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Poria hypolateritia, the Red root pathogen of coffee plant is of economic importance as it causes considerable crop loss. The fungicides, Nativo 75 WG (Tebuconazole 50% + Trifloxystrobin 25% w/w), Propiconazole 25% EC (Tilt), Thiofluzamide 25% SC (Pulsor), Tebuconazole 25% EC (Folicur) and Carbendazim 50% WP (Bavistin) were tested under *in-vitro* conditions against*Poria hypolateritia*. Among the five fungicides evaluated, Tebuconazole 50% + Trifloxystrobin 25% WG and Tebuconazole 25% EC recorded 100% inhibition of the fungal mycelial growth at all the concentrations tested over untreated control. Whereas, growth inhibition of the fungus was to an extent of 99.02% in case of Propiconazole 25% EC. But in case of Thiofluzamide 25% SC growth inhibition of the fungus was 79.35%. The fungicide Carbendezim 50% WP could inhibit the fungal growth only up to 6.10%. The results of the experiment indicated that fungicides tebuconazole 50% + Trifloxystrobin 25% WG and Tebuconazole 25% EC which were found effective in arresting the growth of *Poria* fungus under *in vitro* conditions could be further evaluated in the *in-vivo* experiment to develop effective management packages for the control of Red root disease in coffee.

Key words: Coffee, *Poria hypolateritia,* Red root disease, , fungicides, *in vitro* evaluation

INTRODUCTION

Coffee is a commercial crop which is the world's most valuable agricultural exporting commodity and is grown in about 80 countries across four continents. About 50 producing countries export coffee. Like every crop, coffee is also prone to many diseases. In India, though coffee is susceptible to several fungal diseases of economic importance, viral and bacterial diseases are not reported till date. Among the two commercially cultivated species, arabica coffee is more susceptible to the diseases than robusta coffee. Leaf rust, black rot, root diseases, anthracnose, coffee trunk canker, collar rot, stem necrosis and leaf spot and brown-eye-spot are the important diseases which needs regular plant protection measures for improved crop production. Among these diseases leaf rust is a major problem which may lead yield loss upto 70%. Root diseases are also major threat to the coffee plantation if not managed. There are four types of root diseases reported in coffee. They are brown, red, black and Santavery root disease. Of the four, red root disease caused by the fungus *Poria hypolateritia* Berk. is of economic importance (Daivasikamani *et al.* 2016). In general, the occurrences of the root diseases in coffee plantations are sporadic in nature. No regular control measures are adopted, except when occurrences are reported. Red root disease, a common disease of tea was first reported in coffee by Venkata Ram and Muthappa (1975) from Polibetta estate, Coorg where decline of coffee bushes had been reported since 1973.

The coffee red root disease pathogen *P.hypolateritia* belongs to the class: *Basidiomycetes,* order: Polyporales*,* family: Polyporaceae and the genus: *Poria.* The symptoms ex-

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pressed by the affected plants are gradual yellowing of foliage, wilting of branches, defoliation followed by death of plants (Fig.1). Root system of dying or dead coffee plants show red encrustation of the fungal mycelia (fungal rhizomorph)(Fig.2) covered with soil and gravel adhering to it (Fig.3). The affected root appears externally deep red in color when washed in water which is a good diagnostic symptom of the disease (Sudha *et al.* 2015).

The fallen logs of shade tree stumps left over on the estate, low soil pH with less organic content and soil borne nature of the pathogen are some of the factors for development of the disease. From the diseased shade tree stumps, the fungus spreads through the soil and infects the neighboring coffee bushes. If the soil becomes infected with the fungus then it posses a serious problem in the estate (Daivasiamani *et al.* 2014). *P. hypolateritia* has got a wide range of collateral hosts. Most of the shade trees grown in South Indian coffee estates have been observed to be susceptible to *Poria*. Shade trees such as*Grevillea robusta, Albizia molucana, Acacia decurrens, Erythrina lithosperma, Erythrina indica* and *Tephrosia vogelii* are highly susceptible hosts to *P. hypolateritia.* The shade tree *Maesopsis emini* is reported to be resistant to red root disease pathogen (Anon, 2014).

MATERIALS AND METHODS

The present experiment was conducted at Central Coffee Research Institute (CCRI), Balehonnur to assess the effect of newer fungicides on red root disease pathogen of coffee under *in-vitro* conditions. The fungus *Poria hypolateritia* was isolated from the infected coffee root samples obtained from the red root disease affected coffee plantation. Aseptic and axenic culture of the fungus was derived from the original isolation and maintained at Plant Pathology Division of CCRI, Balehonnur. The fungus culture maintained at the Institute was used as the test fungus for the present study (Fig.4). The different fungicides used for the *in vitro* studies are Tebuconazole 50% + trifloxystrobin 25% WG (Nativo 75 WG), Propiconazole 25% EC (Tilt 25 EC), Thiofluzamide 25% SC (Pulsor 25 SC), Tebuconazole 25% EC (Folicur 25 EC) and Carbendazim 50% WP (Bavistin 50 WP). All the above five fungicides were tested individually at six different concentration of 0.001, 0.0025, 0.005, 0.01, 0.025 and 0.05% a.i.

Efficacy of fungicides was evaluated under *in-vitro* conditions by adopting poison food technique as described by Balouiri *et al.* 2016. To obtain the various test concentrations, required quantity of each of the fungicide was dissolved in 1000 ml of sterilized distilled water separately. One ml of fungicide solution was added to 90 mm Petri plates containing 15 ml of potato dextrose agar medium (PDA) in molten state and it was mixed thoroughly by agitating and allowed for solidification. For each concentration of the test fungicide four replications were maintained. The PDA medium without fungicide served as control. The Petri plates containing the fungicide poisoned PDA medium were then inoculated aseptically with 5 mm diameter discs of *Poria hypolateritia* from the outer margin of the actively growing seven days old culture of the fungus grown on PDA. The discs were placed in the center of the Petri plates in an inverted position to have direct contact with poisoned medium. All the Petri plates were incubated at room temperature ($24^0C \pm 2^0C$).

Observation on the growth of the fungus was recorded after six days of incubation. The linear growth of the fungus was measured. Two perpendicular straight lines were drawn on the bottom of the Petri plate. The crossing point coincided with the center of the 5 mm diameter of the inoculated fungal disc was taken as the centre point and the radial growth of the fungus was measured (Miyashira *et al.* 2010). The average of four replicates were taken as diameter of developing colony in all the treatments and the per cent inhibition of mycelia growth was calculated by adopting the formula as suggested by Vincent (1927)

$$I = 100 \frac{(C-T)}{C}$$

where I = per cent inhibition of the fungal mycelia
C = growth in control
T = growth in treatments

Statistical analysis was carried out as per the procedures given by Panse and Sukhatme (1985). Actual data in percentage were converted to angular transformed values, before analysis according to the table given by Walter (1997).

RESULTS AND DISCUSSION

The various fungicides evaluated under *in vitro* conditions, differed in their ability to inhibit the growth of the fungus *Poria hypolateritia*. The per-

centage inhibition of fungal mycelia growth in different concentration of the fungicides tested is presented in Table 1.Among the five fungicides evaluated against *Poria* under *in vitro* conditions, cent per cent mycelial growth inhibition was observed in tebuconazole and combination of Trifloxystrobin + Tebuconazole even at lower concentration (0.001%) whereas mean least (6.10%) mycelial growth inhibition was observed in Carbendazim in all the concentrations. Propiconazole (99.02%) is on par with Tebuconazole (100%) and Trifloxystrobin + Tebuconazole (100%). This indicated that Tebuconazole and Trifloxystrobin + Tebuconazole are effective against *Poria hypolateritia.* Triazoles are sterol inhibiting fungicides which affect cytochrome P-450 enzymes inhibitors of sterols C-14 demethylation whereas strobins act through inhibition of respiration by binding to the Qo center of the cytochrome b and these strobins are very broad and balanced spectrum of activity. They have a favorable toxicological profile rapidly dissipating from soil and surface water chemicals to control the spread of pathogen from infected plants to healthy plants in tea plantations where red root disease is a major problem. Soil application of Carbendazim, Oxycarboxin and Carboxin under field conditions were effective in management of *Poria* in coffee plantations. *In vitro* studies revealed that the fungicide Carbendazim 12% + Mancozeb 63% WP at 0.01% a.i. and triademefon 25 WP at 0.025% a.i. were effective in arresting the growth of the *Poria* (Anon, 2008).

Asha Shivpuri and Gupta (2011) reported that the fungicide Mancozeb at 0.05% was found effective at higher concentration in inhibiting the growth of *Sclerotinia sclerotiorum* which caused stem rot of mustard. Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75WG) was found effective in minimizing the severity of leaf blight disease of maize caused by*Exserohilum turcicum* at the concentration of 87.5+175 g a.i./ha (Anand *et al.* 2013). Triazoles and strobin group of fungicides were found effective against *Colletotrichum*

Table 1: *In vitro* efficacy of different fungicides on *Poria hypolateritia*

Treatment	Inhibition (%)						Treatment Mean
	0.001	0.0025	0.005	0.01	0.025	0.05	
Thiofluzamide 25% SC	58.85 (50.13)*	61.65 (51.76)	83.30 (65.92)	87.35 (69.24)	91.38 (72.96)	93.58 (75.36)	79.35 (64.23)
Tebuconazole 25% EC	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)
Carbendazim 50% WP	3.33 (10.45)	4.16 (10.81)	4.70 (11.39)	6.66 (14.94)	8.05 (16.45)	9.67 (18.04)	6.10 (13.68)
Propiconazole 25% SC	94.13 (76.02)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	99.02 (87.71)
Tebuconazole 50% + Trifloxystrobin 25% WG	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)
Untreated Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Concentration Mean	71.62 (63.34)	73.27 (66.66)	77.99 (70.02)	78.30 (70.04)	79.88 (71.91)	80.65 (72.71)	
	Treatment	Concen-tration	Treatment x Concentration				
S.Em.±	11.65	11.65	28.54				
CD @ 1%	43.21	43.21	105.83				

*Angular transformed values

which are unlikely to cause hazard to non target organisms and have the properties of both protective and curative effect (Singh, 2005). The studies conducted by various researchers indicated that methyl bromide and metham sodium are effective

capsici (Santhoshreddy and Nargund, 2015). Thifluzamide 24% SC at 90 and 110 g a.i./ha was found effective in reducing the severity of paddy sheath blight. The carboxinilide group of fungicides were reported to be effective both as preventive

and curative in action without any symptoms of phytotoxicity (Prasanna Kumar *et al*. 2012). Thakur and Sachin (2011) reported that Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75 WG) was found effective against blister blight of tea caused by *Exobasidium vexans* at the concentration of 125

Fig. 1 : Root disease affected Coffee plant

g/ha. Nanocopper could act as an efficient novel fungicide which may be used for the management of tea plantations (Ponmurugan *et al.* 2016). Soil isolates *Cunninghamella* sp., *Trichoderma, Stylopage, Verticillium, Blastomyces, Ovulariopsis,*

Fig. 2 : Fungal rhizomorph affected root

Periconia and *Ustilago* are identified as potential antagonist organisms against Red root pathogen in tea plantations (Chong and Noor Fazila, 2012).

The present study indicated that new molecules of the fungicides tebuconazole 50% + Trifloxystrobin 25% WG (Nativo 75 WG) and Tebuconazole 25% EC (Folicur 25 EC) are the most effective ones in suppressing the growth of *P. hypolateritia* even at lowest concentration (0.001% a.i.) under *in vitro* conditions. The study also indicated the

Fig. 3 : Coffee root affected by *Poria hypelateritia*

ineffectivity of presently recommended carbendazim fungicide for the control of red root disease. The newer molecules which were found effective in arresting the growth of the pathogen under *in vitro* conditions could be further evaluated

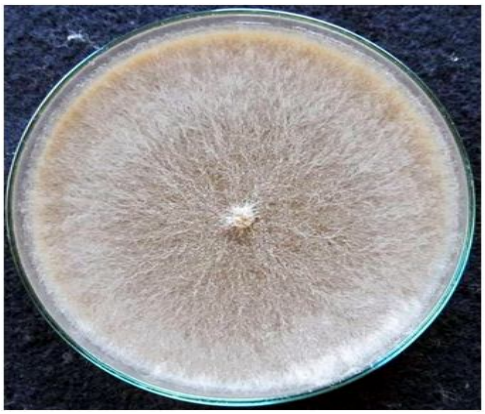

Fig. 4 : Axemic culture of *Poria hypolateritia*

in the *in vivo* experiment to develop effective management packages for the control of Red root disease in coffee plantations. However, as coffee is an export commodity care should be taken for judicious use of fungicides to ensure pesticide residue free final produce and also to maintain the environment, soil health, flora and fauna of coffee plantations whenever plant protection measures are adopted.

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