



A comprehensive overview on fungal diseases of *Aloe vera* in India

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Abstract

This study presented a comprehensive overview on fungal diseases of *Aloe vera* found commonly in India. The detailed analyses of the information obtained from the present study and previously published literature revealed that diseases of *A. vera* can be categorized into two main categories as spots and rots caused by various fungal pathogens. Total fifteen fungal species as *Alternaria alternata*, *Cladosporium sphaerospermum*, *Colletotrichum gloeosporioides*, *Curvularia lunata*, *C. ovoidea*, *Fusarium fusaroides*, *F. proliferatum*, *F. solani*, *Helminthosporium* sp., *Penicillium purpurogenum*, *Phoma betae*, *P. eupyrena*, *Polyrostrata indica*, and *Pythium aphanidermatum* were found associated with different disease of *A. vera*. Reduced leaf length, width, total number and colour & texture of mucilaginous gel were observed in infected plants. The detailed descriptions of the fungal diseases of *A. vera* viz. name of disease, causal organism, disease symptoms, cultural and microscopic characteristics along with systematic details are provided. This compendium will be a useful document for researchers working on various aspects of *A. vera*.

Keywords – *Aloe vera* – causal organisms – diversity – fungal diseases – India

Introduction

In the recent resurgence of herbal products, *Aloe vera* is witnessing a new renaissance worldwide. *A. vera*, being like a cactus plant has enjoyed a long history as an herbal remedy and is perhaps the most popular herb in use today. It is one of the well-known medicinal plants with diverse therapeutic uses. This plant is generally native of warm parts of Africa, especially Cape Province of South Africa and the mountains of tropical Africa (Yeppella et al. 2011). Because of numerous bioactive compounds; *A. vera* has become one of the most demanding plants in herbal and cosmetic industries. Due to the multifarious benefits for medicinal and cosmetic industries, it is now cultivating worldwide on commercial scale. *A. vera* is now popularly known as “magic plant” as it can heal and cure any ailment.

Fungi are the important plant pathogens reported to cause numerous plant diseases. Like other plants, *A. vera* also gets infected with many fungal diseases in the fields. Lack of scientific farming techniques and abiotic factors such as temperature, high moisture and humidity favours the growth of microbial infection in leaves, collar and roots of the plant. The fungal infection may cause reduced plant growth, deteriorate the quality and quantity of the gel and also alters useful

properties of its constituents (Avasthi et al. 2018, 2019a, b, 2020).

Looking into the huge demand of *A. vera* in the industrial sector, it is important to emphasize maintaining the health of plants in the field. Control of fungal diseases of *A. vera* is an important aspect of ensuring that quality raw material can be harvested and processed to industries. However, the correct identification of fungal diseases of *A. vera* and responsible pathogens, their diversity and distribution are equally essential in managing these diseases. As India is among the largest producers of *A. vera*, the present study will be proved useful for herbal industries involved in the preparation of different products of *A. vera*. The information available in previously published research on fungal diseases of *A. vera* in India is scattered. Research published earlier by Avasthi et al. (2019a) included only disease incidence of the fungal diseases on *Aloe vera* plants in Gwalior, Madhya Pradesh, India; the present compilation however, will provide a single document comprehensive account on fungal diseases of *Aloe vera* prevalent in India.

Materials & Methods

Sample collection

Diseased plant samples (infected leaves and roots) were collected from various locations of Gwalior, Madhya Pradesh, India. Total of sixteen nurseries and two botanical gardens located in various areas of Gwalior city were surveyed to explore the fungal disease associated with *A. vera* and for the collection of diseased samples. Photographs were taken before sample collection to note down the disease symptoms in natural conditions. In each site, five plants were selected randomly, and samples of infected plant parts i.e. leaves, roots and collar of *A. vera* plant were collected, placed in individually sterile polythene bags and brought to Mycology and Plant Pathology Laboratory at School of Studies in Botany, Jiwaji University, Gwalior (Avasthi et al. 2019a, b).

Fungal isolation and identification

The morphology of the symptoms on collected plant parts was first studied with the help of hand lens and then with dissecting microscope. Each part of the infected plant viz. leaves, collar and roots, were observed carefully to record the morphology of the disease symptoms, i.e. color, diameter of spots and changes in the morphological characteristics. Isolation was performed from the collected diseased leaves of *A. vera* brought from the nurseries and botanical gardens. Diseased leaves of *A. vera* were washed thoroughly with running tap water to remove the surface dirt and other unwanted materials. The leaves were cut into small pieces using sterile scalpel blades and then surface sterilized with 2% sodium hypochlorite solution (NaOCl) for 2 mins followed by three – four times with sterile distilled water. These surface sterilized pieces were then placed between blotting papers to remove excess water and aseptically inoculated onto Petri dishes containing Potato Dextrose Agar (PDA) media. The plates were incubated at $25\pm 2^{\circ}\text{C}$ for 5 to 6 days, and the growth of fungal colonies were recorded every day. The isolated fungal species were identified on the basis of cultural characteristics (shape, size and color of colony) and microscopic features (characteristic of mycelium, shape, size and color of conidia, setae, pycnidia etc.) as described in published standard literature (Barnett & Hunter 1998, Leslie et al. 2006, Gilman & Joseph 2012, Seifert et al. 2011). Identification of pathogens was further confirmed at the Indian Type Culture Collection (ITCC), IARI, New Delhi and the National Fungal Culture Collection of India (NFCCI), Agharkar Research Institute, Pune, Maharashtra, India. Pathogenicity was also carried out by using the pin prick method on *A. vera* leaves to confirm the Koch's postulates.

In addition, the information on fungal disease of *A. vera* available in all forms of published documentation and literature was also gathered to present a complete account in this paper.

Results & Discussion

During survey for sample collection, *A. vera* was found attacked by number of fungal pathogens. Remarkable changes in diseased plants in terms of colour, texture and appearance were observed in comparison to healthy ones. While, diseased plants exhibited reduction in leaf length,

leaf width and total number of leaves, infected roots also showed dry, curled, thin and maroon brown coloured appearance. The morphological examination of collected plants samples revealed that four types of diseases symptoms, namely, leaf spot, leaf rot, collar rot, and root rot, were associated with *A. vera* plants. Generally, maroon, black, brown, creamish brown spots, spongy and watery soft patches were recorded on leaf surfaces (Avasthi et al. 2018, 2019a, b, 2020). Detailed comparison of disease symptoms produced by various fungi on *A. vera* plants is presented in Fig. 1 and Table 1.

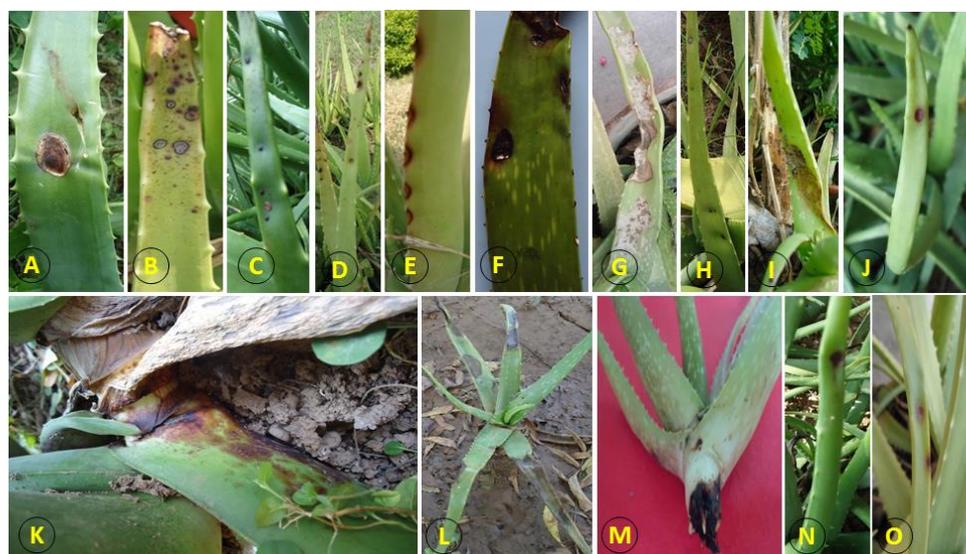


Fig. 1 – Disease symptoms caused by various fungi on *A. vera* plants. A Anthracnose by *Colletotrichum gloeosporioides*. B Leaf spot by *Alternaria alternata*. C Leaf spot by *Cladosporium sphaerospermum*. D Leaf spot by *Curvularia lunata*. E Leaf spot disease by *Curvularia ovoidea*. F Leaf spot by *Fusarium fusaroides*. G Leaf spot by *Fusarium moniliforme*. H Brown leaf spot by *Phoma betae*. I Brown leaf spot by *Phoma eupyrena*. J Brown leaf spot by *Phomopsis* sp. K Collar and root rot by *Penicillium purpurogenum*. L Leaf rot disease by *Pythium aphanidermatum*. M Root rot by *Fusarium solani*. N Leaf spot by *Helminthosporium* sp. O Leaf spot by *Polyrostrata indica*.

Table 1 Morphological characteristics of various fungal disease of *Aloe vera*.

Name of Disease (Period of occurrence)	Name of fungal Pathogen	Morphological Characters			
		Disease Spot/rot	Spot size (average)	Severe symptoms	Specialized structure
Anthracnose (July to September)	<i>Colletotrichum gloeosporioides</i> (Penz.) Penz. & Sacc.	Circular to oval, water soaked dark green to dark brown areas on the tips and the abaxial surfaces of leaves.	3-30 mm	In the advance stage of infection, spots appeared on both leaf surfaces, affected area lost the mucilaginous gel and leads the death of infected leaves.	Formation of acervuli is commonly found.
Black leaf spot disease (December to February)	<i>Alternaria alternata</i> (Fr.) Keissier	Circular to oval, water-soaked spots with concentric double ring; greyish-black centre with dark brown margins the tip and abaxial surface of leaves.	0.5-4.0×0.4-3.2 cm.	As the diseases progressed black sporulation appeared on the centre of the spots. On later stage, spots become necrotic and dry.	--

Table 1 Continued.

Name of Disease (Period of occurrence)	Name of fungal Pathogen	Morphological Characters			Specialized structure
		Disease Spot/rot	Spot size (average)	Severe symptoms	
Leaf spot disease (January and February)	<i>Cladosporium sphaerospermum</i> Penzig.	Circular, oval to irregular, brown to olive black to dark black, sunken spots on the abaxial surface of leaves.	0.4-0.9×0.3-0.6 cm	In later stage sporulation appeared and spots became olive black to dark black in colour. Sometimes spots often joined together and became irregular in shape.	--
Leaf spot disease (January to February)	<i>Curvularia ovoidea</i> (Heroe & N Watan) Munt-Cvetk	Elongated, water-soaked spots, appeared on the leaf tip and spiny margins which later became sunken, reddish brown to dark maroon in colour.	0.5-1.2×0.4-0.7 cm	In severe conditions due to necrosis of tissues spiny margin of leaf is twisted inside.	--
Leaf spot disease (July to August)	<i>Curvularia lunata</i> (Walker) Boedijin	Initially circular, water-soaked spots are appeared on the abaxial surface of leaves. As the disease progresses, spots become sunken, maroon colour	0.5-1.3×0.4-0.8 cm	On later stage spots become dry, necrotic and turned into dark brown in colour.	--
Leaf spot disease (January to February)	<i>Fusarium fusaroides</i> (Frag. & Cif.) Booth	Circular to oval water-soaked maroon to reddish brown spots.	0.5-1.2×0.4-0.8 cm	At maturity, diseased tissues show tissue death, become necrotic, spots turn into black in colour.	Formation of sprodochia is commonly found
Leaf spot disease (December to February)	<i>Fusarium moniliforme</i> Sheldon	Irregular to sometimes circular lesion as sunken and light cream to enlarged, embedded, creamish brown with reddish brown margin on the abaxial or adaxial surface of leaf. Dark brown sporulation observed on the centre of the spots.	1.1-4.0×0.8-3.6 cm	Leaf gel becomes mushy and in severe condition diseased portion break down.	Formation of sprodochia is commonly found
Brown leaf spot disease (January to February)	<i>Phoma betae</i> A.B. Frank.	Water soaked sunken spots appears as oval to circular with dark brown in colour having concentric	0.7-1.8×0.5-1.0 cm	Later, spots get dry, necrotic and shrunken. Sometimes two or more spots coalesce, form a big spot and in severe condition leaf	Formation of Pycnidia is commonly found

Table 1 Continued.

Name of Disease (Period of occurrence)	Name of fungal Pathogen	Morphological Characters			
		Disease Spot/rot	Spot size (average)	Severe symptoms	Specialized structure
Leaf spot disease (July to September)	<i>Phoma eupyrena</i> Sacc.	ring pattern on the tip and the abaxial surface of leaf. Irregular to elongated, sunken scrape lesion of creamish brown colour having maroon margin on the abaxial or adaxial surface of leaf.	0.9-1.7×0.6-1.2 cm	become dry and broken. Later on, lesions dries, tissue become necrotic, brown colour.	Formation of Pycnidia is commonly found
Leaf spot disease (July to August)	<i>Phomopsis</i> sp.	Small and maroon brown to black coloured with maroon margin spots on abaxial surface and tip of leaves which gradually become enlarged, sunken, dark brown in colour.	0.4-0.9×0.4-0.6 cm	Many small black spots are speckled on the centre of the spots.	Formation of Pycnidia is commonly found
Leaf spot disease (January to February)	<i>Polyrostrata indica</i> Prameela and Nita Mathur	The symptoms appear primarily on the abaxial surface of leaf during the winter season. Initially circular to oval water soaked light maroon spots appears which progressively become, sunken, enlarged and turned into light brown in colour	0.6-1.4×0.5-0.9 cm	At the maturity, spots turn into necrotic, dark brown in colour.	Formation of Pycnidia is commonly found
Leaf spot disease (August to September)	<i>Helminthosporium</i> sp. Link.	Water soaked spots which gradually enlarge into ellipsoidal to circular in shape.	0.4-0.9×0.3-0.7 cm	Symptoms of disease are generally noticed in the month of August.	--
Leaf rot disease (July to September)	<i>Pythium aphanidermatum</i> (Edson) Fitzpatrick	Spongy, watery soft patches on leaves. As rotting progressed, patches enlarged rapidly and the epidermis of leaf bulged, caused tissue rot.	--	As rotting progressed and when reached to the collar portion the whole plant die within three to four days.	--
Root rot disease (July to)	<i>Fusarium solani</i> (Mart.) Sacc.	Rotting appears in rainy season in the form of browning	--	The leaves show decline and yellowing colouration and later	Formation of sprodochia is commonly

Table 1 Continued.

Name of Disease (Period of occurrence)	Name of fungal Pathogen	Morphological Characters			
		Disease Spot/rot	Spot size (average)	Severe symptoms	Specialized structure
August)		and decaying of root tips. After decaying, symptoms spread towards the distal portion of root resulted in total rotting of root system and collapsed.		the margin of leaf turned inside due to the dryness of mucilaginous gel.	found
Collar and root rot diseases (January to February)	<i>Penicillium purpurogenum</i> Stoll.	Reddening of the tips, and shrivelling of plant with spongy red patches/spots on the collar region. Started from roots, rot symptoms progress towards the collar portion with appearance of red to dark maroon coloured spots.	--	On severity, green sporulation of fungus appears on the root hairs, which led to browning and decaying of root tips.	--

Fungal isolation and identification

Isolation results exhibited that the fungal diseases of *A. vera* can be categorized into two main categories as spots and rots caused by various fungal pathogens. Total fifteen fungal isolates namely, *Alternaria alternata* (# ITCC- 8184.11), *Cladosporium sphaerospermum* (# ITCC-7801.10), *Colletotrichum gloeosporioides* (# ITCC-7800.10), *Curvularia lunata* (# ITCC-8185.11), *Curvularia ovoidea* (# NFCCI-3053), *Fusarium fusaroides* (# NFCCI-3056), *Fusarium proliferatum* (#NFCCI-3640), *Fusarium solani* (# NFCCI-3052), *Helminthosporium* sp., *Penicillium purpurogenum* (# NFCCI-3055), *Phoma betae* (# ITCC- 8186.11), *Phoma eupyrena*, *Phomopsis* sp. (# ITCC-7802.10), *Polyrostrata indica* (# ITCC-8188.11) and *Pythium aphanidermatum* were isolated from different disease samples of *A. vera*.

Analysis of isolated fungal pathogens for morphological and cultural characteristics showed a great variation in the colony colour, margins, texture and colony reverse colours (Fig. 2). Similarly, deviations in microscopic characters of isolated fungi were also observed (Fig. 3). However, the detailed descriptions of the fungal diseases of *A. vera* viz. name of disease, causal organism, disease symptoms, cultural and microscopic characteristics along with systematic details are displayed in Table 2.

Apart from fungal diseases reported in present study, number of diseases of *A. vera* caused by fungi has also been reported from India. *Aloe vera* has been reported to infect with rust diseases caused by *Uromyces aloes* (Cook) Magn. from Talegaon, Maharashtra (Ajrekar & Tonapy 1923), from Kadur, Maysor (Thirumalachar 1946) and from Madhya Pradesh (Soni et al. 2011); by *Ravenelia aloii* (Dubey & Pandey 2007) and by *Gilmaniella humicola* from Jodhpur, Rajasthan (Sharma & Samota 2007). Leaf spot disease on *Aloe vera* observed as small, circular to oval dark brown necrotic sunken spots was reported to cause by *Alternaria alternata* (Gupta & Masood 2003, Pritam & Kale 2007, Kamalakannan et al. 2008, Sharma & Amrate 2009, Chavan & Korekar 2011) and by *Alternaria brassicae* (Ghosh & Banerjee 2014). Similarly, leaf spot diseases caused by *Nigrospora sphaerica* and *Phoma exigua* (Sharma & Samota 2007) from Sirohi and Udaipur (Rajasthan); *Alternaria tenuissima* and *Fusarium* sp. (Chavan & Korekar 2011) from Osamanabad

(Maharashtra); *Curvularia lunata* (Jat et al. 2014) from Jaipur and by *Phoma sorghina* (Kumar & Mall 2012) were also reported from India. Other diseases like collar and root rot disease of *A. vera* caused by *Sclerotium rolfii* has been reported by from Gwalior, Shivpuri and Morena of Madhya Pradesh (Dubey & Pandey 2009) while root rot disease caused by *Fusarium solani* have been reported from Sirohi and Udaipur of Rajasthan (Sharma & Samota 2007) and by *Aspergillus verocosa* and *Fusarium oxysporum* from Osamanabad of Maharashtra (Chavan & Korekar 2011). Severe leaf rot of *A. vera*, caused by *Pythium aphanidermatum* (Shukla et al. 2009) was reported from Lucknow, Uttar Pradesh.

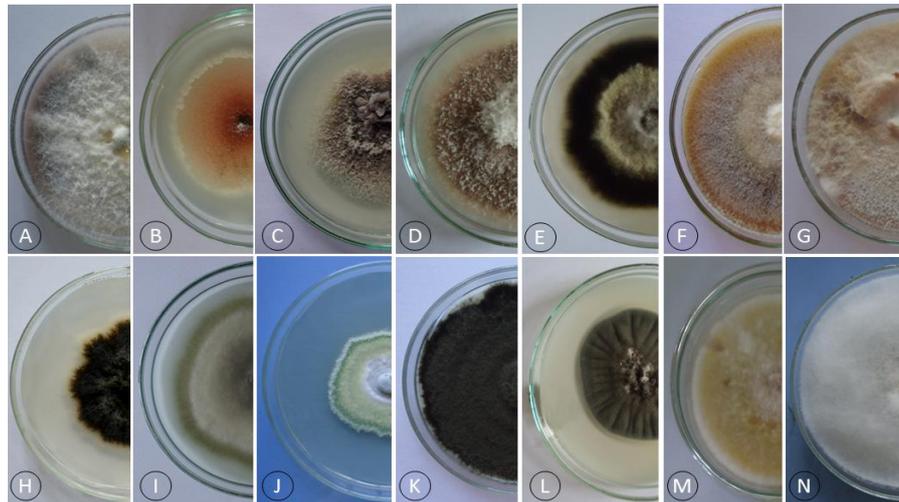


Fig. 2 – Morphological characterization of different fungi isolated from *Aloe vera*. A *Fusarium moniliforme*. B *Phoma betae*. C *Phoma eupyrena*. D *Colletotrichum gloeosporioides*. E *Alternaria alternata*. F *Fusarium solani*. G *Phomopsis* sp. H *Polyrostrata indica*. I *Curvularia lunata*. J *Penicillium purpurogenum*. K *Curvularia ovoidea*. L *Cladosporium sphaerospermum*. M *Fusarium fusaroides*. N *Pythium aphanidermatum*.

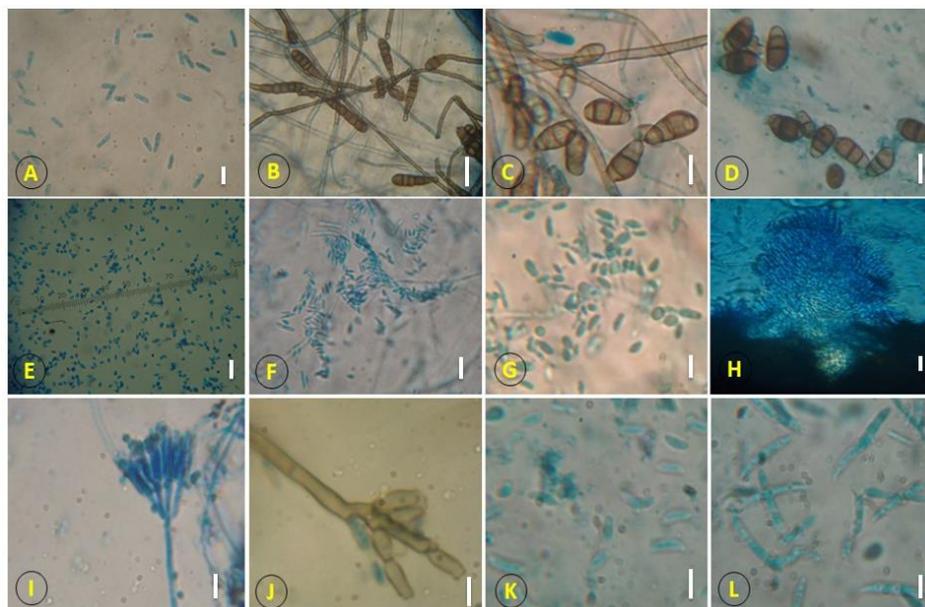


Fig. 3 – Microscopic characters of fungi isolated from *Aloe vera*. A *Colletotrichum gloeosporioides*; B *Alternaria alternata*. C *Curvularia lunata*. D *Curvularia ovoidea*. E *Phoma betae*. F *Fusarium moniliforme*. G *Phoma eupyrena*. H *Polyrostrata indica*. I *Penicillium purpurogenum*. J *Cladosporium sphaerospermum*. K *Fusarium solani*. L *Fusarium fusaroides*. Scale Bar: A-L = 10 μ m.

Table 2 Microscopic characteristics of various fungi causing disease on *Aloe vera*.

Name of Disease	Name of fungal Pathogen	Colony on culture media	Microscopic Characters			
			Mycelium	Conidiophore	Conidia	Any special structure
Leaf spot disease	<i>Colletotrichum gloeosporioides</i> (Penz.) Penz. & Sacc.	Greyish orange with white margins	Greyish orange mycelium with hyaline, septate and branched hyphae	Simple, short and erect	hyaline, one celled, ovoid to oblong and dumbbell shaped (from 12.5-18×3-5 μm)	Black coloured acervuli with dark brown 1-4 septate ranged between 42-150×4-5 μm in size
Leaf spot disease	<i>Alternaria alternata</i> (Fr.) Keissier	dark grey colonies with olive green peripheries	Mycelium hyaline to grey- brownish, multicelled, septate and irregularly branched	Branched, straight and golden brown in colour	Obclavate in shape, 21–53×8-13 μm in size with an average beak length of 7.73 μm, 2-6 transverse and 1-3 longitudinal septa	--
Leaf spot disease	<i>Cladosporium sphaerospermum</i> Penzig.	Velvety, dark olivaceous to greenish black	Mycelium usually greenish blackish having branched, septate, hyphae subhyaline to usually pigmented, smooth, sometimes slightly rough-walled to verruculose	Branched and septate	branched chain with small globose or subglobose terminal conidia (2-5×2-4 μm), apex rounded, base rounded to slightly attenuated, 0-1-septate, sub hyaline, pale olivaceous to olivaceous-brown and thin-walled	--
Leaf spot disease	<i>Curvularia ovoidea</i> (Heroe & N Watan) Munt-Cvetk	Circular, velvety, pale brown to dark brown	Mycelium brown, grey or black, hairy, cottony or velvety; hyphae septate, branched	Pale brown, straight, cylindrical and multi septate	Ovoid, septate, straight or curved, 16-29×10-17 μm, brown with paler end cells	--
Leaf spot disease	<i>Curvularia lunata</i> (Walker) Boedijin	Sub floccose, dark olive-gray, reverse greyish black	Grey to brown mycelium with septate, branched hyphae	Erect, long and unbranched bears conidia more or less in whorl	Curved, brown, three septate and 18-29×10-8 μm	--
Leaf spot disease	<i>Fusarium fusaroides</i> (Frag. & Cif.) Booth	White then soon become pinkish peach	branched at acute and at right angles	Conidiophores scattered over the aerial mycelium, branched bearing macro and microconidia	Microconidia are fusiform to clavate with round apex and pointed base usually one septate measured about 13-15×2-3 μm. Microconidia are curved, fusoid with a narrow round to pointed	Chlamyospores develop usually are lateral and terminal in position

Table 2 Continued.

Name of Disease	Name of fungal Pathogen	Colony on culture media	Microscopic Characters			
			Mycelium	Conidiophore	Conidia	Any special structure
Leaf spot disease	<i>Fusarium moniliforme</i> Sheldon	Reddish-purple pigmentation in culture	The mycelium consists of a mass of branching, thread-like hyaline hyphae	Medium sized, branched bearing macro and microconidia	apex, 4-6 septate, measured 40-55×2.5-3.5 μm An abundance of microconidia, oval and borne in chains measure 7-10×2.5-3.2 μm. Macroconidia appears very slightly sickle shaped to nearly straight, 3-7 septate, measuring 31-58×2.7-3μm	Sporodochia bright in mass and intercalary to terminal chlamydo spores are present
Leaf spot disease	<i>Phoma betae</i> A.B. Frank.	Pinkish brown pigmentation in culture	Brown coloured mycelium consists of septate, hyaline to pink and branched hyphae	Thread like seldom and short	Conidia are hyaline, elliptical, ovoid and one celled, ranged between 5-10×3.5-5.0 μm	The pycnidia are globose or slightly lens-shaped, usually unio stiolate, 175×135 μm in size, releasing abundant variable size and shape conidia.
Leaf spot disease	<i>Phoma eupyrena</i> Sacc.	whitish to light pale colour later changed to dark grey	Pale to dark coloured mycelium with branched, septate, hyphae having hyaline to pale colour	Conidiophore short and elongated	Conidia are ellipsoidal, 4.5-7.5×2.5-3.75 μm, with two large guttules	Pycnidia formed are subglobose-conidial or papillate, indistinctly unio stiolate, 100-260 μm in diameter, glabrous and solitary. Dark pigmented intercalary or terminal chlamydo spores, mostly 4-5 μm long (or larger), form individually or in chains in the mycelium
Leaf spot disease	<i>Phomopsis</i> sp.	Woolly to cottony, white or whitish, pale to light brown	white and fluffy type of mycelium, which gradually turned into greyish having septate	Conidiophore hyaline, simple or branched	The two types of conidia alpha (α) and Beta (β) conidia are generally observed in this fungus.	Pycnidia with or without beak, brown to black

Table 2 Continued.

Name of Disease	Name of fungal Pathogen	Colony on culture media	Microscopic Characters			
			Mycelium	Conidiophore	Conidia	Any special structure
			and hyaline hyphae		The alpha conidia are hyaline, fusiform to ovate, straight, aseptate and frequently biguttulate, with average size 2.5-3.7×2-2.5 µm. The beta conidia are filiform, sigmoidal and hyaline, with average size 3.7-4×2.3-3 µm Conidiogenous cells are hyaline and smooth with large globose guttulae. Conidia are hyaline, aseptate, smooth and rod shaped measuring up to 12.5-20×7.5-15 µm in diameter	
Leaf spot disease	<i>Polyrostrata indica</i> Prameela and Nita Mathur	Dark brown with granular appearance	Mycelium of the fungi is thin, hyaline which turn into thick walled and roughly septate attached to the pycnidia with long thick immersed or semi immersed hairs	Branched, straight and golden brown in colour		Pycnidia are black having beak through which spores discharged in cirrus form
Leaf spot disease	<i>Helminthosporium</i> sp. Link	Brown to dark green colour with spreaded margin	Mycelium is septate, branched, with hyaline hyphae	Erect, unbranched, septate and geniculate at point below the conidia	Conidia are elongated, cylindrical, obclavate, dark brown in colour and 40-90×15-20 µm in size with four to five vertical septa	
Leaf rot disease	<i>Pythium aphanidermatum</i> (Edson) Fitzpatrick	White and puffy cloud on culture medium	Hyphae are hyaline and aseptate and measure up to 10 µm.	--	Sporangia inflated filamentous, branched, varying in length; zoospores uniform,	Oogonia spherical, terminal, rarely intercalary 22-27 µm in diameter. Antheridia

Table 2 Continued.

Name of Disease	Name of fungal Pathogen	Colony on culture media	Microscopic Characters			
			Mycelium	Conidiophore	Conidia	Any special structure
Root rot disease	<i>Fusarium solani</i> (Mart.) Sacc.	Brownish white to loam yellow	Creamish-white mycelium with septate and hyaline hyphae, 3–8 µm in diameter. They typically branch at acute and at right angles.	Arises from arial mycelium/ hyphae which further branched into thin, elongated monophialides that produce macro & microconidia.	laterally bicillate, 12×7.5 µm in size Macroconidia have three to five septa, twisted spindle form, slightly curved and have a slightly blunted apical end measuring 19-50×2.5-3.0 µm. Microconidia forms in abundance, oval shaped, and formed in false heads on very long monophialides	usually monotonous, intercalary through outer terminal; one or two oogonium, barrel or dome shaped, suborbicular, becoming cylindrical or broadly clavate, 9-11×10-14 µm in size Chlamydo-spores are found to be terminal and intercalary, globose to pear shaped
Collar and root rot diseases	<i>Penicillium purpurogenum</i> Stoll.	Closely floccose, light greyish to yellowish green and finally turn into citron. Orange to deep red colour pigmentation	Mycelium highly branched multinucleated septate, varying from pinkish to yellow and yellow red with very small colorless hyphae.	Conidiophore branched, stipes 70-300 µm long, smooth-walled, hyaline, conspicuously encrusted; penicillibiverticillate. Metulae and phialides 10-14 µm long. Phialides acerose. Conidia ellipsoidal,	Conidia are elliptical to sub-globose, 3.4-3.8×2-2.5 µm, smooth and pale green	as well as the production of red pigments on potato agar

Table 2 Continued.

Name of Disease	Name of fungal Pathogen	Colony on culture media	Microscopic Characters			
			Mycelium	Conidiophore	Conidia	Any special structure
				sometimes subspherical, apiculate, irregularly roughened, 3.0-3.5 x 2.5-3.0 μm		

Conclusions

Aloe vera is a precious medicinal plant whose pharmaceutically important constituents are declined by fungal diseases. It may be concluded from the present findings that *A. vera* is attacked by a number of fungal pathogens producing four types of disease symptoms: leaf spot, leaf rot, collar rot, and root rot. These fungal diseases not only decline the quality and texture of mucilaginous gel but significantly results into its quantitative loss and modifies the concentration of biochemical constituents also. The compiled information in this paper will be useful in selection and application of appropriate management strategies to protect *A. vera* plantation from various fungal diseases.

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