | Circular sparsely flattened mycelia | 80.67 (63.91) | 11.52<sup>d</sup> | Medium | 8 | Yellowish with centre white | 1-2 celled Abundantly dispersed microconidia |
| 8.    | Foc 8      | Circular smooth compact aerial | 83.00 (65.65) | 11.85<sup>e</sup> | Medium | 8 | Pale white | Sparsely dispersed 1-2 celled |
|   |   | mycelia |   |   | microconidia |
|---|---|---------|---|---|--------------|
| 9. | Foc 9 | Circular smooth dense mycelia | 75.33 (60.22) | 10.76<sup>e</sup> | Medium | 9 | Milky white | Abundantly dispersed microconidia |
| 10. | Foc 10 | Circular smooth compact mycelia | 69.67 (56.58) | 9.95<sup>hi</sup> | Slow | 10 | Milky white | Abundantly dispersed microconidia and 3-5 celled macroconidia |
| 11. | Foc 11 | Circular sparsely dense flattened mycelia | 70.33 (57.62) | 10.04<sup>b</sup> | Medium | 10 | Pale yellowish | Abundantly dispersed 1-2 celled microconidia with minimum curvature |
| 12. | Foc 12 | Smooth circular compact mycelia | 71.33 (57.62) | 10.19<sup>b</sup> | Medium | 10 | Pale pinkish | Abundantly dispersed 3-5 celled macroconidia |
| 13. | Foc 13 | Circular smooth sparsely dense mycelia | 70.33 (56.99) | 10.04<sup>b</sup> | Medium | 10 | Pale yellowish | Abundantly dispersed 1-2 celled microconidia |
| 14. | Foc 14 | Circular compact aerial mycelia | 86.00 (68.05) | 12.28<sup>b</sup> | Fast | 8 | Deep pinkish | Abundantly dispersed 3 - celled macroconidia |
| 15. | Foc 15 | Circular smooth compact aerial mycelia | 68.33 (55.62) | 9.76<sup>i</sup> | Slow | 10 | Milky white with pale yellowish | Abundantly dispersed microconidia |
Table 4: Conidial characteristics for different isolates of *F. oxysporum* f. sp. *ciceris*

| S. No. | Isolate No | Microconidia Length (µm) | Microconidia Width (µm) | Macroconia Length (µm) | Macroconia Width (µm) | No of conidia / µL | Mycelial dry weight (mg)/100ml* |
|--------|------------|--------------------------|-------------------------|------------------------|-----------------------|-------------------|--------------------------------|
| 1.     | Foc 1      | 6.5                      | 2.6                     | 16.9                   | 4.1                   | 8                 | 553^hi                        |
| 2.     | Foc 2      | 5.6                      | 2.5                     | 17.3                   | 3.8                   | 5                 | 550^fg                        |
| 3.     | Foc 3      | 6.9                      | 2.7                     | 18.5                   | 4.1                   | 5                 | 540^rh                        |
| 4.     | Foc 4      | 11.7                     | 2.9                     | 29.1                   | 4.9                   | 18                | 700^b                         |
| 5.     | Foc 5      | 10.5                     | 2.7                     | 20.2                   | 3.8                   | 7                 | 653^a                         |
| 6.     | Foc 6      | 11.3                     | 2.8                     | 21.2                   | 4.4                   | 9                 | 663^d                         |
| 7.     | Foc 7      | 8.1                      | 2.6                     | 20.5                   | 4.2                   | 15                | 535^hi                        |
| 8.     | Foc 8      | 8.8                      | 2.8                     | 22.9                   | 4.1                   | 7                 | 678^c                         |
| 9.     | Foc 9      | 10.9                     | 2.6                     | 24.9                   | 4.3                   | 15                | 528^ij                        |
| 10.    | Foc 10     | 7.8                      | 2.6                     | 28.4                   | 4.4                   | 17                | 522^f                         |
| 11.    | Foc 11     | 8.1                      | 2.7                     | 20.6                   | 3.8                   | 18                | 597^e                         |
| 12.    | Foc 12     | 10.9                     | 3.0                     | 25.6                   | 4.5                   | 70                | 551^f                         |
| 13.    | Foc 13     | 10.1                     | 2.6                     | 22.0                   | 4.4                   | 18                | 496^k                         |
| 14.    | Foc 14     | 12.7                     | 3.1                     | 23.6                   | 4.4                   | 18                | 723^a                         |
| 15.    | Foc 15     | 11.0                     | 2.7                     | 26.3                   | 4.1                   | 22                | 492^k                         |

* Mean of three replications
Means followed by a common letter are not significantly different at the 5% level by DMRT.

Table 5: Grouping of *F. oxysporum* f. sp. *ciceris* isolates on the basis of pathogenic nature and growth habitat

| S. No | Pathogenic Nature | Name of the isolates | Growth Habitat | Name of the isolates |
|-------|-------------------|-----------------------|----------------|---------------------|
| 1.    | Non-pathogenic (0%) | Nil                   | Slow (10mm /day) | Foc10 and Foc15     |
| 2.    | Weakly pathogenic (1-20%) | Nil | Medium (>10-12mm / day) | Foc1, Foc2, Foc3, Foc7, Foc9 and Foc15 |
| 3.    | Moderately pathogenic (21-50%) | Nil | Fast (>12mm / day) | Foc4 and Foc14      |
| 4.    | Strongly pathogenic (51-70%) | Foc1, Foc2, Foc3, Foc7, Foc9 and Foc15 |                   |                     |
| 5.    | Highly pathogenic (>70%) | Foc4, Foc5, Foc6, Foc8, Foc10, Foc11, Foc12, Foc13 and Foc14 |                   |                     |
Cultural characterization

All the fifteen isolates of *Fusarium oxysporum* f. sp. *ciceris* exhibited a high variability in colony morphology, colony diameter, growth rate, growth habitat, pigmentation and sporulating potential respectively. The colony morphology varied from compact dense aerial mycelia to sparsely flattened mycelia of pale yellowish to deep pinkish coloured with slow to fast growth habitat. Among the fifteen isolates (Foc4) recorded a three types of growth like, slow (Foc10 and Foc15), medium (Foc1, Foc2, Foc3, Foc5, Foc6, Foc7, Foc8, Foc9, Foc11, Foc12 and Foc13), fast (Foc4 and Foc14) are recorded and abundantly production of micro and macro conidia in 7 DAI (Day after inoculation) (Table 3 and 5, Figure 2). These results are coincided with earlier workers like, Gupta *et al.*, (1986), Desai *et al.*, (1994). Burgess *et al.*, (1989) reported that the *Fusarium oxysporum* were extensively variable of cultural and morphological diversity and it’s concluded for identification of genus not species.

Morphological characterization

All the isolates were highly variable in morphological viz., production of micro, macro conidia and chlamydospores. The mean size of micro conidia of the test isolates ranged from 5.6 x 2.5 μm (Foc2) to 12.7 x 3.1 μm (Foc14) and the isolate (Foc4) maximum size of macro conidia in 29.1 x 4.9 μm and mycelial dry weight of 700 mg in 100 ml and highly pathogenic also (Table 4 and Figure 3). Above the results were revealed that Dubey *et al.*, (2010) documented one hundred and twelve isolates by twelve categories, among the isolates were produced micro conidia size varied from 5.1-12.8 x 2.5-5.0 μm and macro conidia (16.5-37.9 x 4.0-5.9 μm) with 1-5 septations. Kaur *et al.*, (2015) reported twenty four isolates of *Fusarium oxysporum* f. sp. *ciceris* produced significant variation to size of micro (8.9-16.9 x 3.1-6.3 μm) and macro (21.7-64.9 x 2.7-10.0 μm) conidia was observed also.

In conclusion, collection of different isolates of *F. oxysporum* f. sp. *ciceris* was highly variable nature through their presence pathogenic nature and growth habitat and cultural characters also. Because the virulent isolate of *F. oxysporum* f. sp. *ciceris* (Foc4) growing fast and production of spores abundantly within seven days and their causing severe incidence in local cultivar of JAKI-9218 in Tamil Nadu.

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References

Burgess, L. W., Nelson, P. E. and Summerell, B. A. 1989. Variability and stability for morphological characters of *Fusarium oxysporum* isolated from soils in Australia. *Mycologia.*, 81: 818-822.

Desai, S., Nene, Y. L. and Reddy, R. 1994. Races of *Fusarium oxysporum* causing wilt in chickpea growth variability. *Indian J. Mycol Pl Pathol.*, 24: 120-127.

Díaz, R. M. 1994. Screening of wild *Cicer* species for resistance to races 0 and 5 of *Dubey*, S. C., Singh, S. R. and Singh, B. 2010. Morphological and pathogenic variability of Indian isolates of *Fusarium oxysporum* f. sp. *ciceris* causing chickpea wilt. *Archives of Phytopathol and Plant Prot.*, 43: 174-189.

Ghosh, R., Sharma, M., Telangre, R. and Pande, S. 2013. Occurrence and distribution of chickpea diseases in central and southern parts of India. *American J. Plant Sci.*, 4: 940-944.

Gupta, O. M., Khare, M. N. and Kotasthane, S.
R. 1986. Variability among six isolates of Fusarium oxysporum f. sp. ciceris causing vascular wilt of chickpea. Ind Phytopathol., 39: 279-281.

Kumar, A., Lal, H. C. and Akhtar, J. 2012. Morphological and pathogenic characterization of Fusarium oxysporum f. sp. ciceris causing wilt of chickpea. Ind Phytopathol., 65(1): 64-66.

Harware, M. P. and Nene, Y. L. 1980. Influence of wilt at different stages on the yield loss in chickpea. Trop Grain Legume Bull., 19: 38-40.

Kaur, A., Sharma, V. K., Sirari, A., Kaur, J., Singh, G. and Kumar, P. 2015. Variability in Fusarium oxysporum f. sp. ciceris causing wilt in chickpea. African J. Microbiol Res., 9 (15): 1089-1097.

Khairare, V. C., Ahmed, R., Chavan, S. S. and Kohire, O. D. 2009. Management of Fusarium oxysporum f. sp. ciceris by different fungicides. Bioinfolet., 6: 41-43.

Leslie, J. F. and Summerell, B. A. 2006. The Fusarium, Laboratory Manual, Blackwell Publishing. pp. 1-388.

Mandhare, V. K., Deshmukh, G. P., Patil, J. V., Kale, A. A. and Chavan, U. D. 2011. Morphological, pathogenic and molecular characterization of Fusarium oxysporum f. sp. ciceris isolates from Maharashtra, India. Indoneisan J Agrl Sci., 12(2): 47-56.

Navas-Cortes, J. A., Hau, B. and Jimenez-Díaz, R. M. 2000b. Yield loss in chickpeas in relation to development of Fusarium wilt epidemics. Phytopathol., 90:1269-1278.

Nene, Y. L., Sheila, V. K. and Sharma, S. B. 1984. A world list of chickpea (Cicer arrietinum L.) and pigeonpea (Cajanus cajan L.) pathogens. Pulse prograss report. ICRISAT, Patencheru. India. 32:19.

Paul, J., Gill, T. S. and Singh, R. S. 2001. Variability among isolates of Fusarium oxysporum f. sp. ciceris from chickpea roots and rhizosphere. Plant Disease Res., 16: 116-118.

Rakhonde, P. N., Mane, S. S., Gawande, A. D., Bangar, S. S. and Moharil, M. P. 2015. Molecular and pathogenic variability among Indian isolates of Fusarium oxysporum f. sp. ciceris causing wilt in chickpea. J Envir. Sci., 7: 21-28.

Rangaswami, G. 2005. Diseases of crop plants in India. Prentice Hall of India Pvt. Ltd. New Delhi. pp. 520.

Sharma, M., Varshney, R. K., Narayanan Rao, J., Kannan, S., Hoisington, D. and Pande, S. 2009. Genetic diversity in Indian isolates of Fusarium oxysporum f. sp. ciceris, chickpea wilt pathogen. African J. Biotechnol., 8 (6): 1016-1023.

Singh, B. P., Saikia, R., Yadav, M., Singh, R., Chauhan, V. S. and Arora, D. K. 2006. Molecular characterization of Fusarium oxysporum f. sp. ciceris causing wilt of chickpea. Afr J. Biotechnol., 5:497-502.

Thaware, D. S., Kohire, O. D. and Gholve, V. M. 2017. In vitro efficacy of fungal and bacterial antagonists against Fusarium oxysporum f. sp. ciceris causing chickpea wilt. Int J. Current Microbiol. Appl Sci., 6(1): 905-909.

Trapero-Casas, A. 1983. Wilt and root rot of chickpea in the Guadalquivir valley: importance, distribution, etiologi, epidemiology and control. Ph.D., Thesis, University of Cordoba, Spain. p. 295.

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