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Cultural, Morphological Characterization and Pathogenic Variations among Cercospora Isolates of Cotton from Major Cotton-Growing Regions of South India

A. Sampathkumar[1], A.H. Prakash[2]

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ABSTRACT

Background: Cercospora leaf spot is an important foliar disease that causes considerable yield loss in cotton. Studies of population structure and mechanisms of variation are primary factors in developing a disease management strategy.

Methods: One hundred samples of *Cercospora* leaf spot were collected from major cotton-growing states in southern India during the survey. The pathogen was isolated on PDA using the tissue segment method. The cultural characteristics of *Cercospora gossypina* isolates were studied on PDA. Conidial and conidiophore characters were examined. Pathogenicity and virulence of *C. gossypina* isolates were assessed on a 25-day-old susceptible cotton cultivar, LRA 5166, under glasshouse conditions. Isolates were classified as highly, moderately, or less virulent based on PDI.

Result: 51 isolates were obtained from samples collected in Karnataka (29) Andhra Pradesh (6), Telangana (7) and Tamil Nadu (9). Colony colour varied from dull to dark grey, ashy or greyish black, with irregular or smooth colony margins. Mycelial characters were recorded as flat, raised to medium raised, with cottony, villous to velvety and smooth textures. Conidiophores were short, unbranched, tufted, pale olivaceous brown and septate. They were fasciculate, pale towards the apex and straight or slightly curved. Conidia were thin-walled, hyaline and multi-septate. They were needle-shaped, slender and slightly curved. They appeared cylindrical, truncated to subtruncate at the base. The tips of the conidia were straight or variously curved. They were acicular with an acute base and the hila were thickened and darkened at the base. Conidia measured 55.72 -165.10 × 3.0 -5.0 µm, with 9 - 19 septa. PDI ranged from 11.0 to 34.0 among 29 Karnataka isolates. Of these, 3 were highly virulent, 13 moderately virulent and 13 less virulent. Telangana isolates showed PDI values from 14.0 to 23.5, with 3 moderately virulent and 4 less virulent. Andhra Pradesh isolates recorded PDI values from 12.0 to 21.5 for 6 isolates. Of these, 2 were moderately virulent and 4 were less virulent. Tamil Nadu isolates showed PDI ranging from 15.0 to 26.0 in 9 isolates. Of these, 5 were moderately virulent and 4 were less virulent.

Key words: Cercospora leaf spot, Cotton, Cultural, Morphological characterisation, Pathogenic diversity.

INTRODUCTION

Cotton, often called the king of fibres, is a vital commercial crop that supplies natural fibre for the textile industry. India ranks first by area and second by production among the world's cotton-growing countries. In India, cotton is grown on 114.47 lakh hectares, with production of 294.25 lakh bales and productivity of 436.99 kg/ha during 2024-25 (https://caionline.in). Several pests and diseases affect cotton from seedling to maturity, leading to yield loss and poor fibre quality. Cercospora leaf spot, caused *by Cercospora gossypina*, is one of the important leaf spot diseases of cotton. It impedes cotton production and productivity in the major cotton-growing states of South India. Symptoms include small, numerous reddish to brownish spots with a whitish centre. Cercospora leaf spot in cotton appears as concentric ring spots, similar to those of target spot and conidia appear as long, thin, whip-like structures with horizontal septation (Kelly, 2021). Disease severity of Cercospora leaf spot ranged from 20.37% in Raichur district, followed by 17.58% in Yadagir district and 14.65% in Koppal district of Karnataka (Indira *et al.,* 2019). Cercospora is expected to cause 5-10% yield losses under severe conditions. It is important to study the cultural and morphological characters, as well as pathogenic diversity. Cercospora leaf spot occurs in all cotton-producing areas of the U.S. and when plants are under stress or in combination with Alternaria or Stemphylim leaf spots, yield and fibre quality reductions are recorded (Kelly, 2021).

[1]Department of Plant Pathology, ICAR-Central Institute for Cotton Research, Regional Station, Maruthamalai Road, Coimbatore-641 003, Tamil Nadu, India.
[2]Department of Plant Physiology, ICAR-Central Institute for Cotton Research, Regional Station, Maruthamalai Road, Coimbatore-641 003, Tamil Nadu, India.

Corresponding Author: A. Sampathkumar, Department of Plant Pathology, ICAR-Central Institute for Cotton Research, Regional Station, Maruthamalai Road, Coimbatore-641 003, Tamil Nadu, India.
Email: sampath000@gmail.com
ORCID: 0000-0001-6320-9109

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The incidence of Cercospora leaf spot in cotton fields is slowly increasing. Cultural and morphological characterisation, together with pathogenic diversity, provide insights into the dynamics of the pathogen population and variability among isolates. Dida *et al.* (2019) studied the cultural and morphological characteristics of 52 *Cercospora zeamaydis* isolates from maize. Colony colour varied from grey, light brown, corn silk to white on the top and from grey, dark grey, brown to corn silk on the reverse, with round to irregular shape and complete or wavy, raised mycelium. Conidia were slightly curved or straight, with 4 to 6 septations.

Variability among pathogen populations is characterised by cultural, morphological and pathogenic differences among isolates. The present study was carried out with the following objectives: (1) collection of Cercospora *l*eaf spot samples from major cotton-growing states in South India and pathogen isolation; (2) cultural and morphological variation among isolates; and (3) pathogenic variation and virulence diversity among isolates.

MATERIALS AND METHODS

Collection of leaf spot samples and isolation of the pathogen

Cercospora leaf spot samples were collected during the 2021-22 and 2022-23 crop seasons by survey in South India. Fifty-five Cercospora leaf spot samples were collected from nine major cotton-growing districts of Karnataka, namely Dharwad, Haveri, Gadag, Belagavi, Raichur, Vijayapura, Yadagiri, Kalaburagi and Ballari. Four districts in Telangana were covered, with 15 samples collected from Ranga Reddy, Warangal, Nirmal and Adilabad. Ten leaf spot samples were collected from the Kurnool district Andhra Pradesh. Twenty leaf spot samples were collected from the Coimbatore, Annur and Kinathukadavu blocks of Coimbatore district, Tamil Nadu. The pathogen was isolated from diseased samples using the tissue segment method (Dhingra and Sinclair, 1995) on potato dextrose agar (PDA). Isolates were named according to the states of origin. The single-spore isolation method was used to purify the isolates. Pure cultures were stored in 80% glycerol for long-term storage and on PDA slants for short-term storage.

Cultural characterization of Cercospora isolates

Cultural characters such as colony colour, margin, growth pattern, mycelial characters, texture, conidial and conidiophore characters and conidial size were studied on PDA. Sporulation capacity was measured on a 15-day-old culture grown on PDA medium.

Morphological characterization of Cercospora isolates

Morphological characterisation was performed on fifteen-day-old Cercospora isolates cultured on PDA. Morphological characters, including colony shape, conidiophore characteristics and conidial size and shape, were examined on PDA. Conidial size was measured using a compound microscope. Thirty conidia were measured for size and the average was calculated for each isolate.

Species identification of Cercospora isolates through conidial characters

Morphological characteristics of conidia, such as length, breadth and shape, were used to identify the Cercospora isolates.

Pathogenicity and pathogenic diversity of Alternaria isolates

Pathogenicity and virulence characterisation of the isolates were carried out on a 25-day-old susceptible cotton cultivar, LRA5166. A spray inoculation method was used under glasshouse conditions. PDA broth cultures of *C. gossypina* were harvested separately, ground with sterile water and adjusted to a concentration of 2×10^6 Cfu/ml. Mild pin-pricking of leaves was performed before inoculation and plants were covered with polybags for 24 hours after inoculation to maintain humidity and enhance infection. Three replicates were maintained for each isolate. After 10, 20 and 30 days of inoculation, PDI was calculated using the 0-4 disease rating scale according to Sheoraj (1988). Isolates were classified as Highly Virulent (> 40.01 PDI), Moderately Virulent (20.01 to 40.00 PDI) and Less Virulent (0.00 to 20.00 PDI) based on symptom expression during artificial inoculation.

RESULTS AND DISCUSSION

Collection and isolation of *Cercospora* from leaf spot samples from the South Zone

A survey was conducted in cotton-growing states of South India and Cercospora leaf spot samples were collected. The pathogen was isolated on PDA. Previous researchers also isolated the *Cercospora* spp. on PDA (Zia Hassan *et al.,* 2018; Dida *et al*., 2019; Mahapatra *et al*., 2023). Out of fifty-five Cercospora leaf spot samples collected from nine major cotton-growing districts of Karnataka during the survey, 29 Cercospora isolates were isolated on PDA from Karnataka. Seven isolates from Telangana, six from Andhra Pradesh and 9 from Tamil Nadu were isolated from the collected samples.

Different leaf spot diseases of cotton were recorded from 8.5-19.8 PDI, including Cercospora leaf spot, across six major cotton-growing districts of Tamil Nadu (Rajaswaminathan *et al*., 2021). Cercospora leaf spot disease incidence in cotton has been widely reported recently. The Cercospora leaf spot incidence ranged from 3.5 to 12.0 PDI among surveyed cotton fields in four states of South India (Sampathkumar *et al*., 2023).

Cultural and morphological characterisation of *Cercospora* isolates

Cultural and morphological characters of *C. gossypina* isolates were studied on PDA (Table 1). Several workers have studied the cultural and morphological characters of Cercospora species (Dida *et al*., 2019; Kumar *et al*., 2021).

Table 1: Cultural and morphological characters of *Cercospora gossypina* isolates from major cotton-growing areas of South India.

Isolate code	Mycelial growth	Colony colour	Texture	Type of margin	* Average length of the conidia (µm)	* Average width of the conidia (µm)	* Average number of horizontal septa
KA1	Raised	Ashy grey	Villous	Smooth	125.15	3.6	14.3
KA2	Raised	Ashy grey	Villous	Smooth	135.72	3.8	16.6
KA3	Medium raised	Dark grey	Cottony	Irregular	155.36	4.7	19.2
KA4	Medium raised	Dark grey	Cottony	Irregular	139. 32	3.9	14.6
KA5	Medium raised	Dark Grey	Cottony	Irregular	125.62	3.5	13.4
KA6	Medium raised	Dark Grey	Cottony	Irregular	96.66	3.0	10.2
KA7	Raised	Ashy grey	Villous	Smooth	110.68	3.2	11.7
KA8	Raised	Ashy grey	Villous	Smooth	131.47	3.7	15.3
KA9	Flat	Greyish black	Velvety	Irregular	99.17	3.1	9.2
KA10	Medium raised	Dark Grey	Cottony	Irregular	146.35	4.2	17.2
KA11	Raised	Ashy grey	Villous	Smooth	87.32	3.0	11.4
KA12	Flat	Greyish black	Velvety	Irregular	141.33	4.1	16.3
KA13	Medium raised	Dark grey	Cottony	Irregular	165. 10	5.0	19.0
KA14	Medium raised	Dark grey	Cottony	Irregular	132.46	3.7	15.6
KA15	Medium raised	Dark Grey	Cottony	Irregular	63.26	3.0	9.0
KA16	Flat	Greyish black	Velvety	Irregular	135.66	3.8	15.4
KA17	Raised	Ashy Grey	Villous	Smooth	55.72	3.0	9.1
KA18	Raised	Ashy grey	Villous	Smooth	140.25	3.3	16.7
KA19	Medium raised	Dark Grey	Cottony	Irregular	156.57	4.0	18.3
KA20	Flat	Greyish black	Velvety	Irregular	127.58	3.7	14.7
KA21	Medium raised	Dark grey	Cottony	Irregular	138.24	3.6	15.3
KA22	Medium raised	Dark grey	Cottony	Irregular	157.14	4.5	18.7
KA23	Raised	Ashy grey	Villous	Smooth	95.62	3.1	10.1
KA24	Raised	Ashy grey	Villous	Smooth	128.74	3.6	13.4
KA25	Flat	Greyish black	Velvety	Irregular	115.78	3.3	14.0
KA26	Medium raised	Dark grey	Cottony	Irregular	133.65	3.6	14.7
KA27	Raised	Ashy grey	Villous	Smooth	109.68	3.9	12.6
KA28	Medium raised	Dark Grey	Cottony	Irregular	128.47	4.1	14.3
KA29	Medium raised	Dark grey	Cottony	Irregular	160.11	4.6	19.1
TG1	Medium raised	Dark grey	Cottony	Irregular	136.21	3.4	15.3
TG2	Raised	Ashy grey	Villous	Smooth	109.47	3.6	11.7
TG3	Raised	Ashy grey	Villous	Smooth	87.55	3.1	9.8
TG4	Medium raised	Dark grey	Cottony	Irregular	123.69	3.7	12.4
TG5	Flat	Greyish black	Velvety	Irregular	114.30	3.9	12.2
TG6	Medium raised	Dark grey	Cottony	Irregular	104.26	3.2	11.0
TG7	Medium raised	Dark Grey	Cottony	Irregular	91.89	3.1	10.3
AP1	Raised	Ashy grey	Villous	Smooth	89.74	3.0	10.6
AP2	Medium raised	Dark grey	Cottony	Irregular	127.56	3.8	13.7
AP3	Medium raised	Dark grey	Cottony	Irregular	106.32	4.1	12.3
AP4	Medium raised	Dark grey	Cottony	Irregular	122.47	3.9	14.3
AP5	Flat	Greyish black	Velvety	Irregular	71.33	3.2	10.4
AP6	Raised	Ashy grey	Villous	Smooth	74.58	3.5	10.3
TN1	Medium raised	Dark grey	Cottony	Irregular	145.24	4.7	17.3
TN2	Flat	Greyish black	Velvety	Irregular	162.10	5.0	19.2
TN3	Medium raised	Dark grey	Cottony	Irregular	137.87	4.2	17.5
TN4	Raised	Ashy grey	Villous	Smooth	150.66	4.5	18.6
TN5	Medium raised	Dark grey	Cottony	Irregular	129.23	3.9	13.7
TN6	Medium raised	Dark grey	Cottony	Irregular	156.93	4.1	18.3
TN7	Raised	Ashy grey	Villous	Smooth	93.14	3.6	11.2
TN8	Flat	Greyish black	Velvety	Irregular	120.45	4.6	13.3
TN9	Medium raised	Dark grey	Cottony	Irregular	117.36	4.1	14.2

* Length and Width of the conidia and No. of horizontal septa - Average of 30 conidia.

In the present study, colony colour varied from ashy to dark grey or greyish black among the isolates. Most colonies were dark grey, followed by ashy grey and greyish black. 51 per cent of the colonies were recorded as dark grey, 31.4 per cent as ashy grey and 17.6 per cent as greyish black. All three colour types were observed across all four study states (Table 1). These results are consistent with those of others across different crops. *Cercospora tezpurensis* from chilli produced greyish colonies with a white margin and less sporulation on PDA (Meghvansi *et al*., 2013). Two types of colony margins were observed in this study: irregular and smooth. Ashy grey colonies recorded with a smooth margin; dark grey and greyish black colonies were observed with an irregular margin, irrespective of the place of collection. Mycelial characters recorded as raised for Ashy grey cultures, medium raised for dark grey cultures and flat to greyish black colonies. Fluffy mycelial growth was observed in raised and medium-raised cultures. Ashy grey colonies produced a villous texture with a smooth margin, dark grey cultures exhibited a cottony texture with an irregular margin and greyish black colonies produced a velvety texture with an irregular margin (Table 1). Colonies of *Cercospora* cf. *flagellaris* from melons were pale pinkish to light grey, with cottony aerial mycelium on PDA (Park *et al*., 2020). The colony colour of *C. canescens* isolated from mung bean varied from grey to light greyish white to brownish, with convex, fluffy growth, a smooth or zig-zag margin and a dense centre (Kumar *et al*., 2021). Cultural characters of *C. canescens* from mung bean varied from white, fluffy to less fluffy, cottony, pale cream colour, with red to radish brown margins (Mahapatra *et al*., 2023). Cultures of *C. dispori* isolated from *Disporum* spp. were olivaceous to pale olivaceous in colour, with an irregularly folded surface and an entire or slightly undulate white margin on PDA (Cho *et al*., 2025).

In the present study, short, unbranched, tufted, pale olivaceous brown, septate conidiophores were observed. They were mostly slightly curved, fasciculate and pale towards the apex. Conidia were thin-walled, hyaline and multi-septate. They were needle-shaped, slender and slightly curved, appearing cylindrical and truncated to subtruncate at the base. The tips of the conidia were straight or variously curved. They were acicular, with an acute base and a thickened, darkened hilum (Table 1). Bakhshi *et al*.

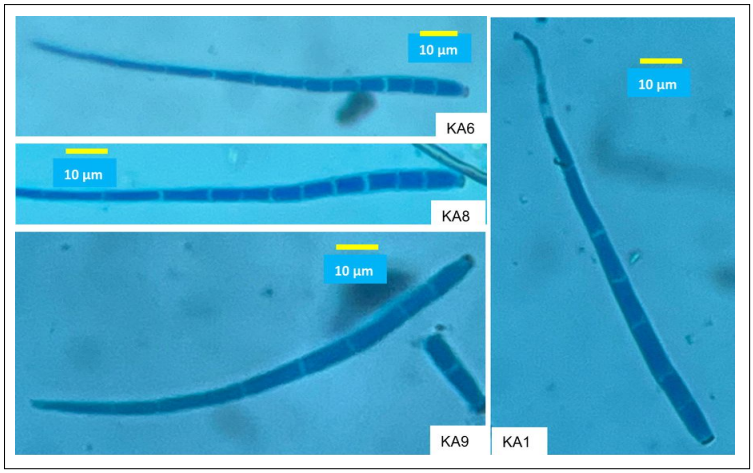


Fig 1: Microscopic images of Conidia of *Cercospora* isolates from Karnataka.

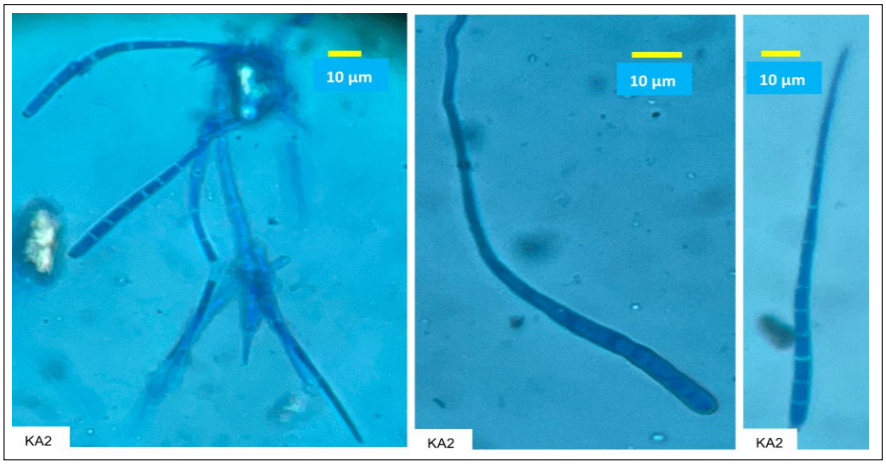


Fig 2: Microscopic images of Conidia of *Cercospora* isolates from Karnataka.

(2018) also described the morphology of *C. gossypii* from *G. herbaceum*, with findings similar to those of the present investigation. They reported that conidiophores were aggregated into dense fascicles, pale brown to brown, simple, straight or flexuous. Conidia were solitary, smooth, obclavate to subcylindrical, 1-7 septate, hyaline, straight or mildly curved and tapering towards the apex. Zia Hasan *et al.* (2018) isolated *Cercospora* sp. from Okra on PDA and found that conidiophores were pale brown and septate. Conidia were long, straight to slightly curved, thin-walled, multi-septate and pale olivaceous brown. *Cercospora canescens* from mung bean produced pale olivaceous conidiophores and straight to slightly curved, multi-septate conidia (Mahapatra *et al.*, 2023).

In this investigation, conidia measured 55.72 - 165.10 × 3.0 - 5.0 µm, with 9-19 horizontal septa across different isolates (Fig 1, 2, 3, 4 and 5; Table 1). These results align with the study of Bakhshi *et al.* (2018), who reported that *C. gossypii* isolates from cotton varied from 30 - 160 × 2-4 µm. The maximum and minimum conidia lengths were recorded for Karnataka isolates. Conidia from *C. canescens* were hyaline, straight to sub-straight or slightly curved, cylindrical, 2-12 septate and measured 10-300 × 1.3-5.0 µm (Kumar *et al.*, 2021). Conidiophores were solitary, dark brown and pale towards the apex. Conidia were solitary, hyaline, acicular to cylindrical, slightly curved, 2- 12 septate and measured 60-210 × 3.5-5 µm (Cho *et al.*, 2025).

Species identification of Cercospora isolates based on conidial characters

An isolated pathogen was identified as *Cercospora gossypina* based on long, slender, hyaline and multicellular conidial characters (Fig 1, 2, 3, 4 and 5).

Pathogenicity and virulence characterization of Cercospora isolates

Pathogenicity and virulence of *Cercospora gossypina* isolates were assessed on 25-day-old susceptible genotype LRA 5166 under greenhouse conditions (Fig 6 and 7 and Table 2). Earlier researchers also studied the pathogenic diversity of Cercospora isolates from other crops (Kumar *et al.,* 2021; Mahapatra *et al.*, 2023).

PDI ranged from 11.0 to 34.0 among 29 Karnataka isolates. Of these, 3 were highly virulent (>40.0 PDI), 13 moderately virulent (20.01 to 40.00 PDI) and 13 less virulent (0.00 to

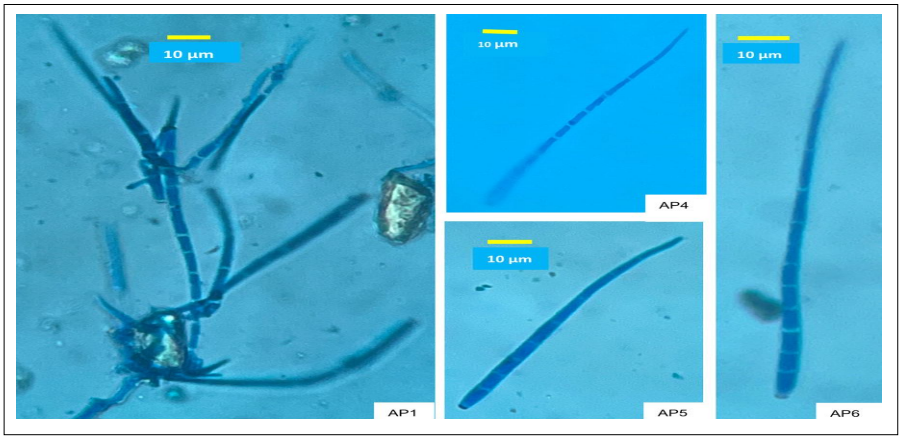


Fig 3: Microscopic images of Conidia of *Cercospora* isolates from Andhra Pradesh.

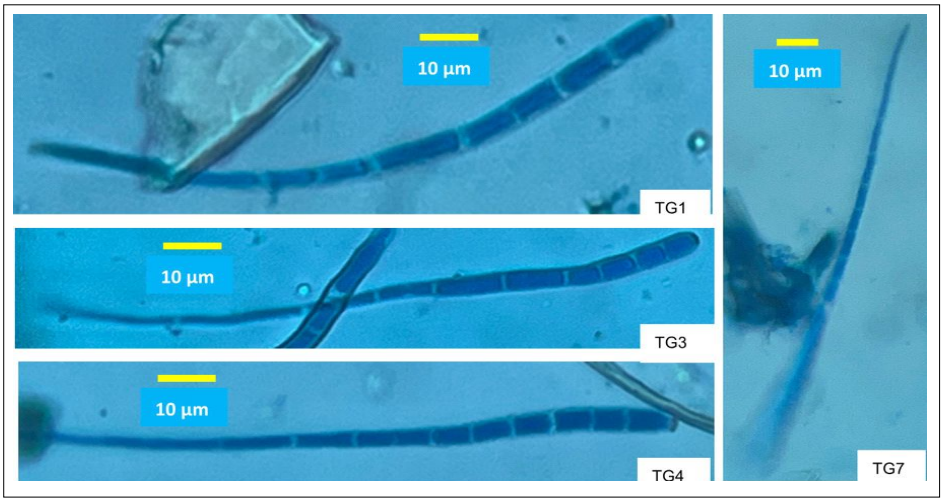


Fig 4: Microscopic images of Conidia of *Cercospora* isolates from Telangana.

20.00 PDI). PDI among 7 Telangana isolates ranged from 14.0 to 23.5, with 3 moderately virulent and 4 less virulent. PDI ranged from 12.0 to 21.5 among 6 Andhra Pradesh isolates. Of these, 2 were moderately virulent and 4 were less virulent. Tamil Nadu isolates showed PDI ranging from 15.0 to 26.0 across 9 isolates. Five were moderately virulent and 4 less virulent (Table 2). Isolates from Karnataka were found to be more virulent than those from other states. Likewise, Moretti *et al*. (2004) tested the virulence of *C. beticola* isolates on a 28-day-old susceptible sugar beet cultivar, Roberta and reported that 3 isolates were the most virulent, 2 were less virulent and the remaining 5 were moderately virulent. Kumar *et al*. (2021) studied the pathogenic variability of ten *C. canescens* isolates on 40-day-old mung bean plants and reported that PDI ranged from 35.30 to 54.48. Isolates from the Nagaur region were found to be more virulent than those from Jaipur and Tonk. Likewise, identifying the resistance source is crucial for a resistance breeding programme. Prasad *et al.* (2024) screened 200 mungbean genotypes against Cercospora leaf spot diseases for two seasons and found that four genotypes*, viz.,* PDM 04-123, PDM 54, EC520034-1 and EC 520022, were resistant to the disease. Integrating different management strategies are important for effective disease control. Foliar applications of garlic extract at 10% and Hexaconazole (0.1%) were effective in controlling the Cercospora leaf spot of mung bean caused by *Cercospora canescens* (Kumar *et al*., 2023).

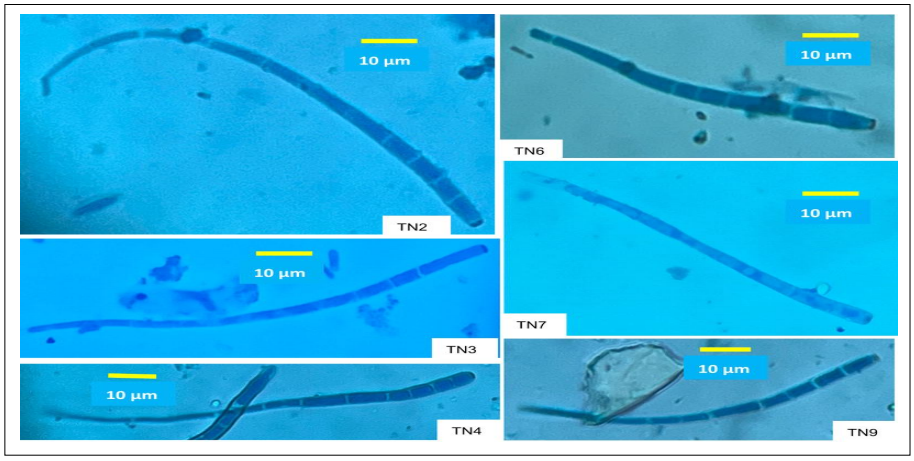


Fig 5: Microscopic images of Conidia of *Cercospora* isolates from Tamil Nadu.



Fig 6: Poly bag covering after spray inoculation of pathogen (LRA5166 seedlings).

Variation within the pathogen population is a continuous process. A study of pathogen variability is paramount for assessing pathogen status and devising a management strategy. In the present investigation, three dark or ashy grey colonies with raised or moderately raised mycelium and a cottony or villous texture, isolated from Karnataka, were found to be highly virulent. Although isolates with these characters were observed in other parts of



Fig 7: Spray inoculation of pathogen on LRA5166 seedlings after pin pricking.

Table 2: Pathogenicity and virulence class of various isolates of *Cercospora gossypina.*

S. no	Isolate code	Disease severity PDI (30 DAI) on LRA5166	Virulence class	S. no	Isolate code	Disease severity PDI (30 DAI) on LRA5166	Virulence class
1	KA1	19.5	Less virulent	27	KA27	21.0	Moderately virulent
2	KA2	12.5	Less virulent	28	KA28	23.5	Moderately virulent
3	KA3	22.0	Moderately virulent	29	KA29	23.0	Moderately virulent
4	KA4	17.5	Less virulent	30	TG1	21.5	Moderately virulent
5	KA5	15.0	Less virulent	31	TG2	17.0	Less virulent
6	KA6	26.5	Moderately virulent	32	TG3	21.0	Moderately virulent
7	KA7	21.0	Moderately virulent	33	TG4	23.5	Moderately virulent
8	KA8	31.0	Highly virulent	34	TG5	18.5	Less virulent
9	KA9	25.0	Moderately virulent	35	TG6	14.0	Less virulent
10	KA10	22.0	Moderately virulent	36	TG7	20.0	Less virulent
11	KA11	15.0	Less virulent	37	AP1	16.5	Less virulent
12	KA12	18.5	Less virulent	38	AP2	12.0	Less virulent
13	KA13	26.5	Moderately virulent	39	AP3	14.0	Less virulent
14	KA14	19.0	Less virulent	40	AP4	21.5	Moderately virulent
15	KA15	12.0	Less virulent	41	AP5	16.0	Less virulent
16	KA16	18.0	Less virulent	42	AP6	20.5	Moderately virulent
17	KA17	21.0	Moderately virulent	43	TN1	16.5	Less virulent
18	KA18	11.0	Less virulent	44	TN2	21.5	Moderately virulent
19	KA19	23.0	Moderately virulent	45	TN3	25.0	Moderately virulent
20	KA20	18.0	Less virulent	46	TN4	26.0	Moderately virulent
21	KA21	23.5	Moderately virulent	47	TN5	19.0	Less virulent
22	KA22	34.0	Highly virulent	48	TN6	22.0	Moderately virulent
23	KA23	30.5	Highly virulent	49	TN7	24.0	Moderately virulent
24	KA24	19.0	Less virulent	50	TN8	15.0	Less virulent
25	KA25	21.5	Moderately virulent	51	TN9	20.0	Less virulent
26	KA26	19.0	Less virulent				

SEd: 2.07; CD (P = 0.05): 4.13.

PDI: Per cent Disease Index; DAI: Days after Inoculation; Highly Virulent: > 30.00 PDI; Moderately Virulent: 20.01 to 30.00 PDI; Less Virulent: 0.00 to 20.00 PDI; Values are mean of three replications.

Karnataka and in states such as Telangana, Andhra Pradesh and Tamil Nadu, they were recorded as either moderately or less virulent. This indicates that the virulence of the isolates depends purely on the environmental factors prevailing in the region, together with a susceptible host and a source of inoculum. Moreover, the genetic makeup of isolates also contributes to their highly virulent nature. These highly virulent isolates were isolated from samples collected from rainfed cotton fields. Under rainfed conditions, the pathogen's adaptability to harsh environments will always be higher because of stronger selection pressure at high temperatures. These could have played a critical role in pathogen virulence and disease spread.

CONCLUSION

In the present study, colony colour varied from ash to dark grey or greyish black among the isolates. Short, unbranched, tufted, olivaceous, pale brown and septate conidiophores were observed. Thin-walled hyaline conidia and multi-septation were observed. Horizontal septa ranged from 9 to 19 among isolates. PDI ranged from 11.00 to 34.0 and Karnataka isolates were more virulent than those from other states. A study of pathogen population structure and continuous monitoring of pathogen variability are necessary for devising a disease management strategy, including a resistance-breeding program. This study mapped the pathogen's virulence across cotton-growing areas in the southern zone. Alternate wetting and drying conditions,along with nutrient and water stress, are conducive to Cercospora infection in cotton. Fungicide sprays and potassium applications can help control Cercospora leaf spot disease in cotton. Further study of fungicide resistance and cultivar screening of the identified highly virulent isolate will help to control the disease efficiently. Molecular characterisation of the isolates will reveal the pathogen's genetic makeup. The influence of weather parameters on disease development should also be studied to support effective disease management.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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