International Journal on Emerging Technologies **10**(3): 296-305(2019)

ISSN No. (Print) : 0975-8364
ISSN No. (Online) : 2249-3255

Occurrence of Fungal Diseases on *Aloe vera* Plants in Gwalior, Madhya Pradesh, India

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(Received 16 June 2019, Revised 29 August 2019 Accepted 03 October 2019)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The survey was conducted to record the disease incidence, severity and frequency of occurrence of fungal pathogens on *Aloe vera* in sixteen nurseries and two botanical gardens of Gwalior during winter and rainy season of 2013 & 2014. The present survey revealed that disease incidence was found significantly higher in winter season as compared to rainy season. Four different fungal diseases namely leaf spot, leaf rot, collar and root rot were found associated with the *A. vera* plants. Amongst all, leaf spot was found as dominant fungal disease with maximum 50.99% and 53.35% incidence in winter season and 32.49% and 31.42% in rainy season during the years 2013 & 2014, respectively. Total fifteen fungal species i.e. *Alternaria alternata*, *Colletotrichum gloeosporioides*, *Cladosporium sphaerospermum*, *Curvularia ovoidea*, *C. lunata*, *Fusarium fusaroides*, *F. proliferatum*, *F. solani*, *Penicillium purpurogenum*, *Phoma eupyrena*, *P. betae*, *Polyrostrata indica*, *Pythium aphanidermatum*, and species of *Helminthosporium* and *Phomopsis* were isolated from different parts of *A. vera*. In winter seasons, *Alternaria alternata* and *Fusarium proliferatum* were recorded as a prominent fungal species causing various diseases in plants. While, *Colletotrichum gloeosporioides* was isolated as a most prevalent fungal species from the leaves of *A. vera* during the rainy seasons. The association of these fungal species may not only diminish the plant growth but, also have the potential to alter the efficacy of phytochemicals which eventually nullify the quality and quantity of gel.

Keywords: *Aloe vera*, Disease, Fungal pathogens, Gwalior, Survey.

I. INTRODUCTION

For centuries, numerous plants have been used for medicinal purposes and acts as key ingredients for dietary supplements. There are about 45,000 plant species found in India and many of them have been reported to have medicinal properties [1]. Indian system of medicine including Ayurveda mainly uses plant based formulations to treat various human ailments as they contain therapeutic characteristics and have minimal side effects. Every plant present on earth possesses numerous medicinal properties. World Health Organization (WHO) estimated that up to 3.5 billion peoples of developing world are still rely on plants or plant based medicines as components of their primary health care.

Aloe vera is a wonderful cactus like plant having about 550 species growing around the world. This plant has enjoyed a long history as an herbal remedy and occupied a key position in herbal industry. Its leaves contain water and more than 200 different biologically active chemical constituents like sugars, proteins, enzymes, anthraquinones, mineral, vitamins, lignin, saponins and salicylic acid.All these compositions have made it a popular plant in various systems of medicines. In ayurvedic formulations, it is used as an appetite-stimulant, purgative, analgesic, emmenogogue, antipyretic and antihelminthic, and its juice further aids the digestion and absorption of nutrients, increase energy production, promotes cardiovascular health and improves liver function [2]. In Siddha, the leaf pulp of *A. vera* is used for treating constipation, enlargement of spleen, zymotic and chengamaari disease [3]. In Indian system of medicine, leaf pulp of this plant exhibited inhibition of AIDS virus by accemannan and inhibition of the prostaglandin synthesis by anthraquinone-type compound [4]. Its gel also has properties like anti-inflammatory, antibacterial, antiviral, antifungal, antioxidant, antidiabetic effects [5-7]. Despite of numerous therapeutic potential, unscientific methods of cultivation along with unfavorable environmental conditions pose threat to these plants. The diseases caused by various plant pathogens also affect the *A. vera* growth and development. *Aloe vera* has been reported to attack by several fungal infections [8-13]. Due to the fungal infection in plant, the quality and quantity of leaf gel get infected and may reduce its effectiveness to be used for herbal and cosmetic industries. Therefore, the aim of the present study was carried out to study in detail the diseases and pathogens infecting *Aloe vera* plants in nurseries and botanical gardens of Gwalior, India.

II. MATERIAL AND METHODS

A. Sample Collection

In the months of winter season (January-February) and rainy season (July-August) of 2013 and 2014, a 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

collection of diseased samples. Infected plant parts i.e. leaves, roots and collar of *A. vera* plant were collected randomly, placed in individually sterile polythene bags and brought to Mycology and Plant Pathology Laboratory at School of Studies in Botany, Jiwaji University, Gwalior.

B. Morphological Examination of Plants

All the collected plant parts were examined morphologically for their color, texture and appearance of symptoms of infection on the plants with the help of magnifying glass. Each part of the infected plant viz. leaves, collar and roots were observed carefully to record the symptoms of the infection, colour & diameter of spots and changes in the morphological characteristics as compared to the healthy plants.

C. Isolation of Associated Fungus from Various Parts of Aloe vera

Isolation of fungus associated with various parts of collected plant samples was carried out by pour plate technique. For this, freshly prepared culture media Potato Dextrose Agar (PDA) was used for the enumeration of fungal species. Infected leaves, collar and roots of *A. vera* were washed thoroughly with running tap water and cut into small pieces with the help of blade. These small pieces (1-2 cm) were surface sterilized with 2% sodium hypochlorite (NaOCl) for 2 min and then washed three-four times in sterile distilled water. Under aseptic conditions surface sterilized pieces (2 pieces per plate) were inoculated to petriplates containing culture media. Petriplates having culture media without plant material served as control. After solidification, plates were incubated at 25±2 ℃ for 5 to 6 days and the growth of fungus was recorded every day. Pure culture of each isolates was prepared by using single spore isolation technique and was maintained on both PDA medium. Pure cultures were stored in refrigerator for identification purposes and further studies.

D. Identification of Isolated Fungi

The fungi growing on culture media were mounted on neat and clean glass slides, stained with lactophenol-cotton blue and examined under compound microscope. Fungal identifications were carried out 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 by [14-20].

E. Data Analysis

The percent disease incidence of each nurseries and botanical gardens located in Gwalior area was calculated by applying the formula given by Ginting and Maryono [21] and frequency of occurrence of isolated fungus was calculated by following formula as described by Abdullah and Al-Mosawi [22]. The formulae in calculating the disease incidence and percent frequency of occurrence are:

$$\text{Disease Incidence (DI)} = \frac{\text{Number of infected/diseased plants}}{\text{Total no. of plants in nursery /gardens}} \times 100$$

Disease severity was classified into following rating scales on the basis of percentage of leaf area covered by infection (infected spot) [23].

Table 1: Rating Description for Infected Area.

Rating Scale	Percent Area of Infection
0	No symptoms
1	0-10% leaf area covered by spots
2	11-25% leaf area covered by spots
3	26-50% leaf area covered by spots
4	51-75% leaf area covered by spots
5	More than 75% leaf area covered by spots

F. Statistical Analysis

The results were expressed as the mean ± standard deviation of the mean (SDM). Raw data were imported to Microsoft Excel program for graphical representation.

III. RESULTS

A. Incidence and severity of Aloe veradiseases

All the sixteen nurseries and two botanical gardens were surveyed to record the disease incidence in *A. vera* for both the seasons i.e. winter and rainy seasons of 2013 and 2014. The survey reports indicated that only single species of Aloe i.e. *Aloe vera* (*Aloe barbadensis*) was growing in all experiment sites. The preliminary results of survey revealed that none of the nursery and botanical garden was free from fungal diseases. It is interesting to notice that disease incidence and severity was found significant higher in winter season as compared to rainy season during both the years. Area wise highest disease incidence was observed in the nurseries of Chetakpuri (60.66±19.52% and 64.63±15.53%) and lowest (48.31±13.63% and 50.46±12.21%) incidence was recorded in Lashkar area in winter season of 2013 and 2014, respectively (Table 1). Similarly, in rainy season of 2013, highest 39.35±6.82% incidence was recorded in City Centre and lowest 33.44±7.69% in Kampoo area whereas, highest incidence 40.59±4.01% (Chetakpuri area) and lowest 35.3±2.15% (Lashkar area) was observed during 2014. Disease severity was found higher in winter season ranging from 11-75% while in rainy season it was 10-50% (Table 2 & 3).

Table 1: Area wise total percent disease incidence in winter and rainy seasons (2013 and 2014).

S. No.	Area	Seasons			
		2013		2014	
		Winter	Rainy	Winter	Rainy
1.	Morar	52.49±5.44	38.89±5.61	57.25±12.91	38.34±4.76
2.	City Centre	55.23±16.41	39.35±6.82	56.86±18.83	39.13±9.20
3.	Chetakpuri	60.66±19.52	36.06±5.24	64.63±15.53	40.59±4.01
4.	Lashkar	48.13±13.63	34.33±7.52	50.46±12.21	35.73±2.15
5.	Kampoo	56.05±11.63	33.44±7.69	53.97±1.45	35.90±5.79
	Total DI	**54.54±4.56****	**36.41±2.65****	**56.59±5.23****	**37.93±2.10****

*= Significant at p≤ 0.05

**= Significant at p≤ 0.01

Table 2: Percent disease incidence in nurseries and botanical gardens during winter Season.

S. No.	Collection Sites	Nurseries/Botanical Gardens	Total Number of Plants		Diseased Plants		Rating Scale		Disease Incidence (%)	
			2013	2014	2013	2014	2013	2014	2013	2014
1.	Morar	Agriculture Nursery	20	17	11	13	3	4	55	76.47
		Yadav Nursery	50	27	26	15	3	3	52	55.55
		Gambhir Nursery	40	56	24	35	3	4	60	62.50
		Jai Maa Ambe Nursery	11	16	5	7	2	3	45.45	43.75
		Royal Nursery	12	25	6	12	2	3	50	48
									52.49±5.44	57.25±12.91
2.	City Centre	Botanical Garden	642	654	234	263	3	3	36.44	40.21
		Charak Udhyan	26	32	21	28	4	4	80.76	87.50
		Kamla Nursery	19	14	10	7	3	3	52.63	50
		Preeti Nursery	23	20	11	9	3	3	47.82	45
		Forest Nursery	41	28	24	17	3	4	58.53	60.71
									55.23±16.41	56.68±18.83
3.	Chetakpuri	Baveja Nursery	16	43	13	34	4	4	81.25	79.06
		Kuldeep Nursery	33	110	14	53	3	4	42.42	48.18
		Ganesh Nursery	12	15	7	10	4	3	58.33	66.66
									60.66±19.52	64.63±15.53
4.	Lashkar	Chaudhary Ratiram Nursery	15	19	9	11	3	3	60	57.89
		Vinay Nursery	31	21	16	12	3	2	51.61	57.14
		Jamuna Bagh Nursery	9	11	3	4	2	2	33.33	36.36
									48.31±13.63	50.46±12.21
5.	Kampoo	Lata Nursery	14	20	9	11	3	2	64.28	55
		Surbhi Nursery	23	17	11	9	2	3	47.82	52.94
									56.05±11.63	53.97±1.45

B. Morphological Examination of Plants

Results of morphological examination of *Aloe vera* plants revealed remarkable changes in diseased plants in terms of color, texture and appearance in comparison to healthy ones. Healthy plants were full-grown, with thick, fleshy, succulent, bright green leaves without any symptoms of infection. Roots were also thick and creamish brown in color. Whereas, diseased plants exhibited reduction in leaf length, leaf width and total number of leaves.

Infected leaves were found light green color, mushy, less fleshy with distorted margins. Generally maroon, black, brown, creamish brown spots, spongy and watery soft patches were recorded on the adaxial surface of leaves. Infected roots were dry, curled, thin and maroon brown color as compared to healthy roots.

C. Fungal Diseases Associated with Aloe vera

A total four types of diseases symptoms namely, leaf spot, leaf rot, collar rot and root rot were found associated with *A. vera* plants. While, leaf spot, root rot and collar rot were recorded during winter and rainy seasons, leaf rot infection was observed only during rainy season. Among the four diseases, maximum incidence was recorded in leaf spots i.e. (50.99% and 53.35%) followed by collar rot (11.93% and 12.51%) and root rot (5.29% and 3.25%), during the winter season of two consecutive years. While, maximum 32.49% and 31.42% leaf spot incidence was recorded in rainy season of 2011 & 2012, incidence of rest of the disease in 2011 was 10.48% (collar rot), 9.57% (leaf rot) and 4.58% (root rot). However, incidence of leaf rot (11.45%), collar rot (10.82%) and root rot (8.41%) was observed in 2012 (Table 4).

Table 3: Percent disease incidence in nurseries and botanical gardens during rainy season.

S. No.	Collection Sites	Nurseries/Botanical Garden	Total Number of Plants		Diseased Plants		Rating Scale		Disease Incidence (%)	
			2013	2014	2013	2014	2013	2014	2013	2014
1.	Morar	Agriculture Nursery	14	18	6	8	2	3	42.85	44.44
		Yadav Nursery	33	29	12	11	2	2	36.36	37.93
		Gambhir Nursery	27	30	11	14	2	2	46.66	40.74
		Jai Maa Ambe Nursery	17	27	6	10	1	2	35.29	37.03
		Royal Nursery	15	19	5	6	1	1	33.33	31.57
									38.89±5.61	38.34±4.76
2.	City Centre	Botanical Garden	620	648	205	221	2	3	33.06	34.10
		Charak Udhyan	22	28	11	15	2	3	50	53.57
		Kamla Nursery	11	20	4	6	1	2	36.36	30
		Preeti Nursery	17	14	6	5	2	1	35.29	35.71
		Forest Nursery	19	26	8	11	2	2	42.10	42.30
									39.35±6.82	39.13±9.20
3.	Chetakpuri	Baveja Nursery	12	23	5	10	3	3	41.66	43.47
		Kuldeep Nursery	16	25	5	9	1	2	31.25	36
		Ganesh Nursery	17	26	6	11	2	3	35.29	42.30
									36.06±5.24	40.59±4.01
4.	Lashkar	Chaudhary Ratiram Nursery	21	16	9	6	3	2	42.85	37.50
		Vinay Nursery	19	22	6	8	2	2	31.57	36.36
		Jamuna Bagh Nursery	7	9	2	3	1	2	28.57	33.33
									34.33±7.52	35.73±2.15
5.	Kampoo	Lata Nursery	18	20	7	8	2	2	38.88	40
		Surbhi Nursery	25	22	7	7	1	2	28	31.81
									33.44±7.69	35.90±5.79

Isolation result exhibited that total fifteen fungal isolates, *Fusarium fusaroides* (Frag. & Cif.) Booth (# NFCCI-3056), *Fusarium proliferatum* (Matsushima) Nirenberg (#NFCCI-3640), *Fusarium solani* (Mart.) Sacc. (# NFCCI-3052); *Curvularia ovoidea* (Heroe &N Watan) Munt- Cvetk. (# NFCCI-3053) and *Curvularia lunata* (Walker) Boedijin (# ITCC-8185.11); *Phomabetae*A.B. Frank (# ITCC- 8186.11) and *P. eupyrena* Sacc.; *Alternaria alternata* (Fr.) Keissl. (# ITCC- 8184.11), *Colletotrichum gloeosporioides* Penz. & Sacc. (# ITCC-7800.10), *Cladosporium sphaerospermum* Penzig (# ITCC-7801.10), *Polyrostrata indica* Prameela & Nita Mathur (# ITCC-8188.11), *Penicillium purpurogenum* Stoll (# NFCCI-3055), *Pythium aphanidermatum* (Edson) Fitzpatrick, and species of *Phomopsis* (# ITCC-7802.10)and *Helminthosporium* Link were isolated from different diseases samples of *A. vera*.

During winter seasons *Alternaria alternata*, *Colletotrichum gloeosporioides*, *Cladosporium sphaerospermum*, *Curvularia ovoidea*, *C. lunata*, *Fusarium fusaroides*, *F. moniliforme*, *Penicillium purpurogenum*, *Phoma betae* and *Polyrostrata indica* were isolated from diseased plants whereas, *Colletotrichum gloeosporioides*, *Curvularia lunata*, *Fusarium solani*, *Helminthosporium* sp., *Penicillium purpurogenum*, *Phomopsis* sp., *Phoma eupyrena* and *Pythium aphanidermatum* were found in rainy season during 2013 and 2014 from different nurseries and botanical gardens.

Table 4: Percent incidence of fungal diseases in nurseries and botanical gardens during winter and rainy seasons.

S. No.	Nurseries/ Botanical Gardens	Disease Incidence (%)															
		Winter Season 2013				Rainy Season 2013				Winter Season 2014				Rainy Season 2014			
		LS	LR	CR	RR	LS	LR	CR	RR	LS	LR	CR	RR	LS	LR	CR	RR
1.	Agriculture Nursery	55	-	-	-	42.85	-	-	-	76.47	-	-	-	44.44	11.11	-	-
2.	Yadav Nursery	40	-	12	-	27.27	-	9.09	-	55.55	-	-	-	37.93	-	-	-
3.	Gambhir Nursery	60	-	-	-	40.74	-	-	-	62.50	-	-	-	36.66	10	-	-
4.	Jai Maa Ambe Nursery	45.45	-	-	-	23.52	11.76	-	-	43.75	-	-	-	29.62	-	-	7.40
5.	Royal Nursery	50	-	-	-	33.33	-	-	-	36	-	12	-	31.57	-	-	-
6.	Botanical Garden	31.93	-	4.51	1.24	23.54	2.74	5	1.76	33.18	-	7.03	1.22	20.37	4.32	6.17	3.85
7.	Charak Udhyan	69.23	-	11.53	-	27.27	9.09	13.63	-	75	-	12.5	-	42.85	10.71	-	-
8.	Kamla Nursery	52.63	-	-	-	36.36	-	-	-	50	-	-	-	30	-	-	-
9.	Preeti Nursery	47.82	-	-	-	35.29	-	-	-	45	-	-	-	21.42	-	14.28	-
10.	Forest Nursery	58.53	-	-	-	42.10	-	-	5.26	60.71	-	-	-	23.07	15.38	-	7.69
11.	Baveja Nursery	62.5	-	18.75	9.37	41.66	-	-	8.33	79.06	-	-	-	34.78	-	-	-
12.	Kuldeep Nursery	42.42	-	-	-	25	12.5	-	3	38.18	-	10	-	28	-	-	12
13.	Ganesh Nursery	58.33	-	-	-	29.41	11.76	-	-	66.66	-	-	-	42.30	-	-	-
14.	Chaudhary Ratiram Nursery	60	-	-	-	42.85	-	-	-	36.84	-	21.05	5.26	31.25	-	12.5	-
15.	Vinay Nursery	38.70	-	12.90	-	26.31	-	10.52	-	57.14	-	-	-	27.27	13.63	-	-
16.	Jamuna Bagh Nursery	33.33	-	-	-	28.57	-	-	-	36.36	-	-	-	22.22	-	-	11.11
17.	Lata Nursery	64.28	-	-	-	38.88	-	-	-	55	-		-	30	15	-	-
18.	Surbhi Nursery	47.82	-	-	-	20	-	12	-	52.94	-	-	-	31.81	-	-	-
	Total Incidence	50.99	-	11.93	5.29	32.49	9.57	10.48	4.58	53.35	-	12.51	3.24	31.42	11.45	10.98	8.41

LS- Leaf Spot; LR- Leaf Rot; CR- Collar Rot; RR- Root Rot

In winter season of 2013, *Alternaria alternata* has highest total frequency of occurrence 30.82±7.80% followed by *Fusarium proliferatum* (26.13±7.64%), *Curvularia ovoidea* (18.23±6.13%), *Fusarium fusaroides* (16.84±8.54%), *Phoma betae* (15.49±6.51%), *Curvularia lunata* (14.47±7.04%), *Polyrostrata indica* (13.72±4.27%), *Penicillium purpurogenum* (12.91±4.42%) and lowest was recorded in *Cladosoprium sphaerospermum* (7.92±1.68%). Whereas in winter of 2014, *Fusarium proliferatum* was observed as the most prevalent fungal species with total frequency 31.16±5.73% followed by *Alternaria alternata* (22.77±3.54%), *Phoma betae* (18.33±3.12%), *Polyrostrata indica* (16.03±3.08%), *Fusarium fusaroides* (15.39±3.47%), *Curvularia lunata* (14.88±5.77%), *Penicillium purpurogenum* (13.20±5.32%), *Curvularia ovoidea* (11.74±2.88%), and lowest frequency was found in *Colletotrichum gloeosporioides* (10.26±0.36%) and *Cladosoprium sphaerospermum* (9.84±0.54%) (Fig. 1&2; Table 5).

Table 5: Area wise percent frequency of fungal species isolated from *Aloe vera* during 2013 and 2014 (Winter Season).

S. No.	Fungi Isolated	(% Frequency)											
		Morar		City Centre		Chetakpuri		Lashkar		Kampoo		Total % Frequency	
		2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
1.	*Alternaria alternata*	30.45	19.37	26.10	23.55	32.48	28.29	22.22	22.67	42.85	20	30.82±7.80	22.77±3.54
2.	*Colletotrichum gloeosporioides*	-	-	-	-	-	-	-	10.52	-	10	-	10.26±0.36
3.	*Cladosporium sphaerospermum*	6	8.92	-	10	9.09	-	-	9.52	8.69	-	7.92±1.68	9.84±0.54
4.	*Curvularia ovoidea*	16.66	14.81	-	11.32	25	11.62	-	9.09	13.04	-	18.23±6.13	11.74±2.88
5.	*Curvularia lunata*	11.66	23.52	10.14	12.58	25	11.66	11.11	-	-	11.76	14.47±7.04	14.88±5.77
6.	*Fusarium fusaroides*	27.27	18.75	8.0	15.62	12.12	11.81	20	-	-	-	16.84±8.54	15.39±3.47
7.	*Fusarium proliferatum*	18.75	37.92	16.99	25.04	33.33	29.76	31.18	36.36	30.43	26.76	26.13±7.64	31.16±5.73
8.	*Penicillium purpurogenum*	12	12	8.02	9.76	18.75	10	12.90	21.05	-	-	12.91±4.42	13.20±5.32
9.	*Phoma betae*	7.50	17.64	20.14	21.42	-	20	12.90	14.28	21.42	-	15.49±6.51	18.33±3.12
10.	*Polyrostrata indica*	18.18	11.70	9.65	17.85	-	13.95	13.33	19.04	-	17.64	13.72±4.27	16.03±3.08

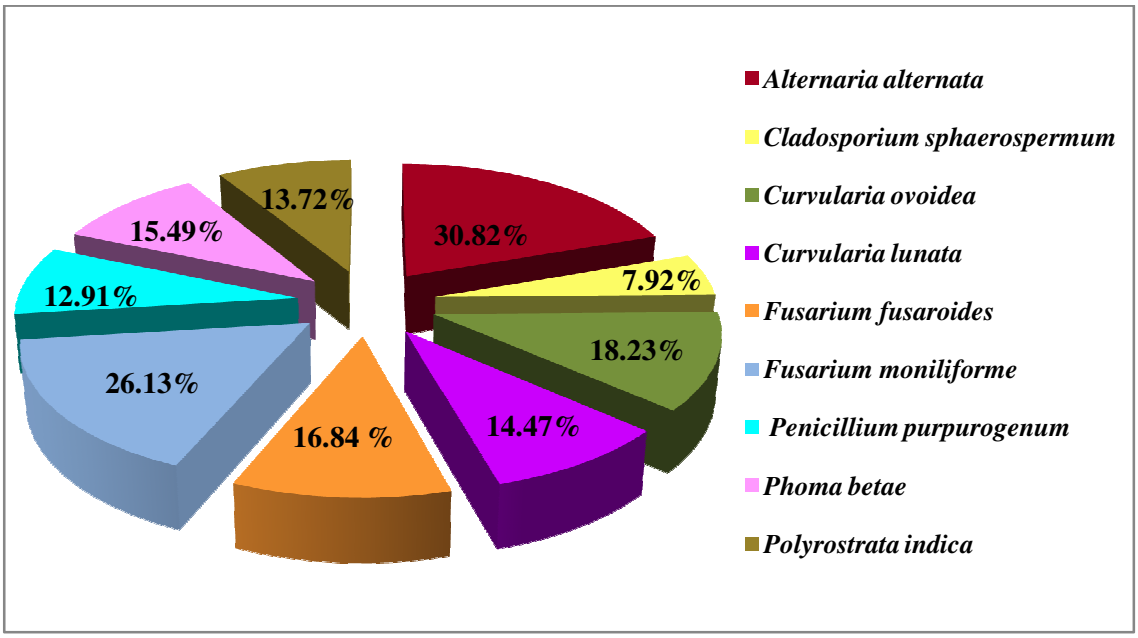

Fig. 1. Total percent frequency of fungal species isolated during 2013 (Winter Season).

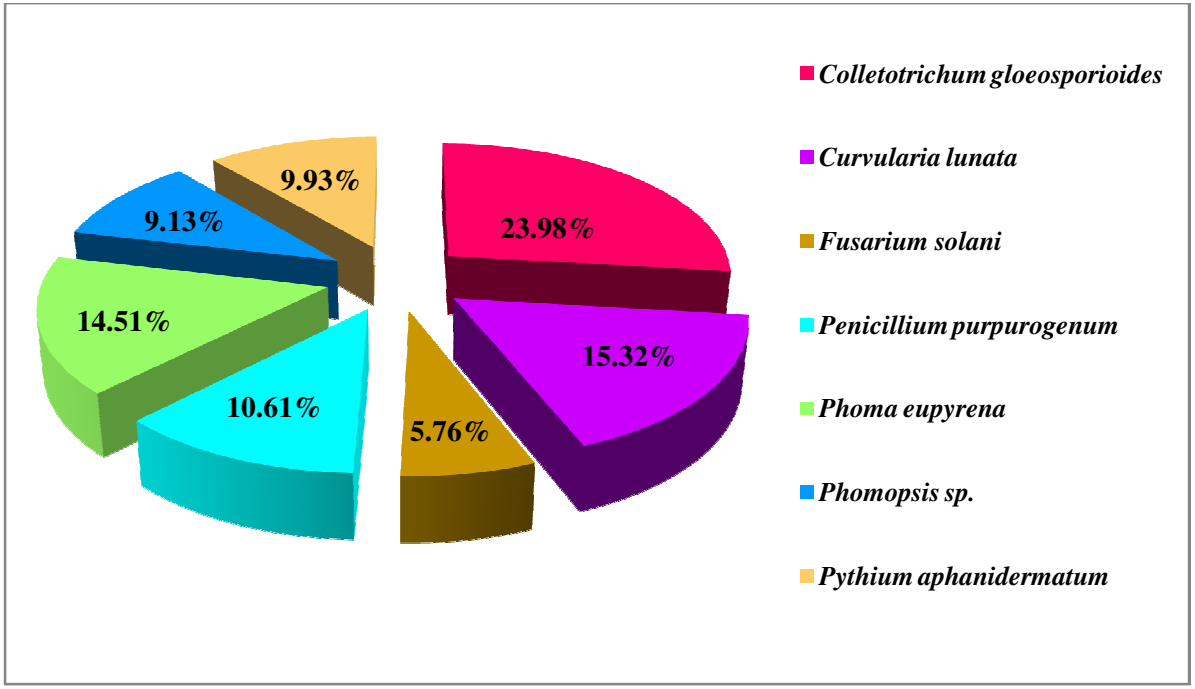

Fig. 2. Total percent frequency of fungal species isolated during 2013 (Rainy Season).

Table 6: Area wise percent frequency of fungal species isolated from *Aloe vera* during 2013 and 2014 (Rainy Season).

S. No.	Fungi Isolated	(% Frequency)											
		Morar		City Centre		Chetakpuri		Lashkar		Kampoo		Total % Frequency	
		2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
1.	*Colletotrichum gloeosporioides*	25.56	27.77	23.97	22.62	25	27.0	24.30	24.74	21.11	30.0	23.98±1.72	26.42±2.83
2.	*Curvularia lunata*	16.36	12.03	13.49	10.26	17.15	-	14.28	18.75	-	18.18	15.32±1.71	14.80±4.29
3.	*Fusarium solani*	-	7.40	3.19	5.46	8.33	8.69	-	11.11	-	-	5.76±3.68	8.16±2.37
4.	*Helminthosporium* sp.	-	10.72	-	-	-	10.34	-	-	-	9.09	-	10.05±0.85
5.	*Penicillium purpurogenum*	-	-	9.31	10.22	-	-	10.52	12.50	12	-	10.61±1.34	11.36±1.61
6.	*Phoma eupyrena*	15.28	13.82	14.37	17.85	11.76	11.53	-	12.50	16.66	-	14.51±2.06	13.92±2.77
7.	*Phomopsis* sp.	8.24	6.89	-	5	-	7.69	10.02	-	-	9.09	9.13±1.25	7.16±1.70
8.	*Pythium aphanidermatum*	11.76	10.55	5.91	10.13	12.13	-	-	13.63	-	15	9.93±3.48	12.32±2.36

During rainy season of 2013 and 2014, *Colletotrichum gloeosporioides* was recorded as the dominant fungal species with highest 23.98±1.72% and 26.42±2.83% frequency of occurrence, respectively. In 2010, total frequency (TF) of other fungal species was: *Curvularia lunata* (15.32±1.71%) followed by *Phoma eupyrena* (14.51±2.06%), *Penicillium purpurogenum* (10.61±1.34%), *Phomopsis* sp. (9.13±1.25%), *Pythiumaphanidermatum* (9.93±3.48%) and *Fusarium solani*(5.76±3.68%). Similarly, total frequency of occurrence of other fungal isolates was: 14.80±4.29% (*Curvularia lunata*), 13.92±2.77% (*Phoma eupyrena*), 12.32±2.36% (*Pythiumaphanidermatum*), 11.36±1.61% (*Penicillium purpurogenum*), 10.05±0.85% (*Helminthosporium* sp.),8.16±2.37% (*Fusarium solani*) and 7.16±1.70% in (*Phomopsis* sp.) during rainy season of 2014 (Fig 3&4; Table 6).

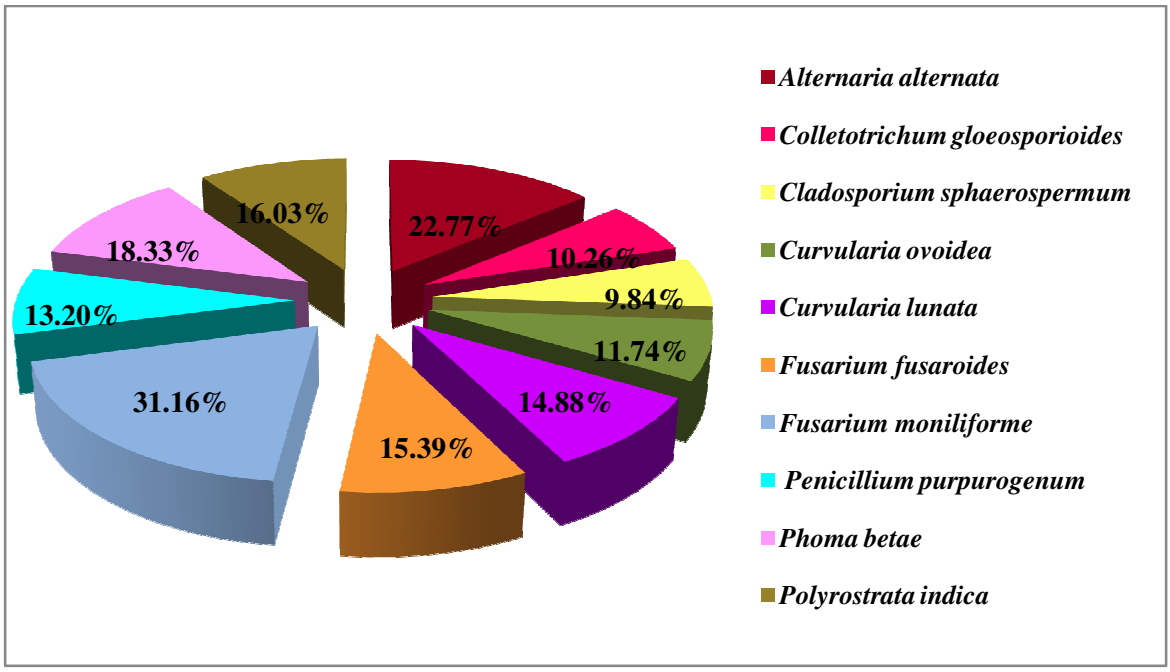

Fig. 3. Total percent frequency of fungal species isolated during 2014 (Winter Season).

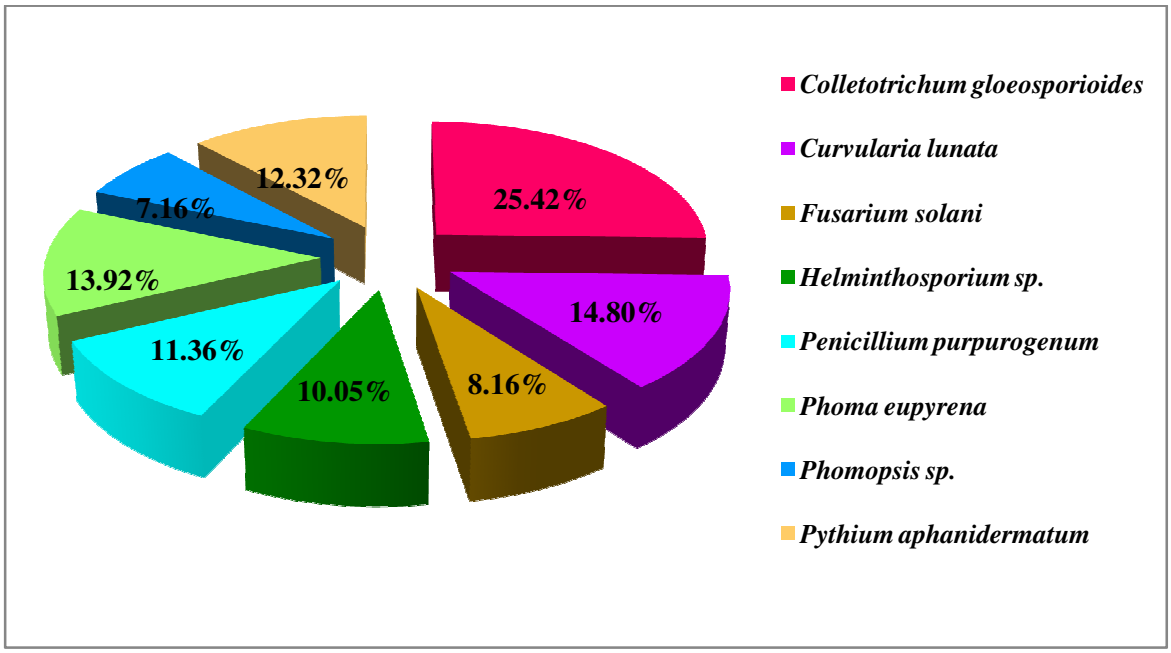

Fig. 4. Total percent frequency of fungal species isolated during 2014 (Rainy Season).

IV. DISCUSSION

Aloe vera has been known as the source of several important products of nutritional and therapeutic value, since antiquity. The leaf gel of *A. vera* is often used as an integral part of cosmetic and pharmaceutical industries due to the presence of many biologically active compounds such as sugars, anthraquinones, lignin and saponins. Some abiotc conditions like temperature, high relative humidity and rainfall plays a significant role in the initiation and development of fungal diseases. The survey reports indicated that only single species of Aloe i.e. *Aloe vera* (*Aloe barbadensis*) was found grown in all experimental sites (nurseries and botanical gardens) and suffered with leaf spot, leaf rot, collar and root rot diseases, due to fungal pathogens. Incidences of leaf spot disease from Rajasthan [24], leaf rot disease from Lucknow [25] and leaf spot and root rot diseases from Osmanabad [26] have also been reported from India. During the study narrow spacing between aloe plantations was observed that may cause increase in humidity and reduction in air circulation which block light between the closer plants and enhance the possibility of incidence of diseases [27]. Variations in the morphological features due to fungal diseases during growth indicate that newly emerging leaves and young plants of *A. vera* were more susceptible to infection. Agrios [28] has also supported this fact that the age of plant is important in disease initiation and young plants are more susceptible for infection. Disease incidence (DI) was found higher in winter season as compared to rainy season during survey. High (64.63%) diseases incidence in winter season may be due to moderate temperature (23-27℃) and high (89-94%) relative humidity which might have favored the initiation of infection and subsequently showing increase in disease incidence. Jarvie [29] reported that variation in climatic conditions from one season to another also influences the occurrence and severity of the disease.

Fifteen fungal species i.e. *Alternaria alternata*, *Colletotrichum gloeosporioides*, *Cladosporium sphaerospermum*, *Curvularia ovoidea*, *C. lunata*, *Fusarium fusaroides*, *F. proliferatum*, *F. solani*, *Penicillium purpurogenum*, *Phoma betae*,*P. eupyrena*, *Polyrostrata indica*, *Pythium aphanidermatum*, *Helminthosporium* sp., and *Phomopsis* sp.,were isolated from different parts of *A. vera*. Previously, *Alternaria alternata* has also been reported as a main leaf spot pathogen of *A. vera* which damage 30-40% crop and also altered the properties of plant [30-33]. Cedeno *et al.,* [34] and Avasthi *et al.,* [35] have isolated *Colletotrichum gloeosporioides* from *A. vera* leaves causing anthracnose disease. Occurrence of *Curvularia lunata* and *Curvularia ovoidea*causing leaf spot disease in *A. vera* has been reported by Jat *et al.,* [36] and Avasthi *et al.,* [37]. *Cladosporium sphaerospermum* and *Polyrostrata indica*both isolated as leaf spot pathogen from *A. vera* has been reported by Avasthi *et al.,* [38, 39].*Pythium aphanidermatum* were isolated as a rot pathogen from leavesof *A. vera* has been reported by Shukla *et al.,* [25]. Root rot disease of *A. vera* caused by *Fusarium solani* has been reported from India [40] and from China [41]. *Phoma eupyrena* and *Phoma betae* were isolated as leaf spot pathogen of *A. vera* [42, 43]. Avasthi *et al.,* [44] has also isolated *Penicillium purpurogenum* from the collar and root portion of *A. vera*. Species of *Phomopsis* isolated from *A. vera* leaves has been reported by Avasthi *et al.,* [45].

V. CONCLUSION

Results of present study showed that *A. vera* plant was found to be suffered with various fungal diseases. Lacking of appropriate growing techniques and weather conditions are the major factors responsible for fungal infection in *A. vera*. The extent of fungal infection was mainly enhanced due to environmental factors such as moderate temperature, high relative humidity and rainfall as well as negligence of plant. Association of fungal pathogens in *A. vera* may retard the plant development but, also changes their useful properties. These fungi can produced toxins which eventually destroy the medicinal properties of *A. vera*. Therefore, the problem of disease incidence and association of fungal pathogens can be resolved by adopting appropriate cultivation practices and control measures, so as to retain the alteration in the efficacy of gel.

REFERENCES

[1]. Kumari, S., Shukla, G., & Rao, A. S. (2011). The present status of medicinal plants-Aspects and prospects. *International Journal of Research in Pharmaceutical and Biomedical Sciences*, *2*(1), 19-22.

[2]. Joseph, B., & Justin, R. S. (2010). Pharmacognostic and phytochemical properties of *Aloe vera* Linn. - An overview. *International Journal of Pharmaceutical Sciences Review and Research*, *2*, 106-110.

[3]. Raamachandran, J. (2001). *Aloe vera*, Herbs of Siddha medicines. http://www.thesiddhamedicine.com/page-18.

[4]. Hassannuzzaman, M., Ahmed, K. U., Khilequzzaman, K. M., Shamsuzzaman, A. M. M., & Nahr, K. (2008). Plant characteristics, growth and leaf yield of *Aloe vera* as affected by organic manure in pot culture. *Australian Journal of Crop Science*, *2*(3), 158-163.

[5]. Choi, S., & Chung, M. H. (2003). A review on the relationship between *Aloe vera* components and their biological effect. *Seminars in Integrative Medicine*, *1*, 53-62.

[6]. Ni, Y., Turner, D., Yates, K. M., & Tizard, I. R. (2004). Isolation and characterization of structural components of *Aloe vera* L. leaf pulp. *International Immunopharmacology*, *4*, 1745-1755.

[7]. Ramachandra, C. T., & Rao, S. P. (2008). Processing of *Aloe vera* gel: A review. *American journal of Agricultural and Biological Science*s, *3*(2), 507-510.

[8]. Roy, A. K., & Bilgrami, K. S. (1975). Leaf spot diseases of some medicinal plants common at Bhagalpur University. *Journal of Nature and Science*, *8*, 8-26.

[9]. Roy, A. K. (1976). Some new records of fungi on medicinal plants. *Current Science*, *45*, 464-465.

[10]. Gupta, D., Padhi, B., & Chowdhry, P. N. (1984). New hosts records of *Cercospora*. *Indian Phytopathology*, *38*(4), 787.

[11]. Harsh, N. S. K., Nath, V., & Jamaluddin. (1990). New forest disease record for India. *Journal of Tropical Forestry*, *6*(2), 175-176.

[12]. Dubey, R., & Pandey, A. K. (2009). A new report on collar and root rot disease of *Aloe vera* caused by *Sclerotium rolfsii*. *Journal of Mycology and Plant Pathology*, *39*(2), 300-301.

[13]. Majumdar, V. L., Bhatnagar, K., Sharma, H., & Verma, O. P. (2007). Three new diseases of *Aloe barbadensis* L. *Journal of Mycology and Plant Pathology*, *37*(1), 124-125.
[14]. Barnett (1969). Illustrated Genera of Imperfect Fungi. Burgess Publishers, USA.
[15]. Barnett, H. L., & Hunter, B. B. (1998). Illustrated Genera of Imperfect Fungi, 4th Edition. 218 pp. APS Press, St. Paul Minnesota, USA.
[16]. Navi, S. S., Bandyopadhyay, R., Hall, A. J., & Bramel-Cox, P.J. (1999). A pictorial guide for the identification of mold fungi on sorghum grain. Information Bulletin no. 59 (In En. Summaries in En, Fr). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.
[17]. Leslie, John, F., & Summerell, Brett, A. (2006). The *Fusarium* Laboratory Manual. Ames: Blackwell publishing, State Avenue, Ames, Iowa 50014, USA.
[18]. Gilman, J. C., & Joseph, C. (2012). A Manual of Soil Fungi. Daya Books, New Delhi, India.
[19]. Ellis, M. B. (2011). Dematiceous hypomycetes. London, CABI Publishers.
[20]. Seifert, K. A., Kendrick, B., Morgan-Jones, G., & Gams, W. (2011). The Genera of Hyphomycetes. Netherlands, CBS Fungal Biodiversity Centre.
[21]. Ginting, C., & Maryono, T. (2009). Physic nut (*Jatropha curcas* L.) diseases in Lampung province. *Biotropia*, *16*(1), 45-54.
[22]. Abdullah, S. K., & Al-Mosawi, K. A. (2010). Fungi associated with seeds of sunflower (*Helianthus annuus*) cultivars grown in Iraq. *Phytopathologia*, *57*, 11-20.
[23]. Wokocha, R. C. (1990). Integrated control of *Sclerotium rolfsii* infection of tomato in the Nigeria savanna: effect of *Trichoderma viride* and some fungicides. *Crop Protection*, *9*, 231-234.
[24]. Sharma, S. S., & Samota, R. K. (2007). Some new fungal diseases on *A. barbadensis* Miller. *Indian Phytopathology*, *60*(2), 277.
[25]. Shukla, R. S., & Alam, M. (2009). *In vitro* production and isolation of phytotoxin from *Alternaria alternata* causing black leaf spot disease of *A. vera*. www.Cimap.res.in/ANNUALREPORT 2009/12.pdf.
[26]. Chavan, S. P., & Korekar, S. L. (2011). A survey of some medicinal plants for fungal diseases from Osmanabab district of Maharashtra. *Recent Research in Science and Technology, 3*(5), 15-16.
[27]. Ghosh, L., Neela, F. A., Mahal, M. F., Khatun, M. J., & Ali, M. R. (2012). Effect of various factors on the development of leaf spot disease in Mulberry. *Journal of Environmental Science and Natural Resources*, Vol. *5*(1): 205-209.
[28]. Agrios, G. N. (2005). Plant Pathology. Fourth Edition. Acedemic Press, San Diego, London. pp: 155-156.
[29]. Jarvie, A. (2002). The status of dry bean diseases as influenced by cultivar changes. Retrieved 25th September from. http://www.pannar.com/ download/Art1.htm.
[30]. Gupta, S., & Masood, A. (2003). Leaf spot disease of Indian Aloe (*Aloe vera* Linn. Syn. *Aloe barbadensis* Mill.) caused by *Alternaria alternata*. Emerging Trends in Indian Medicinal Plants, Lucknow, 10-12, pp: 15.
[31]. Verma, O. P., Singh, N., & Sharma, P. (2006). Dry rot of leaf - a new symptom caused by *Alternaria alternara* on Indian Aloe. *Journal of Mycology and Plant Pathology*, *36*, 302-303.
[32]. Pandey, M., Trivedi, S., Gurha, S. N., & Tripathi, V. K. (2008). Dry rot and leaf spot of *Aloe barbadensis* caused by *Alternaria alternata*. *Annals of Plant Protection Sciences*, *16*(2), 512-513.
[33]. Bajwa, R., Mukhtar, I., & Mushtaq, S. (2010). New report of *Alternaria alternata* causing leaf spot of *Aloe vera* in Pakistan. *Canadian Journal of Plant Pathology*, *32*(4), 490-492.
[34]. Cedeno, L., Briceno, R. A., & Fermin, G. (2010). Anthracnose on Aloe caused by *Colletotrichum gloeosporioides* at the arid zone of Merida State, Venezuela. *Fitopatologia*, *23*, 30-34.
[35]. Avasthi, S., Gautam, A. K., & Bhadauria, R. (2011). First report of anthracnose disease of *Aloe vera* caused by *Colletotrichum gloeosporioides*. *Journal of Research in Biology, 6,* 408-410.
[36]. Jat, R. N., Jat, R. G., & Nitharwal, M. (2013). Management of Leaf Spot of Indian Aloe (*Aloe barbadensis* Mill.) caused by *Curvularia lunata* (Wakker) Boedijn. *Journal of Plant Science and Research*, *29*(1), 89.
[37]. Avasthi, S., Gautam, A. K., & Bhadauria R. (2015). Occurrence of leaf spot diseases on *Aloe vera* (L.) Burm.f. caused by *Curvularia* species from Madhya Pradesh, India. *Biodiversitas*, *16*, 79-83.
[38]. Avasthi, S., Gautam, A. K., & Bhadauria, R. (2016). First report of *Cladosporiumsphaerospermum* causing leaf spot disease of *Aloevera* in India. *Journal of Crop Protection, 5*, 649-654.
[39]. Avasthi, S., Gautam, A. K., & Bhadauria, R. (2017). First report of leaf spot disease caused by *Polyrostrataindica* on *Aloe vera* from Madhya Pradesh, India. *Suan Sunandha Science and Technology Journal, 4*(1), 14-18.
[40]. Avasthi, S., Gautam, A. K., & Bhadauria, R. (2018). Isolation and Characterization of *Fusarium* species causing leaf spot and root rot diseases on *Aloevera*. *Journal on New Biological Reports*, *7*(1), 1-9.
[41]. Ji, G., Wei, L., He, Y., & Wu, Y. (2007). First report of aloe root and stem rot in China caused by *Fusarium solani*. *Plant Disease*, *91*(6), 768.
[42]. Avasthi, S., Gautam, A. K., & Bhadauria, R. (2017). First report of leaf spot disease caused by *Phoma eupyrena* Sacc. on *Aloe vera* from Madhya Pradesh, India. *Archives of Phytopathology and Plant Protection*, *50,* 62-69.
[43]. Avasthi, S., Gautam, A. K., & Bhadauria, R. (2013). First report of *Phoma betae* on *Aloe vera* in India. Archives of Phytopathology and Plant Protection, *46*, 1508 –1511.
[44]. Avasthi, S., Gautam, A. K., & Bhadauria, R. (2015). First report of *Penicilliumpurpurogenum* causing collar and root rot infection in *Aloe vera*. *Plant Pathology & Quarantine*, *5*(1), 20–24.
[45]. Avasthi, S., Gautam, A. K., & Bhadauria, R. (2016). First report of *Phomopsis* sp. on *Aloe vera* in India. *Plant Pathology & Quarantine*, *6*(2), 176-179.

How to cite this article: Avasthi, S., Gautam, A.K., Vasu, D. and Bhadauria, R. (2019). Occurrence of Fungal Diseases on *Aloe Vera* Plants in Gwalior, Madhya Pradesh, India. *International Journal on Emerging Technologies*, **10**(3): 296–305.