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Inhibitory Effect of Bioagents, Plant Extracts and Fungicides on the *in vitro* Growth of *Asperisporium caricae* (speg.) Maubl causing Papaya Black Spot Disease

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ABSTRACT: Papaya (*Carica papaya* L.) is a tropical fruit having commercial importance because of its nutritive and medicinal value. One of the reason for the low yiled of papaya is due to the infection of *Asperisporium caricae* which causes black spot disease both on leaves and fruits and responsible for both pre and post harvest losses of fruits. As this disease is profoundly affecting the market value of the fruit, it is initially essential to validate an *in vitro* effectiveness of different botanicals and bioagents on the papaya fruit, as they are eco-friendly, cost-effective and sustainable efficient strategy to manage the disease including different chemicals for effective control of disease. Among different bioagents, *Trichoderma asperellum* (67.30%) inhibited highest mycelial growth of the pathogen followed by *T. hamatum* (62.17%), also fungal bioagents showed greater per cent of inhibition in comparison with bacterial bioagents. The plant extract *Allium sativum* (32.36%) was highly effective against *A. caricae* at 15 per cent concentration and was significantly superior over *Prosopis juiflora* (25.20%). Among different contact and systemic fungicides, *A. caricae* was completely (100%) inhibited at highest concentration (2000ppm) by chlorothalonil and even at least concentration (75 ppm) by carbendazim.

Keywords: Bioagents, Black spot disease, fungicides, Papaya, Plant extracts.

INTRODUCTION

Papaya (*Carica papaya* L.) is a very popular and vital table fruit of tropical and subtropical countries grows up to 1,000 m above mean sea level. Papaya belongs to the family *Caricaceae* with a chromosome number of 2n=18, and it is native to Mexico and Central America (Aravind *et al*., 2013).Papaya is a short-lived perennial crop growing up to 30 ft (9.14 m) height. Its hollow, herbaceous stem is usually unbranched. The fruit is not only healthy and delicious, whole plant parts like fruits, pulp,seeds, bark, peel and roots are also known to havea good medicinal property. Hence, papaya has been called as "common man's fruit" (Watson, 1997).

The top papaya producing countries in the world are India, Brazil, Indonesia, Nigeria,

Mexico, Philippines and Thailand. In India, papaya is grown over an area of about 144000 Ha, with annual production of 5951000 MT. Major papaya growing states are Gujarat, Andhra Pradesh, Karnataka, Madhya Pradesh and Tamil Nadu. Karnataka stands third in the papaya production (NHB, 2020-21). In the world, India stands first in the production followed by Brazil and Indonesia.

The low yield of papaya is mainly attributed to the occurrence of several diseases like foot rot, powdery mildew, anthracnose, papaya ringspot, leaf curl and mosaic, brown spot and black spot. Among them, an emerging disease in papaya is black spot disease which is caused by *Asperisporium caricae* and is highly lethal. Leaf spots are visible on both the leaf surfaces as black, circular or sometimes angular of 1–4mm in diameter, with yellow halo margins. On the fruits, the presence of round spots of watery aspect was observed initially, later the lesions became brown and that may attain up to 5mm of diameter. These spots generally were epidermal and didn't reach the pulp of the fruit, causing only a hardening of the skin of the part affected (Ventura, 2008).

The lesions are fully covered with black or grey masses of fungal spores, which are conspicuous on the lower surface of the leaf. Sporulation is hypophyllous ranging from dark blackish brown to black. Stroma well developed, erumpent. Conidiophores are olivaceous brown, geniculate, smooth in dense fascicles with several prominent conidial scars at the tip up to 52 µm long × 6 – 9 µm wide. Conidiogenous cells are polyblastic with thickened and darkened scars. Conidia are solitary, ellipsoidal, pyriform or clavate with 1-3 septation (mature), hyaline to mid pale brown, verrucose, 16–32×5–11 µm (Maublanc, 1913).

The use of plant products has been reported for the control of most destructive plant diseases. The presence of phytochemical compounds such as steroid, tannin, flavonoid, alkaloid, and saponin were reported for antimicrobial activity in plant extracts (Oloumi, 2014; Yogi *et al.*, 2016). Likewise, the utility of biocontrol agents has received great attention in the management of plant diseases over the years. Several researches have reported the successful evaluation and identification of bioagents for the control of plant

diseases (Saravanakumar *et al*., 2007; Manikandan *et al*., 2010; Nagendran *et al*., 2013). The growth promotion, antagonism, lysis and induction of defence enzymes have been reported as mechanism of biological control of plants diseases (Harish *et al*., 2008; Saravanakumar *et al*., 2009; Karthiba *et al.,* 2010). Fungicides are indispensable to global food security and their use is forecasted to intensify. These are used predominantly on fruits and vegetables and contribute to more than 35% of the pesticide market share worldwide (Zubrod *et al*., 2019).

Gabrekiristos and Dagnew (2021) reported that among the emerging diseases of papaya in Ethiopia, black spot disease caused by *A. caricae* is the most lethal by causing disease on photosynthetic and economic plant parts. The fruits are affected on the surface, reducing the fresh-market value. In Ethiopia, *A. caricae* has been observed in most papaya producing areas. However, the severity of the pathogen has not been well profiled. The pathogen was not also characterized, which is the base to device management options. Currently, the use of fungicides and resistant cultivars are the preferred management options. Bacus and Linsangan (2022) developed an application classifying papaya black spot disease using Raspberry Pi as a prototype Android device in order to convenience the farmers, for their fast detection of the disease. This will help to prevent the rotting of fruits due to infection by the pathogen and to take a proper precautionary or control measures. Biratu et al. (2022) reported that black spot disease caused by a fungus *A. caricae* was considered as a minor problem on papaya. However, currently black spot is a very widespread and considered as major disease wherever papaya is grown. Integrated management strategies have been developed in the way that combining various control measures like cultural, biological and chemicals; since single control method alone is not effective and environmentally friendly.

In India, though this disease was observed as early as 1977 in the papaya variety Coorg Honeydew at Chettali village of Karnataka, in Palani hills of Tamil Nadu in Variety Co-1 during colder months (January to March) (Ullasa *et al*., 1978), and in Chittoor village of Andhra Pradesh (Reddi Kumar *et al*., 2015), the disease did not emerge devastatingly thereafter. There is a wide area under papaya cultivation in Karnataka, the productivity levels are low because of black spot infection. Although this crop has been suffering a lot due to black spot disease, limited work has been done on this aspect in Karnataka and less information is available on some vital aspects of the disease such as susceptible growth stage of the crop for black spot infection. The effect of host range and management strategies which are well suited for this particular zone to bring down the disease incidence. Keeping in view the economic importance of the crop and losses caused by black spot disease, present investigations on the aspects of *in vitro* evaluation of bioagents, plant extracts and chemicals against *A. caricae* was undertaken.

MATERIALS AND METHODS

Evaluation of bioagents, plant extracts and fungicides *in vitro* against papaya black spot pathogen

Evaluation of bioagents *in vitro* against papaya black spot pathogen . The efficacy of six bioagents *viz*., *Trichodrema viride*, *T. harzianum*, *T. asperellum*, *T. hamatum, Bacillus* subtilis, *B. megatherium* and *Pseudomonas fluorescens* were evaluated against *A. caricae* for per cent inhibition of radial growth on the PDA medium using dual culture technique. Twenty ml of the sterilized PDA medium was melted, cooled at 45^0C and poured aseptically into sterilized Petri dishes of nine cm diameter. Mycelial discs of five mm diameter was cut from the edge of actively growing ten days old culture of *A. caricae* and mycelial discs (5 mm) of *Trichoderma* spp. were cut from the actively growing culture of the respective species using a sterilized cork borer and were placed on the periphery about one cm from the edge of the Petri dish at the opposite sides. Whereas, in case of bacterial antagonist's evaluation, the bacterium was streaked using the loop. The Petri dish containing PDA medium inoculated with the pathogen alone served as control. All the treatments were triplicated and were incubated at room temperature (28 ± 1°C). After incubation when the growth of the pathogen was completed in the control, the colony diameter (mm)of the pathogen were measured and per cent inhibition over control was calculated by using the formula given by Vincent (1947). The data were analysed statistically.

$$I = \frac{C - T}{C} \times 100$$

Where;
I = Per cent inhibition
C = Radial growth of fungus in control
T = Radial growth of fungus in treatment

Evaluation of plant extracts *in vitro* against papaya black spot pathogen

Preparation of aqueous extract. Fresh plant sample materials were collected, washed in normal tap water and then in sterile distilled water. Hundred grams of fresh sample were chopped and then crushed in a surface sterilized pestle and mortar by adding 100 mL sterile distilled water (1: 1 w/v). The plant extract was filtered through two layers of muslin cloth. Finally, the extract obtained was used as a stock solution. The poisoned food technique was used to study the antifungal mechanism of plant extracts (Nene and Thapliyal 1973). Five, ten and fifteen mL of stock solution were mixed with 95, 90, 85mL of sterilized molten PDA medium respectively so as to get 5,10 and 15 per cent concentration.

Evaluation of fungicides *in vitro* against papaya black spot pathogen. The bio-efficacy of four non-systemic fungicides and five systemic fungicides at different concentrations (Table 2) were tested against *A. caricae* for radial growth inhibition on PDA medium using poisoned food technique (Nene and Thapliyal 1973) *in vitro.* Required quantities of each fungicide

were added separately to molten and cooled potato dextrose agar in order to obtain the desired concentration of fungicide i.e., 500, 1000, 1500, 2000 ppm. The PDA medium was thoroughly shaken for uniform mixing of plant extract and fungicides. Twenty mL of PDA medium was poured into sterile Petri plates, mycelial discs of five mm size from periphery of actively growing culture were cut out by sterile cork borer and one such disc was placed at the centre of each plate. Control has been maintained without adding any of the fungicides/ plant extract to the medium. Each treatment was replicated thrice. Such plates were then incubated for 10 days at room temperature and colony diameter(mm) was measured. The efficacy of a plant extracts and fungicides were expressed as per cent inhibition of mycelial growth over control that was calculated by using Vincent's (1947) formula.

Experimental Design and Statistical Analysis. The experiments were conducted in a complete randomized design (CRD) two factorial complete randomized design (FCRD) with three replicates using analysis of variance technique. The data was transformed wherever necessary using ICAR - Central Coastal Agricultural Research Institute, WASP 1.0 software at 1 per cent level of probability.

RESULTS AND DISCUSSION

Evaluation of bioagents, plant extracts and fungicides *in vitro* against papaya black spot pathogen

Evaluation of bioagents *in vitro* against papaya black spot pathogen. Plant diseases need to be controlled in order to maintain the quality and abundance of food. Different approaches may be used to mitigate, prevent or to control the plant diseases. So, in the present-day constraints to control the plant diseases, some management strategies especially those on the use of fungicides, biopesticides are increasingly occupying the minds of people all over the world as they are environmentally friendly and cost effective. Hence, the present investigation was taken in order to identify the best bioagents for effective management of black spot disease of papaya.

Evaluation of biological agents, indicated a significant difference between the fungal and bacterial antagonists on per cent inhibition of mycelia growth of *A. caricae*. The results revealed that all the antagonists significantly reduced the growth of *A. caricae.* Among them *T. asperellum* (67.30%) inhibited highest percentage followed by *T. hamatum* (62.17%), *T. viridae* (62.59%) and *T. harzianum* (58.36%). *Bacillus megaterium* recorded the inhibition percentage of 13.21 per cent against the pathogen, followed by *Bacillus subtilis* (6.60%) and *Pseudomonas fluorescens* (3.22%). When compared to bacterial bioagents, fungal bioagents are effective in inhibiting the pathogen (Table 3).

Besides the chemical control, biological method of control is an effective, environmentally friendly and an alternative approach for disease management. These microbial antagonists act on the pathogen by adapting different mechanisms *viz.,* competition, siderophore production, antibiosis, lysis and hyperparasitism (Vidyasekaran, 1999). So, the use of bioagents is more emphasized in the country and is the best and widely accepted practice. Bioagents also overcome the residual problems which is associated with the use of fungicides for the management of disease. The obtained results were in confirmation with the findings of Taj and Kumar (2013) wherein they reported that *T. viride* was extremely effective in inhibiting the mycelial growth of *A. caricae* (53.33%). Similar results were also reported in *Cercospora* spp. by Siddaramaiah (1986); Satyaprasanth (2004).

Evaluation of plant extracts against papaya black spot pathogen *in vitro.* Generally extensive use of chemicals leads to various environmental problems, human health and their residual content and persistence in the fruits. To sort out these problems' plant extracts were tested in laboratory against *A. caricae.* The results revealed that among the seven plant extracts evaluated against *A. caricae*, highest inhibition (27.15%) was obtained by *A. sativum* and was significantly superior over *L. inermis* (22.05%), *P. julifora* (19.17%), *O. sanctum* (5.66%), *L. camara* (4.66%) and *V. nigunda* (3.33%) whereas *A. indica* (0.80%) was least effective in inhibiting the mycelial growth of the pathogen.

Among the different concentrations tested, significantly highest inhibition of mycelial growth was obtained both at fifteen (13.62%) and ten per cent (13.825) followed by five per cent (8.05%) concentrations of plant extracts. Minimum colony diameter of the fungus by inhibiting the radial growth was noticed in *L. inermis* at 10 per cent concentration (34.96%) followed by *A. sativum* (32.36%), *P. julifora* (25.20%), *O. sanctum* (5.66%), *L. camara* (4.8%) and *V. nigunda* (3.33%) at 15 per cent concentration. Neem (1.2%) was worthless in inhibiting the radial growth of pathogen. However, plant extracts at 15 per cent concentrations was significantly superior over 10 per cent concentration Table 4 Fig. 1.

Contrary to the drawback associated with the use of chemical fungicides, plant extracts are eco-friendly, indigenously available, renewable, non-pollutive, readily biodegradable, in-exhaustible, fairly cost effective and thus it constitutes as a suitable plant protection measure to control the diseases. Hence, detection of plant extracts for its effectual antifungal activity against the pathogen is indispensably required to minimize the use of fungicides (Khadar, 1999; Nagesh, 2000). Reddy *et al*. (2009) wherein they opined that *A. sativum* and *O. sanctum* effectively inhibited the mycelial growth of *Cercospora morricola* whereas, *Azadirachta indica* was least effective. The results were also opposite to the findings of Rajasab and Ravikumar (1996); Mukesh (2018) reported that *A. indica* was effective in inhibiting the mycelial growth of *G. sorghi* and *C. punicae* respectively.

Evaluation of chemicals *in vitro* against papaya black spot pathogen. Evaluation of chemicals *in vitro* provides useful and preliminary information regarding efficacy of fungicides against the pathogen within a

limited period of time and therefore, serves as an agent for field testing. In the present investigation, six systemic and four non-systemic fungicides at four concentrations were tested in the laboratory to find out their efficiency against the pathogen.

The data pertaining to the results of non-systemic fungicides are detailed in Table 5 Fig. 2. The results revealed that, there was significant difference among the fungicides, its concentration tested and their interactions. Among the four non-systemic fungicides evaluated, significantly highest inhibition of mycelial growth of *A. caricae* was obtained by Chlorothalonil (81.81%) followed by Captan (33.90%), Mancozeb (24.20%) and Wettable sulphur (20.05%).

Among the different concentrations tested, highest inhibition was noticed at 2000ppm (58.25%) which was significantly superior over 1500ppm (44.40%), 1000ppm (39.38%) and 500ppm of concentrations. Maximum mycelial growth inhibition (100%) was recorded by Chlorothalonil at 1000, 15000 and 2000ppm. However, Captan (49.94%), Mancozeb (52.67%) and Wettable sulphur (30.37%) was moderately effective at 2000ppm in reducing the colony diameter which in turn inhibiting the *A. caricae*.

Similar observations were made by Mukesh (2018) wherein he reported that Captan successfully inhibited the mycelial growth of *C. punicae.* Pairashi and Jahagirdar (2007) opined that mycelial growth of *C. nicotianae* was inhibited by Carbendazim + Mancozeb.

The results of systemic fungicides evaluated *in vitro* against *A. caricae* are presented in Table 6 and Fig. 3. Among the six systemic fungicides evaluated, Carbendazim and Tebuconazole completely inhibited the growth of *A. carice* at all the four concentrations; while the next best fungicide was 25% Trifloxystrobin+ 50% Tebuconazole showed 100 per cent inhibition at 500, 1000 and 1500 ppm with the mean inhibition percentage of 94.44 per cent and was significantly superior over Hexaconazole (54.94%), Thiophenate methyl (53.21%) and Azoxystrobin (24.93%). With an increase in the concentration of fungicides, significantly increases the inhibition percentage of fungal mycelium. At 1500 ppm highest inhibition of mycelial growth (74.69%) was observed followed by 1000ppm (69.29%), 500ppm (66.95%) and 100 ppm (51.09%) concentrations.

As few systemic fungicides *viz*., Carbendazim, 25% Trifloxystrobin+ 50% Tebuconazole and Tebuconazole were highly effective in completely inhibiting the *A. caricae* at lower concentration (100ppm), it is essential to know the efficacy of those fungicides at lowest concentration hence, the pathogen was again evaluated at 10, 25, 50 and at 75ppm. The data pertaining to the results of systemic fungicides which were tested at lower concentrations are detailed in Table 7 and Fig. 4. Significantly highest inhibition of mycelial growth (100%) was observed in Carbendazim at all concentrations followed by Tebuconazole which accounted more than 80 per cent inhibition over control (86.94%) and 25% Trifloxystrobin+ 50% Tebuconazole (25.18%). Among the different concentrations tested, maximum inhibition was observed at 75ppm (72.05%) followed by 50 (71.48%), 25 (70.76%) and 10ppm (65.68%) concentrations.

These findings have been enumerated by Taj and Kumar (2013) wherein they reported that 25% Trifloxystrobin+ 50% Tebuconazole and Hexaconozole inhibited highest mycelial growth of *A. caricae* and Trifloxystrobin was least effective. Suresh (2013) reported that Hexaconazole was effective in inhibiting the mycelial growth and Azoxystrobin was found to be less effective. Veena (2012) opined Carbendazim inhibited the growth of *C. canescens.* Shreedevasena *et al*. (2022) reported that trifloxystrobin 25% + tebuconazole 50% WG, propiconzole 25% EC and zineb 68% + hexaconazole 4% WP were successful in completely (100%) inhibiting the growth of *A. caricae* at 50ppm concentration.

Table 1: Plant extracts used for *in vitro* evaluation of *A. caricae.*

Sr. No.	Botanical name	Common name	Family	Parts used
1.	*Prosopis juliflora*	Iron swood	*Fabaceae*	Leaves
2.	*Azadirachta indica*	Neem	*Meliaceae*	Leaves
3.	*Lawsoniainermis*	Henna	*Lythraceae*	Leaves
4.	*Ocimum sanctum*	Tulsi	*Lamiaceae*	Leaves
5.	*Allium sativum*	Garlic	*Amaryllidaceae*	Bulbs
6.	*Vitex negunda*	Chinese Chaste tree	*Lamiaceae*	Leaves
7.	*Lantana camara*	Wild sage	*Verbanaceae*	Leaves

Table 2: Fungicides used for *in vitro* evaluation of *A. caricae.*

Sr. No.	Common name	Trade name
	I. Non systemic fungicides	
1.	Wettable sulphur	Sulfex 80% WP
2.	Chlorothalonil	Kavach 75% WP
3	Mancozeb	Indofil M-75% WP
4.	Captan	Captaf 50% WP
	II. Systemic fungicides	
1.	Carbendazim	Bavistin 50% WP
2.	25%Trifloxystrobin+ 50%Tebuconazole	Nativo 75%Wg
3.	Thiophenate methyl	Topsin M 70% WP
4.	Hexaconazole	Contaf 5% EC
5.	Tebuconazole	Folicar 250 EC
6.	Azoxystrobin	Amistar 23% SC

Table 3: Efficacy of different bio-agents in inhibiting mycelial growth of the *A. caricaein vitro.*

Sr. No.	Bioagents	Per cent inhibition over control
1.	*Trichoderma harzianum*	58.36 (49.84)
2.	*Trichoderma viride*	62.59 (52.31)
3.	*Trichoderma asperellum*	71.9 (58.01)
4.	*Pseudomonas fluorescens*	3.22 (10.34)
5.	*Bacillus subtilis*	6.6 (14.96)
6.	*Bacillus megaterium*	13.21 (21.32)
7.	*Trichoderma hamatum*	67.18 (55.07)
8.	Control	0.00 (0.00)
F		**
SE m±		0.18

Values in parenthesis are arcsine transformed values

Table 4: Efficacy of different plant extracts in inhibiting mycelial growth of *A. caricaein vitro.*

Sr. No.	Plant extracts	Per cent Inhibition			
		Concentration (%)			Mean
		5	10	15	
1.	*Prosopis juliflora*	12.22 (20.47)	20.10 (26.65)	25.20 (30.14)	19.17 (25.75)
2.	*Azadirachta indica*	0.5 (4.05)	0.7 (4.80)	1.2 (6.29)	0.80 (5.05)
3.	*Lawsoniainermis*	9.11 (17.57)	34.96 (36.26)	22.1 (28.05)	22.05 (27.29)
4.	*Ocimum sanctum*	4.61 (12.40)	4.62 (12.41)	7.77 (16.19)	5.66 (13.67)
5.	*Allium sativum*	22.03 (28.00)	27.06 (31.36)	32.36 (34.68)	27.15 (31.35)
6.	*Vitex negunda*	3.3 (10.47)	3.3 (10.47)	3.4 (10.63)	3.33 (10.52)
7.	*Lantana camara*	4.6 (12.39)	4.6 (12.39)	4.8 (12.66)	4.66 (12.48)
Mean		8.05 (15.05)	13.62 (19.19)	13.83 (19.81)	11.83 (18.02)
		Botanicals	**Concentrations**		**B × C**
SE m±		0.38	0.59		0.22
CD @ P=0.01		1.17	1.78		0.67

Values in parenthesis are arcsine transformed values

Table 5: Efficacy of different contact fungicides in inhibiting the mycelial growth of *A. caricae in vitro.*

Sr. No.	Fungicides	Per cent Inhibition				
		Concentration (ppm)				Mean
		500	1000	1500	2000	
1	Wettable sulphur	11.08 (19.44)	16.62 (24.06)	22.14 (28.07)	30.37 (33.44)	20.05 (26.25)
2	Mancozeb (Indofil M-75%WP)	8.74 (17.19)	13.25 (21.34)	22.15 (28.07)	52.67 (46.53)	24.20 (28.28)
3	Chlorothalonil (Kavach 75%WP)	27.63 (31.71)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	81.91 (75.42)
4	Captan (Captaf 50% WP)	24.73 (29.82)	27.63 (31.71)	33.30 (25.24)	49.94 (44.96)	33.90 (35.43)
Mean		18.05 (24.54)	39.38 (41.78)	44.40 (45.34)	58.25 (53.73)	40.02 (41.34)
		Fungicides (F)		**Concentrations (C)**		**F × C**
SE m±		0.063		0.063		0.032
CD @ P=0.01		0.063		0.063		0.125

Values in parenthesis are arcsine transformed values

Table 6: Efficacy of different systemic fungicides in inhibiting the mycelial growth of *A. caricae in vitro*

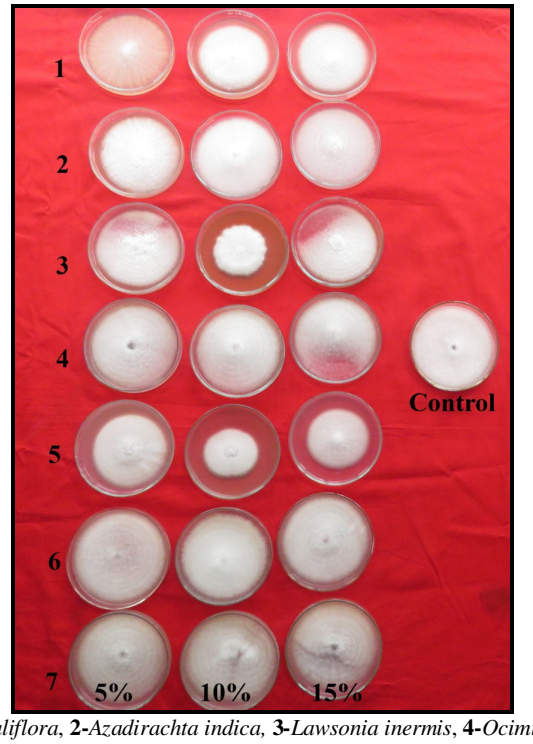
Sr. No.	Fungicides	Per cent Inhibition				
		Concentration (ppm)				
		100	500	1000	1500	Mean
1.	Carbendazim (Bavistin 50% WP)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
2.	25% Trifloxystrobin+ 50% Tebuconazole (Nativo 75%Wg)	77.77 (61.86)	100 (90.00)	100 (90.00)	100 (90.00)	94.44 (82.96)
3.	Thiophenate methyl (Topsin M 70% WP)	5.1 (13.03)	64.06 (53.16)	67.02 (54.95)	76.66 (61.11)	53.21 (45.56)
4.	Hexaconazole (Contaf 5% EC)	51.83 (46.05)	51.66 (45.95)	57.03 (49.04)	59.23 (50.31)	54.94 (47.84)
5.	Tebuconazole (Folicar 250 EC)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
6.	Azoxystrobin (Amistar 23% SC)	20.72 (27.03)	19.03 (25.86)	22.39 (28.24)	37.56 (37.79)	24.93 (29.74)
Mean		51.09 (54.67)	66.95 (65.83)	69.29 (67.03)	74.69 (69.87)	24.93 (64.35)
		Fungicides (F)		**Concentrations (C)**		**F × C**
SE m±		0.762		0.933		0.380
CD @ P=0.01		0.724		0.591		1.447

Values in parenthesis are arcsine transformed values

Table 7: Efficacy of different systemic fungicides at lower concentration in inhibiting the mycelial growth of *A. Caricae.*

Sr. No.	Fungicides	Per cent Inhibition				
		Concentration (ppm)				
		10	25	50	75	Mean
1.	Tebuconazole (Folicar 250 EC)	81.77 (64.72)	87.81 (69.56)	88.99 (70.62)	89.20 (70.81)	86.94 (68.93)
2.	25% Trifloxystrobin+ 50% Tebuconazole (Nativo 75%Wg)	15.26 (22.99)	24.47 (29.65)	25.44 (30.29)	26.94 (31.26)	23.03 (28.55)
3.	Carbendazim (Bavistin 50% WP)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
Mean		65.68 (59.23)	70.76 (63.07)	71.48 (63.63)	72.05 (64.02)	69.99 (62.49)
		Fungicides (F)		**Concentrations (C)**		**F × C**
SE m±		0.44		0.31		0.22
CD @ P=0.01		0.13		0.16		0.27

Values in parenthesis are arcsine transformed value

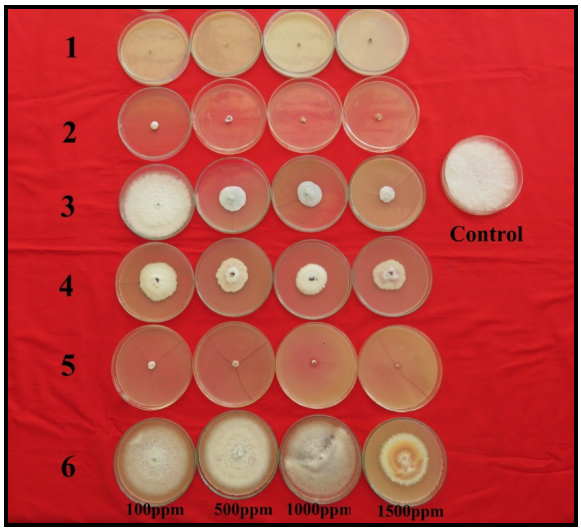


1-*Prosopis juliflora*, **2**-*Azadirachta indica*, **3**-*Lawsonia inermis*, **4**-*Ocimum sanctum*, **5**-*Allium* sativum, **6**-*Vitex negunda*, **7**-*Lantana camara*

Fig. 1. Efficacy of different plant extracts on per cent inhibition of mycelial growth of *A. caricaein vitro.*

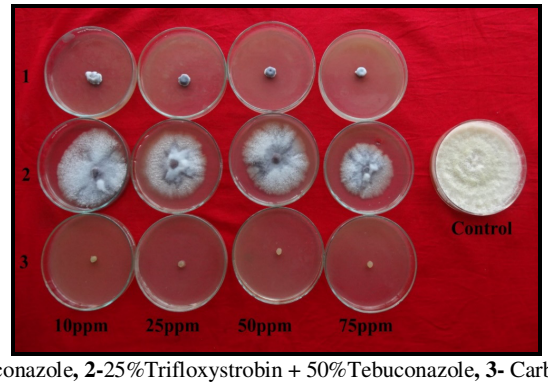
1- Wettable sulphur, **2-** Chlorothalonil, **3-** Mancozeb, **4-**Captan

Fig. 2. Efficacy of different non-systemic fungicides on per cent inhibition of mycelial growth of *A. caricae*.



1- Carbendazim, **2-**Nativo 75%Wg, **3-**Thiophenate methyl, **4-** Hexaconazole, **5-** Tebuconazole**, 6-** Azoxystrobin

Fig. 3. Efficacy of different systemic fungicides on per cent inhibition of mycelial growth of *A. caricae.*



1- Tebuconazole**, 2-**25%Trifloxystrobin + 50%Tebuconazole**, 3-** Carbendazim

Fig. 4. Efficacy of different systemic fungicides at lower concentration on per cent inhibition of mycelial growth of *A. caricae*.

CONCLUSIONS

Plant diseases are an inherent component of an agro eco-system. So, management of these diseases is not only based on the principle of eradication, but also maintaining the damage or loss that occurs below an economic injury level. Due to the absence of resistant cultivars, use of plant extracts, bioagents and chemicals to manage the diseases is an age-old practice. When there is an outbreak of epidemic for any reason perhaps use of fungicides is one of the best choice available. Hence, these fungicides have to be used judiciously

according to the need and type of organism present in an ecosystem. Besides the chemical control, biological method of control is an effective, environmentally friendly and an alternative approach for disease management. Therefore, bioassay of fungicides, bioagents and plant extracts provides a basis for preliminary evaluation against a pathogen within the shortest period of time and therefore, it will be helpful for further evaluation of fungicides, bioagents and plant extracts in field conditions.

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