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Epidemiology and management of *Fusarium oxysporum* causing leaf rot disease in *Aloe vera*

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Abstract
Aloe vera (*Aloe barbadensis*) is a perennial, succulent plant belongs to the family Liliaceae. Production of *Aloe vera* is limited due to various diseases. Among them, leaf rot is one of the major limiting factors in *Aloe vera*, which decreases leaf, gel quantity and quality significantlyThe field experiments were conducted during 2015-16 at Experimental farm of NDUA&T, Kumarganj, Faizabad (U.P.) The highest disease severity (86.89%) for leaf rot disease was recorded in the month of July at an average temperature of 28.7^{0}C and 80.3% relative humidity. Under chemical management of leaf rot in *Aloe barbadensis* Propiconazole-25EC @0.25% was found most effective with lowest PDI (35.50%) and maximum PDC (57.68%) as compared to Carbendazim-50% WP@ 0.25% and Mancozeb-75% WP @0.25%. Whereas, among botanicals Garlic @ 5% was most effective having PDI (67.93%) and PDC (19.01%) as compared to Tulsi @ 5% with PDI (70.32) and PDC (16.16%) and Neem@ 5% with PDI (73.83%) and PDC (11.98%).Thus, it can be concluded from the present experimentation that Propiconazole 25 EC @ 0.25% is the best treatment to overcome the Leaf rot disease of *Aloe vera* as a chemical fungicide and among the botanicals Garlic bulb extract @ 5% followed by Tulsi leaf extract at the same concentration revealed lesser disease control as compared to chemical fungicides.

Keywords: Epidemiology, *Aloe barbadensis*, leaf rot, disease severity and correlation

Introduction
Aloe vera (*Aloe barbadensis* Miller) is a perennial, drought resisting succulent plant belong to the family Liliaceae which it's believed to have originated in African continent specifically in Egypt (Daodu 2000) [5]. Aloe leaves are filled with gel which was the important part of the plant and has great medicinal value. The *Aloe vera* contains amino acids, anthraquinones, enzymes, lignin, minerals, mono and polysaccharides, salicylic acid, saponins, sterols and vitamins (Barcroft and Myskja, 2009) [2]. Commercial cultivation of *Aloe vera* in the USA began in the 1920s in Florida (Grindlay and Reynolds 1986).Although *Aloe vera* originated in the warm, dry climates of Africa, the plant is readily adaptable and grows worldwide (Steenkamp and Stewart 2007) [11].

The structural components of leaf portions of the *Aloe vera* plant, the rind was found to compose 20–30% and the pulp 70–80% of the whole leaf weight. On a dry-weight basis, the rind and pulp contain 2.7% and 4.2% lipids, and 6.3% and 7.3% proteins, respectively (Femenia *et al.*, 1999) [6]. The percentages of soluble sugars (11.2% and 16.5%), primarily as glucose, and the percentages of ash (13.5% and 15.4%), in particular calcium, were relatively high in the rind and pulp, respectively. Non-starch polysaccharides and lignin represented the bulk of each leaf fraction and were found to be 62.3% and 57.6% of the dry weight of the rind and pulp, respectively (Boudreau *et al.*, 2013a) [3].

Aloe (*Aloe barbadensis*), an important medicinal plant grown in the state of Tamil Nadu, India has suffered heavy losses due to disease in 2006. The symptoms observed were small, circular to oval dark brown necrotic sunken spots located on the leaf surface, with average diameter of 1.0 mm and reaching 3.0 mm. The pathogen was isolated and identified as *Alternaria alternata* and the pathogenicity was established. The conidiophores were branched, straight, golden brown in colour, measuring 15 mm long and 2-6 mm thick. The conidia were golden brown in colour, produced in long branched chains, obclavate in shape, with short conical flask. The literature indicates that this is the first report of a leaf spot disease of Aloe in India (Kamalakannan *et al.*, 2008) [8]. A great number of species were recorded for the genus *Alternaria* in fecting different crops causing world-wide economic loss.

The disease was very serious and abundant in the area where abundant moisture available. The infection started from the leaves edge and the symptoms appeared on the leaves, and leaves become rotten and dried with dark brown colour symptoms on the leaves.

Materials and Methods

The experiment was conducted at Department of Plant Pathology, College of Agriculture, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.). The field experiment was carried out at Main Experiment Station of Department of Medicinal and Aromatic plants and analytical works were undertaken in laboratory of Department of Medicinal and Aromatic Plants during *Kharif* season in the year of 2016.

Meteorological Data

The experimental site falls under the district Faizabad comes under Eastern region of U. P., which is distributed in three seasons *viz.* rainy, winter and summer. The rainy season occurs from mid June to mid of September. The winter months prevails from November to March with mild to severe cool. The severe cold was recorded in the month of December and occasionally winter rains and frost was also noticed. The summer months occur from April to June. The dry and hot wind waves were also noticed in the months of mid May and June.

Weekly meteorological, data during the course of investigation, were recorded at the Meteorological Observatory of Narendra Deva University of Agriculture and technology, Kumarganj, Faizabad and presented in Table 5.

Experimental Details

Design	-	RBD
Plot size	-	7×2 m^2
Replications	-	3
Treatments	-	7
Row to row distance	-	50 cm
Plant to plant	-	40 cm

Treatments Detail

$T_{1=}$Three foliar sprays with Carbendazim 50 WP @ 0.25%
$T_{2=}$Three foliar sprays with Mancozeb75 WP @ 0.25%
$T_{3=}$Three foliar sprays with Propiconazole 25 EC @ 0.25%
$T_{4=}$Three foliar sprays with Neem leaf extract @ 5%
$T_{5=}$ Three foliar sprays with Garlic bulb extract @ 5%
$T_{6=}$ Three foliar sprays with Tulsi leaf extract @ 5%
$T_{7=}$ Control (Untreated)

Preparation of Botanicals

The leaf and bulb extracts of Neem, Garlic and Ocimum were prepared by cold water extraction method. The samples were washed separately in tap water and finally three changes in distilled water. They were crushed in mortar and pestle by adding distilled water @ 1 ml/g fresh weight. The extracts were clarified by passing through two layers of cheese cloth and finally through What Mann No. 1 filter paper. The filtered extracts were quoted in the study as 100 % extract.

Preparation of Botanical Concentration

The appropriate volume of plant extract was mixed in sterilized distilled water to make the desired concentration (w/v) for experiments. For bioassay, double strength concentrations of botanicals were prepared by dissolving 5 ml of plant extract in 95 ml of sterilized distilled water, respectively to get the final concentrations of 5 per cent.

Observations recorded

Five plants from each plot were randomly selected and tagged. Observations were recorded on percent disease incidence, leaf yield per hectare. Percent disease incidence and per cent disease control was calculated as per formula given by (Kushalappa and Ludwig, 1982) [9].

Disease incidence

The number of infected plants was counted from the total number of plants in a plot. Per cent disease incidence and per cent disease control were calculated by using the following formula:

Per cent disease intensity (PDI)

$$= \frac{\text{Sum of all numerical ratings}}{\text{Total number of leaves examined} \times \text{Highest rating}} \times 100$$

Per cent disease control (PDC)

$$= \frac{\text{\% disease in control} - \text{\% disease treatment}}{\text{\% disease in cotrol}} \times 100$$

Or

$$\text{PDC} = \frac{C-T}{C} \times 100$$

Where, C = Per cent disease incidence in untreated plot
T = Per cent disease plot incidence in treated plot

Yield of *Aloe barbadensis*

Aloe vera yield per plot was recorded by taking the weight of the entire produce harvested from the plot and the data were expressed in q/ha.

$$\text{Yield q/ha} = \frac{\text{Yield per plot}}{\text{Area of the plot}} \times 10{,}000$$

Statistical Analysis

The data was analyzed statistically at the Computer Centre of Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Faizabad, (UP) using Completely Randomized Block Design (RBD). The treatments were compared by the means of critical differences (CD) at 5% level of significance.

$$\sin^{-1}\sqrt{\text{PDI before statistical analysis}}$$

Result and Discussion

The crop suffers from leaf spot, leaf rot and Anthracnose disease and much fungal disease but the leaf rot disease causing heavy loss in yield. The Percent disease intensity (PDI) was recorded at weekly interval starting from the initiation of symptoms up to harvesting of leaves. The percent disease intensity (PDI) was recorded during April to August 2016.

In the month of April the intensity mean have negative correlation (-0.725) with minimum temperature while the maximum temperature was significantly positive (0.193) for disease intensity. Similarly, in month of May the disease intensity significantly positively correlated (0.103) with the minimum temperature but maximum temperature was negatively correlated (-0.287) with disease intensity followed by June month. In the July month disease intensity mean have significantly positive correlation (0.847) and (0.999) with minimum and maximum temperature, respectively Table-2.

The highest disease severity of leaf rot disease was observed in the month of July (86.89%), while the lowest one was observed in the month of April (53.27%) Table- 1. Furthermore Chavan and Korekan (2011) [4] found that *Alternaria alternata* and *Fusarium* spp. caused the leaf spot disease in all three seasons summer winter and rainy season on *Aloe barbadensis* in India which limits the cultivation of *Aloevera* production to reduce the disease the foliar spray of Carbendazim, Mancozeb, Propiconazole, Neem, Garlic, and Tulsi combination with respect to disease intensity, yield q/ha and amount of gel data recorded Table-3, indicate that all treatments were found significant over control during 2016-17.The minimum percent disease incidence were recorded in Propiconazole 25 EC @ 0.25% PDI (35.50) and among the botanicals Garlic bulb extract @ 5% PDI (67.93) shows encouraging results where as Reddy *et al*. (2009) [10] tested antifungal activity of botanical extracts such as *Azadirachta indica, Allium cepa, Allium sativum,* against the growth of pathogenic fungi on leaf spot of (*Morus alba* L.). Bandara *et al*. (1989) [1] tested the crude extract of *Achorus calamus* and *Zingiber zerumbet* rhizomes against the growth and spore formation of pathogenic fungi. The inhibiting activity of extract of Garlic was not at the level of inhibiting activity of Propiconazole against the pathogen *Fusarium oxysporum* thus the presence of this pathogenic fungi effects the production of juice and mucilage.

Table 1: Effect of meteorological data on development of disease on *Aloe barbadensis*

Date of sowing	Month in which data was recorded	Standard week	Rainfall	Temperature ^{0}C		RH %	Diseases Severity
				Max.	Min.		
25th August 2015	April 2016	14	0.00	30.4	20.3	44.0	52.85
		16	0.00	41.4	23.5	43.5	51.45
		17	0.00	41.6	20.5	38.1	55.53
	May 2016	18	12.10	38.9	22.4	44.0	64.86
		19	0.00	38.0	24.2	48.7	62.78
		21	2.40	37.5	24.6	53.3	66.50
	June 2016	23	87.70	38.0	25.5	60.9	80.85
		25	1.20	34.6	27.0	75.2	79.50
		26	0.00	36.8	27.3	68.9	83.45
	July 2016	28	5.00	31.5	27.2	70.7	87.43
		29	114.80	31.3	24.9	86.1	85.80
		30	27.60	31.5	26.0	84.2	87.45
	August 2016	32	21.80	32.7	25.9	82.6	60.85
		33	21.80	32.2	35.9	82.6	65.80
		34	3.20	32.8	26.3	70.9	66.50

Table 2: Correlation co-efficient of disease severity in relation to meteorological data

Month	Rainfall	Temperature^0 C		Relative Humidity	Disease severity
		Min.	Max.		
April 2016	00	-0.7258	0.19356	-0.91272	53.27
May 2016	0.253799	0.103137	-0.2878	0.434252	64.71
June 2016	-0.19145	0.330553	0.489129	-0.27093	81.26
July 2016	-0.97871	0.84765	0.999944	-0.58625	86.89
August 2016	-0.59518	0.4305	-0.25083	-0.59518	64.38

Table 3: Management of *Aloe barbadensis* leaf

Treatments	PDI	Yield (q/ha)	Mucilage %	PDC
T_1- Carbendazim - 50%WP @ (0.25%)	53.3	936	63.50	36.46
T_2- Mancozeb - 75%WP @ (0.25%)	58.47	900	60.80	30.29
T_3- Propiconazole – 25 EC (0.25%)	35.50	1083	66.20	57.68
T_4- Neem (Water leaf extract) @ (5.0%)	73.83	780	57.80	11.98
T_5- Garlic (Water bulb extract) @ (5.0%)	67.93	828	59.10	19.01
T_6- Tulsi (Water leaf extract) @ (5.0%)	70.32	786	58.15	16.16
T_7- Control (Untreated)	83.88	525	51.81	
SEm±	2.97	31.45	0.55	
CD(P=0.05)	9.14	94.68	1.68	
C.V. (%)	8.11	6.53	1.62	

Conclusion

The minimum percent disease intensity was recorded in month of April followed by May and June. The maximum percent disease intensity was noted in month of July. In the month of April the disease intensity mean have negative correlation with minimum temperature while the maximum temperature was significantly positive. Similarly, in month of May the disease intensity was positively correlated with the minimum temperature but maximum temperature was negatively correlated with disease intensity followed by June month. In the July month disease intensity mean have significantly positive correlation with minimum and maximum temperatures, respectively. In all the months of experimentation expect May, the disease intensity was negatively correlated with rain fall and relative humidity (RH) while in the month of May it was significantly positive.

Thus, it can be concluded from the present experimentation that Propiconazole 25 EC @ 0.25% is the best treatment to overcome the Leaf rot disease of Aloe vera as a chemical fungicide and among the botanicals Garlic bulb extract @ 5% followed by Tulsi leaf extract at the same concentration revealed lesser disease control as compared to chemical

fungicides. The medicinal plants now days also used as crude drug for ayurvedic preparations. *Aloe vera* leaves affected by the presence of pathogenic fungi (*Fusarium oxysporum*) can be controlled by using the botanicals instead of chemical fungicides despite more effective just to keep the medicinal and aesthetic value of *Aloe vera* plant.

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