

Morphological Characterization and Prevalence of Different Groups of Fungal Pathogens Associated with Leaf Spot of Spinach and Anthracnose of Chilli

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ABSTRACT

The purpose of this study was to characterize fungal species causing leaf spot of spinach (*Spinacia oleracea* L.) and anthracnose of chilli (*Capsicum annuum* L.). Fungi induced diseases are one of the biotic factors causing a decline in yields and overall quality of spinach and chilli. Both spinach and chilli are widely consumed crops worldwide, with India ranking among the top nine countries in terms of spinach production and the world's largest producer, consumer and exporter of chillies. In this work, infected spinach leaves and chilli fruit samples were collected from markets in Ajmer (Rajasthan); morphological features characterization was performed. Results showed six different genera of fungal pathogens isolated from spinach and chilli, viz. *Phoma*, *Cladosporium*, *Stemphylium*, *Cercospora*, *Alternaria* from spinach leaves and *Colletotrichum* from chilli, belonging to seven fungal species. Using the most recent identification keys and micro-morphological and macro-morphological criteria, the isolated fungi were identified down to the genus and species level. Numerous fungal species have been linked to spinach leaf spot and chilli anthracnose, according to the study, and can cause a range of disease symptoms.

Keywords: Leaf spot, *Spinacia oleracea* L., *Capsicum annuum* L., Anthracnose, Fungal pathogens.

INTRODUCTION

Spinach (*Spinacia oleracea* L.) is one of the most crucial leafy vegetables belonging to the family Chenopodiaceae. It is widely grown worldwide, notably in India, and is indigenous to South-West and Central Asia (Roughani & Miri, 2019). In many Indian states, including

Uttar Pradesh, West Bengal, Maharashtra, Rajasthan, Punjab, Haryana and Gujarat, it is grown for commercial use (Meena et al., 2016). A good source of β -carotene, lutein, vitamin A, C, K, iron, magnesium, manganese, and calcium, spinach also contains a lot of oxalates (Dhaliwal, 2017).

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There are a number of fungi that cause spinach leaf spot (Correll et al., 1994), such as *Cercospora* leaf spot (*Cercospora beticola* Sacc.), *Alternaria* leaf spot (*Alternaria alternata* (Fr.) Keissl.), *Cladosporium* leaf spot (*Cladosporium variabile* (Cooke) G.A. de Vries), *Stemphylium* leaf spot (*Stemphylium botryosum* Wallr.), and *Phoma* leaf spot (*Phoma betae* A.B. Frank). Leaf spots have become the main obstacle to spinach production, limiting productivity and overall quality and ultimately impacting growers and seed producers' financial systems (Shane & Teng, 1992; Marraiki et al., 2012; Agrios, 2005).

Chilli (*Capsicum annuum* L.) is another economic crop that is consumed widely throughout the world (Poulos, 1992), and anthracnose is a serious production limitation that causes significant economic losses globally (Pakdeevraporn et al., 2005). A broad variety of economically valuable crops are susceptible to anthracnose infections, caused by species of the ascomycetes fungus *Colletotrichum* (Bailey & Jeger, 1992).

The present study was conducted at Microbiology and Plant Pathology Laboratory, Department of Botany, Samrat Prithviraj Chauhan Government College, Ajmer, during August-November 2024 on diseases of some so far studied fungal species associated with leaf spot of spinach and anthracnose of chilli

to comprehend the relevance of these fungal diseases and the need for crop protection. The current study focused on isolation, identification and morphological characterization of various pathogenic fungal genus/ species causing leaf spot of spinach and anthracnose of chilli.

MATERIALS AND METHODS

Isolation and Morphological Characterization

Leaves of spinach and chilli fruit infected with dark fungi were collected from local markets in Ajmer, Rajasthan, during August-November 2024. Using the baiting plate method, the mycobiota associated with infected spinach leaves and chilli fruit was estimated as described by Christensen (1963) and employed by Abdel Hafez et al. (1987, 1993). In the baiting plate method, firstly, the collected infected samples were carefully washed under running water to get rid of any dust or debris. Then, after being cut into 10mm diameter pieces, the samples were dried between sterile filter paper. The PDA plate was finally inoculated with four segments.

Following five days of incubation at 28°C, the growing fungi were counted and morphologically characterized using macro and microscopic characteristics on PDA medium according to Ellis (1971), Clements and Shear (1954).

Fungal isolation & purification																											Total % of occurrence						
<i>Cladosporium variabile</i>	0	0	0	3	3	3	2	0	0	3	0	1	3	0	3	1	0	1	0	0	0	1	3	0	0	3	0	3	3	-	-	36 (30%)	
<i>Alternaria alternata</i>	0	4	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	-	-	10 (8.33%)	
<i>Cercospora beticola</i>	4	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0	-	-	13 (10.83%)		
<i>Phoma betae</i>	0	0	0	0	0	0	0	0	0	1	0	1	1	0	3	4	3	1	0	0	0	0	0	0	0	0	0	0	-	-	14 (11.66%)		
<i>Stemphylium botryosum</i>	0	0	4	0	0	0	2	3	3	0	3	3	0	3	0	0	0	2	2	2	0	0	0	0	0	0	0	0	-	-	27 (22.50%)		
<i>Colletotrichum spp.</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	8 (100%)			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
	No. of samples																																

Table 1. Fungal counts and per cent occurrences of species isolated from infected spinach leaves and chilli fruit with the baiting plate method in PDA medium at 28°C for 4-5 days

RESULTS

Fungal Pathogens Causing Leaf Spot of Spinach and Anthracnose of Chilli

Thirty samples of infected leaves of spinach and two samples of chilli fruit were collected from different markets in Ajmer (Rajasthan). Seven fungal species were isolated from the samples on PDA medium at 28°C. Using the baiting plate method, fungal species were obtained from the samples. The fungal total count in the baiting plate method was 100/120 segments in *Spinacia oleracea* and 8/8 in *Capsicum annuum*. Five genera comprised a total of five species were collected from thirty samples of *Spinacia oleracea* viz. *Cladosporium variabile*, *Stemphylium botryosum*, *Phoma betae*, *Alternaria alternata*, *Cercospora beticola* and one genera comprised a total of two species were collected from two samples of *Capsicum annuum* viz. *Colletotrichum* sp.1 and *Colletotrichum* sp.2. With a count of 36/120 segments, *Cladosporium variabile* was the most prevalent species according to the baiting plate method. The highest count was estimated in sample no. 4,5,6,9,12,14,23,27,29, and 30. With a count of 27/120 segments, *Stemphylium botryosum* came in second in the baiting plate method, while sample no.3 had the highest value.

Morphological Characterization of Fungal Species

The colony morphology (colour, texture) and morphological features (conidia shape, size, septum and hyphae) as mentioned in relevant scientific literature describing key morphological characteristics available served as the foundation for the identification of different fungal species from the isolates. Fungal species were identified by employing a compound microscope at 10X and 40X magnification with the following standard manuals [Ellis (1971), Clements and Shear (1954)].

The morpho-cultural characteristics of six fungal pathogens associated with leaf spot of spinach and anthracnose of chilli are:

Alternaria alternata

The *Alternaria alternata* colony on PDA medium first showed light greyish green mycelial development and later on, black in

colour. Flat elevation, rough topography, light yellow edge, green colour pigment on the reversed side of the petri dish, and regular growth were the characteristics of the colony. Conidia are multicelled, muriform to ellipsoidal, olivaceous to dark brown in colour and range in size from 42.7-48.4µm×9.9-14.8µm, with 1-3 longitudinal and 5-6 transverse septation (Figure 1).

Cercospora beticola

The test pathogen, *Cercospora beticola*, generated cottony aerial mycelium with creamy white to mild yellow mycelial development that later became pale pinkish to light grey. Regular development, light yellowish to brown reverse pigment, white edge, elevated elevation and smooth topography were the colony defining features. Conidia had a filiform shape, were straight to slightly curved, colourless with 2-13 septation, and were 46-52µm×4.3-6.1µm (Figure 2).

Stemphylium botryosum

At first, the *Stemphylium botryosum* colony on PDA media showed white mycelial development, which eventually turned brown to dark brown. The colony of *Stemphylium botryosum* exhibited consistent growth, dark brown on the inverse side of the petri dish, rough topography and flat elevation. Conidia are globose, holoblastic, solitary, pale to mid brown in colour, with 3-7 transverse and 1-3 longitudinal septa. They measure 33-35µm×24-26µm (Figure 3).

Cladosporium variabile

Colonies of *Cladosporium variabile* were effuse, velvety and olive green, with white and regular margins. Reverse colour olivaceous black. Aerial hyphae was tortuous and spirally coiled. Conidia shape oblong, rounded at the ends, ellipsoidal or subglobose. The size of conidia was 5-30µm(length)× 3-13µm (width) and 0-1 septum was found. Conidiophore width 1.517-6.308µm (Figure 4).

Phoma betae

The colonies had a greenish grey colouring and a powdery or velvety texture and spread. *Phoma* species can be distinguished from other dematiaceous fungi by their genus-specific morphological traits, which include chlamydospores (for some species only), conidia and pycnidial conidiomata (fruiting

structures that serve as a mechanism of disseminating conidia). Large, round to pyriform, olivaceous black asexual fruiting structures, pycnidia, range in diameter from 70-100 μ m. They have one or more surface apertures from which the conidia are released. The conidia are unicellular, hyaline and ellipsoidal to cylindrical, aseptate (Figure 5).

Colletotrichum sp.1

On PDA medium, the morphology of *Colletotrichum* sp.1 colonies was pale yellowish white with thin, scanty white aerial mycelia. The reverse side of the colony was

white. Conidial morphology under the microscope revealed long cylindrical conidia with slightly rounded ends, with the presence of one globule in the center, and measured 12-24.2 \times 3.8-7.3 μ m in size (mean 16.5 \times 5.5 μ m) (Figure 6).

Colletotrichum sp. 2

On PDA medium, the morphology of *Colletotrichum* sp.2 colonies was pale grey to dark grey. The reverse side was dark brown. Conidial morphology revealed falcate shaped conidia with dimensions 18.8-29.87 \times 2.7-4.9 μ m (Figure 7).

Table 2. Morphological and cultural characteristics of different groups of fungal pathogens associated with leaf spot of spinach and anthracnose of chilli on PDA medium at 28°C for 4-5 days.

Characteristics	<i>Alternaria alternata</i>	<i>Cercospora beticola</i>	<i>Stemphylium botryosum</i>	<i>Cladosporium variabile</i>	<i>Phoma betae</i>	<i>Colletotrichum spp. 1</i>	<i>Colletotrichum spp. 2</i>
Colony							
Color	Light greyish brown, later on black color	Creamy white to mild yellow, later on became pale pinkish to light grey	Whitish color which eventually turned brown to dark brown	Olive green, white and regular margins	Greenish grey	Pale yellowish white	Pale grey to dark grey
Texture	Regular, floccose (woolly or cottony)	Regular, fluffy, cottony	Velvety to cottony	Effuse, velvety	Powdery or velvety	Thin, scanty	Thick, cottony
Reverse	Green color	Yellowish to brown	Dark brown	Olivaceous black	Dark brown	White	Dark brown
Conidia							
Shape	Muriform to ellipsoidal	Filiform, straight to slightly curved	Globose	Oblong, rounded at ends, ellipsoidal or subglobose	Ellipsoidal to cylindrical	Long cylindrical with slightly rounded ends	Falcate
Size	42.7-48.4 μ m \times 9.9-14.8 μ m	46-52 μ m \times 4.3-6.1 μ m	46.4-57 μ m \times 7.8-17.8 μ m	4.126-5.468 μ m \times 1.517-4.098 μ m	-	12-24.2 μ m \times 3.8-7.3 μ m	18.8- 29.87 μ m \times 2.7-4.9 μ m
Septum	1-3 longitudinal and 5-6 transverse	2-13	3-7 transverse and 1-3 longitudinal	0-1	Aseptate	Aseptate	Aseptate

DISCUSSION

In this study, seven species were isolated, viz. *Phoma betae*, *Cladosporium variabile*, *Stemphylium botryosum*, *Cercospora beticola*, and *Alternaria alternata* from spinach and two *Colletotrichum* species from chilli were identified by morphological methods, and the most common species in the count were *Cladosporium variabile* and *Stemphylium botryosum*. Our result has been in agreement with Correll et al. (1994), who estimated that there are various fungi that can infect spinach and cause leaf spot disease, such as *Cercospora* leaf spot (*Cercospora beticola*), *Alternaria* leaf spot (*Alternaria* sp.), *Cladosporium* leaf spot (*Cladosporium macrocarpum*) and anthracnose (*Colletotrichum dematium* f. sp. *Spinaciae*).

This study agreed with the description obtained by du Toit and Derie (2001), who identified *Stemphylium botryosum* and *Cladosporium variabile* as the principal pathogens causing leaf spot of spinach seed crops in western Washington. The morphological and cultural characters of *Alternaria alternata* in this study were consistent with those reported by previous researchers (Marrarkai et al., 2012; Aslam et al., 2019; Kuarer et al., 2019). The morphological and cultural characteristics of *Cercospora beticola* are comparable to those described by previous researchers (Vistal, 1933; Forsyth et al., 1963; Esh & Moghaieb, 2011; Mukhtar et al., 2019). *Stemphylium botryosum* morphological and cultural traits resemble those described by previous

researchers (Koike et al., 2001; Hernandez-Perez & du Toit, 2006). Previous researchers Hernandez-Perez and du Toit (2006) described the morphological and cultural characteristics of *Cladosporium variabile*, which are comparable with our findings, while those of *Phoma betae* resembled Bassimba (2014), Seyyedi and Amirmijani (2017). Morphological and cultural characteristics of *Colletotrichum* sp. isolated from chilli were as per the observations made by Liu et al. (2016). Leaf spot of spinach, caused by various fungal pathogens, which are identified morphologically, with unique and relatively stable colonies, could be easily distinguished. However, anthracnose of chilli, caused by *Colletotrichum*, has complex species, and in addition to morphological characterization, molecular identification is required to discriminate between closely related species.

Despite the fact that fungal infections in healthy people are still rare, new research

indicates that temperature change and antibiotic resistance may be contributing to an increase in sporadic occurrences (Fisher et al., 2022; WHO, 2022). Immunocompromised individuals are at an increased risk of developing severe fungal infections, despite the fact that the majority of fungal species are essential for the production of antibiotics, food fermentation, and other biotechnological applications (Bongomin et al., 2020; & Kowalski et al., 2022). Evaluation of environmental fungi potential to produce mycotoxin is essential for risk assessment and the citation of focused public health (Eskola et al., 2020; & Vila-Donat et al., 2024). Improved workplace safety precautions are necessary because agricultural workers, especially those who handle crops or soil, are exposed to fungal infections and mycotoxins at the workplace (Oliveira et al., 2023; & Richardson et al., 2021).

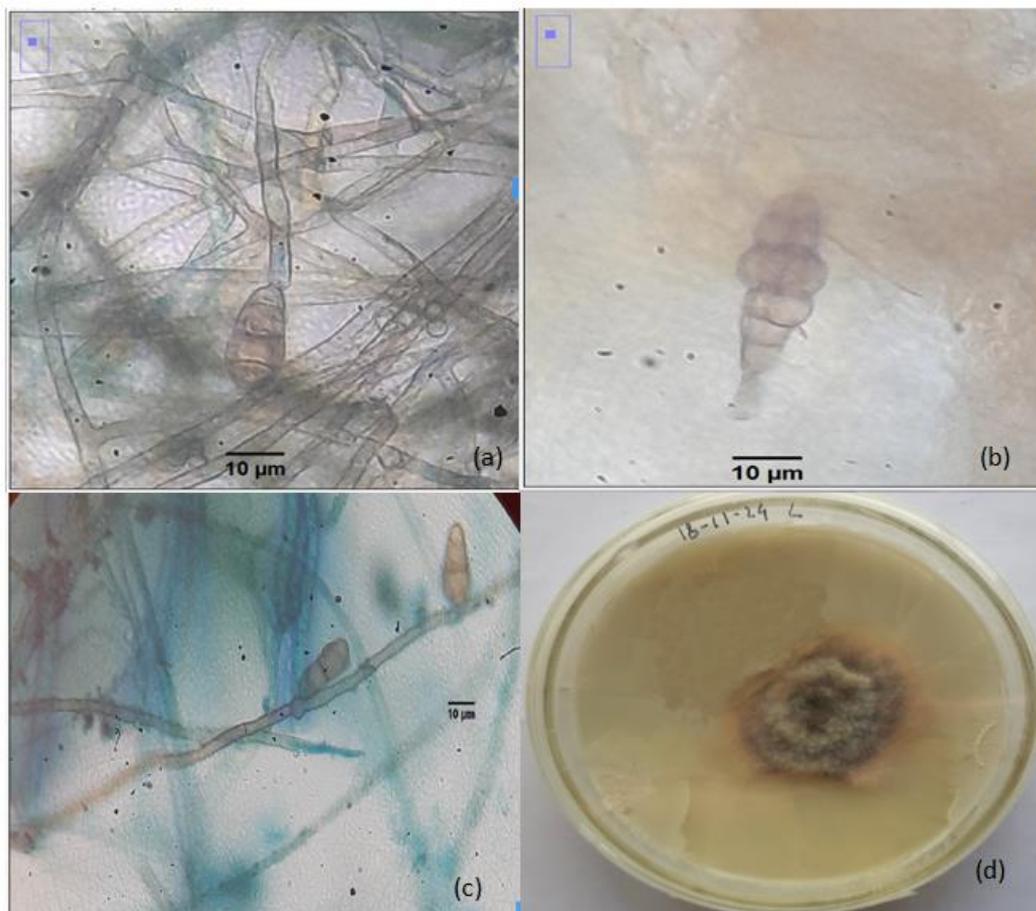


Figure 1. *Alternaria alternata*- assemblages (a-c), colony growth on PDA at 5 days after incubation (d), scale bars=10μm.

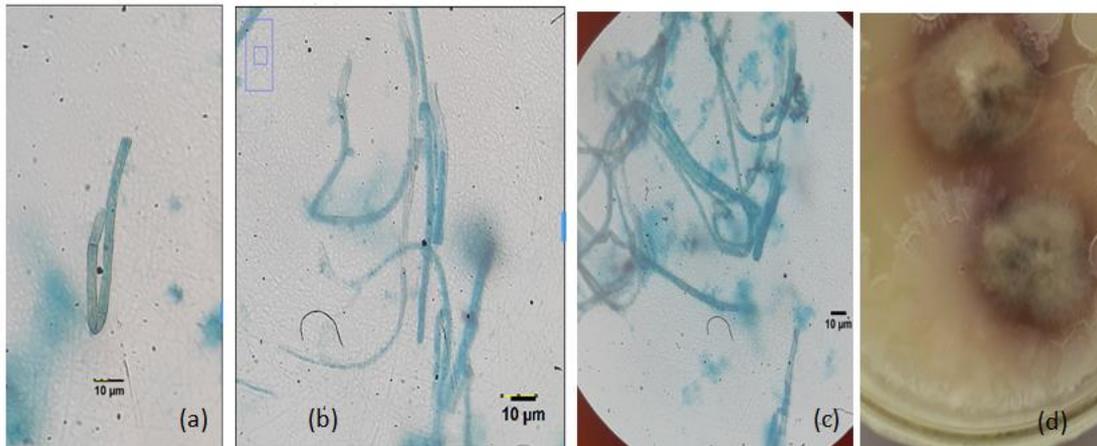


Figure 2. *Cercospora beticola*- assemblages (a-c), colony growth on PDA at 5 days after incubation (d), scale bars=10μm.

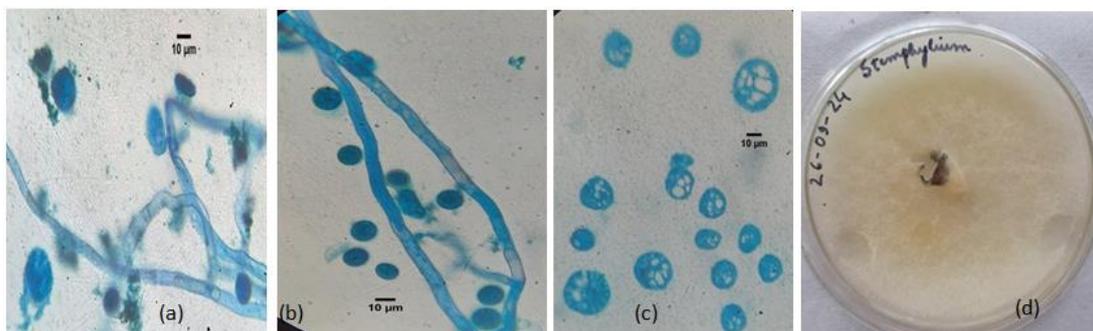


Figure 3. *Stemphylium botryosum*- assemblages (a-c), colony growth on PDA at 5 days after incubation (d), scale bars=10μm.

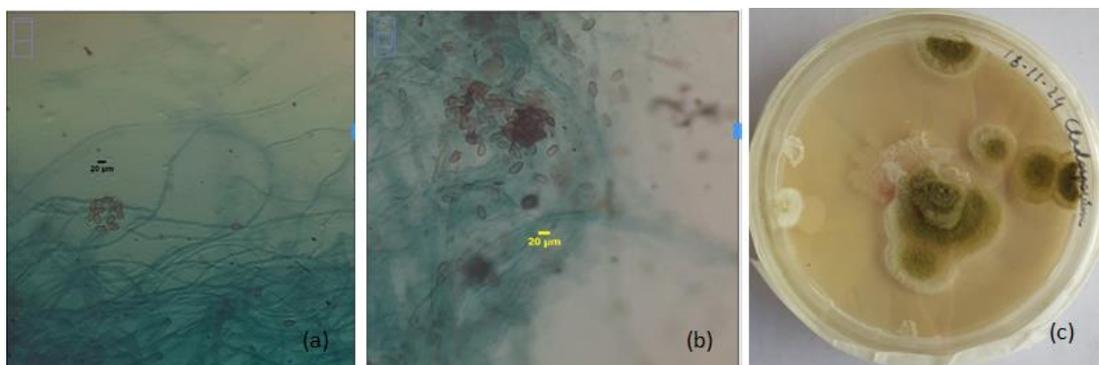


Figure 4. *Cladosporium variabile*- assemblages (a-b), colony growth in PDA at 5 days after incubation (c), scale bars=20μm.

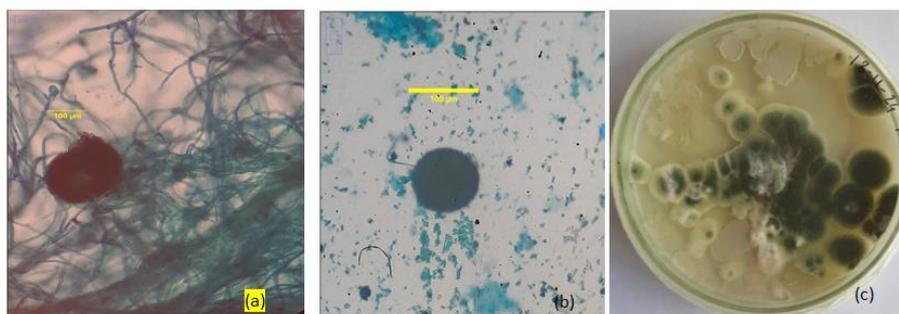


Figure 5. *Phoma betae*- pycnidium with septate hyphae (a), conidia protruding out from pycnidia (b), colony growth on PDA at 5 days after incubation (c), scale bars=100μm.

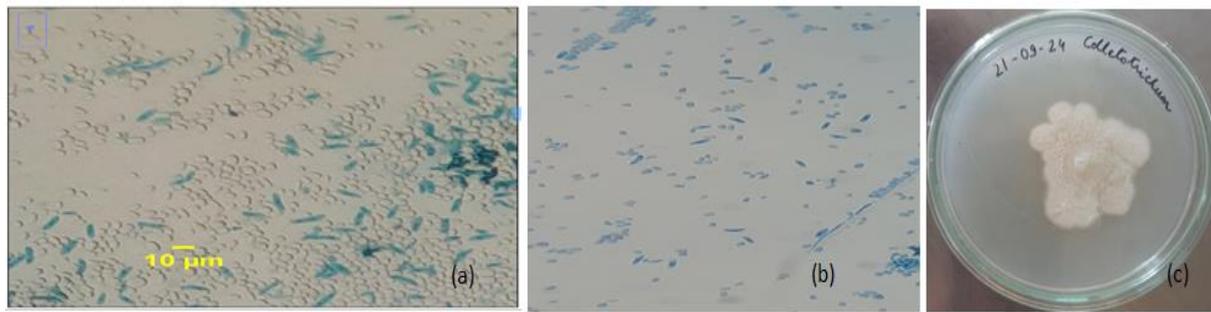


Figure 6. *Colletotrichum* sp.- conidia (a-b), colony growth on PDA at 5 days after incubation (c), scale bars=10μm.

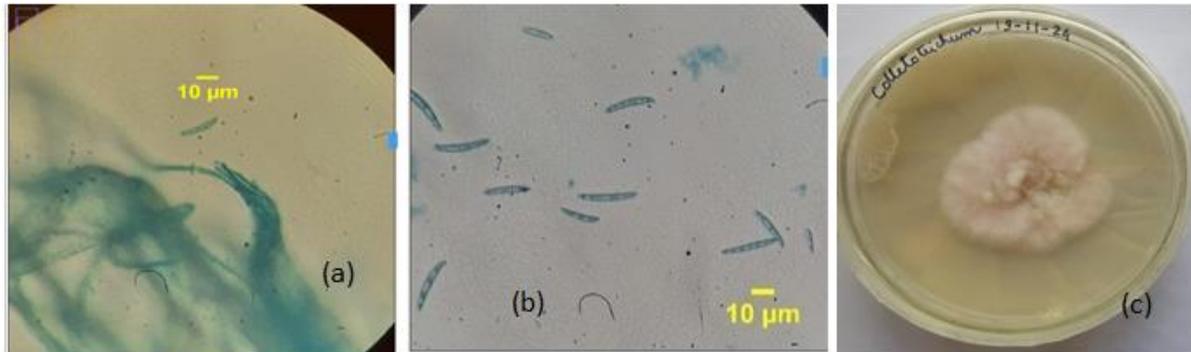


Figure 7. *Colletotrichum* sp.- conidia (a-b), colony growth on PDA at 5 days after incubation (c), scale bars=10μm.



Figure 8. Leaf spot of spinach caused by (a) *Alternaria alternata*, (b) *Stemphylium botryosum*, (c) *Cercospora beticola*, (d) *Phoma betae*, (e) *Cladosporium variabile*; Anthracnose of chilli caused by (f,g) *Colletotrichum* sp.

CONCLUSION

Growing spinach and chilli is common around the world, and it is critical to keep them free of diseases like spinach leaf spot and chilli anthracnose. A deep learning based method has been used in this study to identify several phytopathogenic fungi that cause spinach leaf spot and chilli anthracnose. Identification of fungal pathogens found in different plants can be aided by the distinctive traits and assemblages found in this study. Isolation and identification of different groups of fungal pathogens associated with leaf spot of spinach and anthracnose of chilli revealed the prevalence of economically significant fungal species, highlighting both agricultural and public health concerns. Also, the study provided precise differentiation between fungal species associated with leaf spot of spinach and anthracnose of chilli, using traditional morphological identification. In future, other aspects focusing on fungicidal activities against leaf spot of spinach and anthracnose of chilli caused by the identified fungal pathogens should be addressed to ensure prevention of disease incidence and maintain the overall quality.

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Author Contributions

L.J. carried out experiments and wrote the manuscript. G.R. supervised the work. Both authors discussed the results and commented on the manuscript.

REFERENCES

Agrios, G. N. (2005). *Plant Pathology* (fifth ed.). Elsevier-Academic Press, New York.

Aslam, S., Aslam, H. M. U., Abbas, A., Ali, M. A., Alam, M. W., Amrao, L., & Gleason, M. L. (2019). First Report of Leaf Spot of Spinach Caused by *Alternaria alternata* in Pakistan. *Plant Disease*, 103(6), 1430.

<https://doi.org/10.1094/PDIS-12-18-2211-PDN>

Bailey, J. A., & Jeger, M.J. (1992). *Colletotrichum: Biology, Pathology and Control*. CAB International, Wallingford UK.

Bassimba, D. D. M., Mira, J. L., & Vicent, A. (2014). First report of leaf spot of spinach caused by *Pleospora betae* in Spain. *Plant Disease*, 98(11), 1583.

<https://doi.org/10.1094/PDIS-04-14-0367-PDN>

Bongomin, F., Gago, S., Oladele, R. O., & Denning, D. W. (2020) Global and multi-national prevalence of fungal diseases—Estimate precision. *J Fungi*, 6(3), 150.

Christensen, C. M. (1963). Influence of Small Differences in Moisture Content Upon the Invasion of Hard Red Winter Wheat by *Aspergillus restrictus* and *A. repens*. *Cereal Chemistry*, 40, 385-390.

Clements, F. E., & Shear, C.L. (1931). *The Genera of Fungi*. H.W. Wilson Company, New York.

Correll, J. C., Morelock, T. E., Black, M. C., Koike, S. T., Brandenberger, L. P., & Dainello, F. J. (1994). Economically important diseases of spinach. *Plant Disease*, 78(7), 653-660.

<https://doi.org/10.1007/BF00467102>

Dhaliwal, M. S. (2017). *Handbook of vegetable crops* (third ed.). Kalyani Publishers, India.

du Toit, L. J., & Derie, M. L. (2001). *Stemphylium botryosum* pathogenic on spinach seed crops in Washington. *Plant Disease*, 85(8), 920.

Ellis, M. B. (1971). *Dematiaceous Hyphomycetes*. Kew Commonwealth

- Mycological Institute, Surrey, England.
- Esh, A. M., & Moghaieb, R. E. (2011). Analysis of morphological, pathological and genotypic diversity in *Cercospora beticola* Sacc. from different sugar beet cultivation in Egypt. *Arab Journal of Biotechnology*, 14(1), 77-88.
- Eskola, M., Kos, G., Elliott, C. T., Hajšlová, J., Mayar, S., & Krska, R. (2020). Worldwide contamination of food-crops with mycotoxins: Validity of the widely cited 'FAO estimate' of 25%. *Crit Rev Food Sci Nutr*, 60(16), 2773-89. <https://doi.org/10.1080/10408398.2019.1658570>.
- Fisher, M. C., Alastruey-Izquierdo, A., Berman, J., Bicanic, T., Bignell, E. M., Bowyer, P., Bromley, M., Bruggemann, R., Garber, G., Cornely, O. A., Gurr, S. J., Harrison, T. S., Kuijper, E., Rhodes, J., Sheppard, D. C., Warris, A., White, P. L., Xu, J., Zwaan, B., & Verweij, P. E. (2022). Tackling the emerging threat of antifungal resistance to human health. *Nature reviews microbiology*, 20(9), 557-571.
- Forsyth, F. R., Unwin, C. H., & Jursic, F. (1963). Cultural and pathogenic studies of an isolate of *Cercospora beticola* Sacc. *Journal of the Association for Information Science and Technology*, 12(6), 485-491.
- Hernandez-Perez, P., & du Toit, L. J. (2006). Seedborne *Cladosporium variabile* and *Stemphylium botryosum* in spinach. *Plant disease*, 90(2), 137-145. <https://doi.org/10.1094/PD-90-0137>
- Koike, S. T., Henderson, D. M., & Butler, E. E. (2001). Leaf spot disease of spinach in California caused by *Stemphylium botryosum*. *Plant disease*, 85(2), 126-130. <https://doi.org/10.1094/PDIS.2001.85.2.126>
- Kowalski, C. H., Morelli, K. A., & Stajich, J. E. (2022). Fungal contributions to biotechnology and medicine. *Curr Opin Microbiol*, 67, 102–9.
- Liu, F., Tang, G., Zheng, X., Li, Y., Sun, X., Qi, X., Zhou, Y., Xu, J., Chen, H., Chang, X., Zhang, S., & Gong, G. (2016). Molecular and phenotypic characterization of *Colletotrichum* species associated with anthracnose disease in peppers from Sichuan Province, China. *Scientific reports*, 6(1), 32761. <https://doi.org/10.1038/srep32761>
- Marraiki, N., Siddiqui, I., Rizwana, H., & Javaid, A. (2012). First report of *Alternaria alternata* leaf spots on spinach in Saudi Arabia. *The Journal of Animal & Plant Sciences*, 22(1), 247-248.
- Meena, V. K., Subramanian, S., Dipti, N. V., & Simta, K. (2016). Introduction of palak (*Spinacia oleracea* L.) in Ernakulam district of Kerala through front line demonstration and on farm testing. *Agricultural Science Digest*, 36(2), 130-133.
- Mukhtar, I., Khokhar, I., Yan, Y., & Xie, B. (2019). First report of *Cercospora* leaf spot caused by *Cercospora beticola* on spinach in Pakistan. *Plant Disease*, 103(7), 1779. <https://doi.org/10.1094/PDIS-12-18-2274-PDN>
- Oliveira, R. C., Pena, G. H., & Keller, L. A. M. (2023). Mycotoxin exposure in agricultural settings: Health risks and preventive strategies. *EHP*, 131(2), 025001.
- Pakdeevaporn, P., Wasee, S., Taylor, P. W. J., & Mongkolporn, O. (2005). Inheritance of resistance to anthracnose caused by *Colletotrichum capsici* in Capsicum. *Plant Breeding*, 124(2), 206-214. <https://doi.org/10.1111/j.1439-0523.2004.01065.x>
- Poulos, J. M. (1992). Problems and progress of chilli pepper production in the tropics.

- In: Proceedings of the Conference on Chilli Pepper Production in the Tropics (Eds.: Hock, C. B., Hong, L. W., Raejab, M., & Syed, A. R.). Kuala Lumpur, Malaysia, pp.98-129.
- Richardson, M., Bowyer, P., & Denning, D. W. (2021). Human fungal pathogens: Agricultural exposures and opportunities for protection. *J Occup Health*, 63(4), e12271.
- Roughani, A., & Miri, S. M. (2019). Spinach: An important green leafy vegetable and medicinal herb. *The 2nd International Conference on Medicinal Plants, Organic Farming, Natural and Pharmaceutical Ingredients*, 1-6.
- Seyyed, N., Amirmijani, A., & Sadeghian, M. (2017). Occurrence of spinach leaf spot caused by *Phoma betae* in Jiroft. *3rd Iranian Mycological Congress, University of Kurdistan, Sanandaj, Iran*.
- Shane, W. W., & Teng, P. S. (1992). Impact of *Cercospora* leaf spot on root weight, sugar yield, and purity of *Beta vulgaris*. *Plant Disease*. 76(8), 812-820.
- Vila-Donat, P., Marín, S., Sanchis, V., & Ramos, A. J. (2024). Mycotoxin risk assessment in the agri-food supply chain: Recent advances and future perspectives. *Trends Food Sci Technol.*, 143, 104289. <https://doi.org/10.1016/j.tifs.2023.104289>.
- World Health Organization. (2022). WHO fungal priority pathogens list to guide research, development and public health action. World Health Organization. <https://www.who.int/publications/i/item/9789240060241>