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Management of diseases plays an important role in healthy upkeep of coffee plantations. Of the coffee diseases prevailing in the field, root diseases are important, occur sporadically in nature and cause death of coffee plants as well as valuable shade trees. Among the four root diseases, brown root disease caused by *Phellinus noxius* is predominantly observed and affects both arabica and robusta cultivars. Presently, brown root disease is managed by adopting integrated disease management practices which also includes drenching of the fungicide carbendazim 50 WP. Of late, it has been observed that the ineffectiveness of the fungicide may be due to the acquired resistance of the fungicide against the pathogen. In addition, most importantly carbendazim is included in draft order of banned pesticides list. Hence, exploring an alternative fungicide is need of the hour. In this context, laboratory bioassays were carried out to find an alternative fungicide for the management of brown root disease of coffee. Eight fungicide molecules with three concentrations *viz.,* 1000, 2000 and 3000 ppm were tested by following poison food technique. Results indicated that, Propiconazole 25% EC, Tebuconazole 25.9% EC, Difenoconazole 25% EC, Propiconazole 13.9% + Difenoconazole 13.9% EC, Trifloxystrobin 25% + Tebuconazole 50% WG and Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L were highly effective and recorded 100 % mycelial inhibition. Whereas, Azoxystrobin 18.2% + Difenoconazole 11.4% SC recorded inhibition of 99.38% followed by azoxystrobin 23% SC (72.10%). Present study has aided us to find alternative fungicides against the pathogen.

Keywords: Brown root disease, coffee, fungicide moleculesand *Phellinus noxius*

INTRODUCTION

Coffee is one of the leading commodities in the international trade next to petroleum both in terms of volume and foreign exchange. One of the major limiting factors in coffee plantation is root diseases. These occur in endemic patches and cause death of the coffee plants as well as valuable shade trees grown in coffee plantations.

Among the four root diseases occurring on coffee, brown root disease caused by *Phellinus noxius* (Corner) G. Cunn.is predominantly observed and affects both arabica and robusta cultivars. Brown root disease is also known as 'stump rot' as it is mostly associated with the rotting stumps of shade trees after timber extraction in the vicinity of the affected coffee plants (Daivasikamani *et al.,* 2014). In India, detailed studies on brown root disease were carried out as early as 1930. Brown root disease spreads to neighbouring plants by means of root contact of infected to healthy plants. This disease affects both arabica and robusta coffee and also many of the valuable shade tree species grown in the coffee plantations. This disease has a wide occurrence in all the coffee growing regions of the country. Corner speculated that the fungus was the cause of brown root rot of rubber trees and tea bushes. It has a wide host range and has been reported on more than 200 plant species representing 59 families (Ann *et al.* 2002). Although most hosts are woody plants, some herbaceous plants are also susceptible to the

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pathogen. *P. noxius* and is said to be widespread among the tropical countries in South East Asia, Africa, Oceania, Central America, and the Caribbean Island.

In India apart from coffee, the disease has also been found on tea, cocoa, nutmeg, oil palm, rubber, citrus, *Tephrosia candida*, *Erythrina* sp., *Grevillea* sp. and a number of jungle tree stumps. The pathogen of brown root disease has reported on majority of the recommended shade trees commonly grown in coffee plantations (Sudha *et al.* 2015). Over a period of time, this disease can cause a considerable amount of yield loss, if the disease management strategies are not adapted at an early stage of infection as the pathogen causes death of coffee plants at their prime yielding age.

Presently, brown root disease is managed by adopting integrated disease management practices which includes drenching of the fungicide carbendazim 50 WP @ 8g/L. Of late, it is observed the ineffectiveness of the fungicide both *in vitro* and *in vivo* may be due to the acquired resistance of the fungicide against the pathogen. In addition, carbendazim is included in draft order of banned pesticides list. In the present paper results of evaluation of new fungicide molecules against *Phellinus noxius* in laboratory were explicated

MATERIALS AND METHODS

Isolation of Phellinus noxius from brown root disease infected coffee plant

The pathogen was isolated from brown root disease infected root sample of robusta coffee (*Coffea canephora* Pierre ex Frohner) plant collected from the coffee estate located at Kattinmane village of Chikkamagaluru District, Karnataka, India.The infected root sample was observed keenly, and brown encrustation of the pathogen was noticed on tap root and secondary roots just below the collar region. Further, root sample was washed under tap water to remove the soil particles adhered on infected tissue, slightly scraped the upper bark with sterilized knife and close observation of the surface of the infected roots revealed the presence of closely interwoven brown strands of mycelia of the pathogen.This infected tissue was subjected to isolation at Plant Pathology laboratory, Central Coffee Research Institute (CCRI), Chikkamagaluru district Karnataka. Brown root disease infected tissue samples were cut into small pieces of 5 × 5 mm^2 size and surface sterilized with 1% sodium hypochlorite solution for 3 min followed by repeated washing in sterilized distilled water. The infected pieces were transferred onto Petri plates containing Potato Dextrose Agar (PDA) medium with the help of sterile forceps and incubated at 25 $\pm 1^0$C for seven days. The pathogen *Phellinus noxius* was purified and maintained in the laboratory for further studies.

Evaluationof fungicide molecules against pathogen Phellinus noxius

Eight fungicide molecules *viz.,* Azoxystrobin 23% SC, Propiconazole 25% EC, Tebuconazole 25.9% EC, Difenoconazole 25% EC, Propiconazole 13.9% + Difenoconazole 13.9% EC, Trifloxystrobin 25% + Tebuconazole 50% WG, Azoxystrobin 18.2% + Difenoconazole 11.4% SC, Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L and Carbendazim 50 WP as standard check were tested in three concentrations *viz.,* 1000, 2000 and 3000 ppm by following poison food technique as described by Nene and Thapliyal (1979). Per cent inhibition of radial growth of mycelia was computed based on colony diameter on control plate adopting the formula as suggested by Vincent (1927)

$$I = C - T / C \times 100$$

where, I = Per cent inhibition, C= Mycelial growth inhibition in control and
T = Mycelial growth inhibition in fungicide treatments

RESULTS AND DISCUSSION

Soil is a reservoir of microbes including plant pathogens, when congenial conditions prevail, plants are under regular attack by the soilborne pathogens. If inoculum levels are high enough and environmental conditions become favourable for infection, susceptible plants will develop disease. Soilborne pathogens are readily spread if infested soil or contaminated water moves into other fields or planting areas through root-to-root contact from infected to healthy. *Phellinus noxius* is one of soil borne fungal pathogen infects most of the plantations like coffee, tea, rubber and other forest trees.

The substantial problems caused by soilborne pathogens in crop production include abridged

crop performance, declined yield, and higher production costs. Management of these soil borne diseases takes longer duration to reduce the pathogen population in the infected soiland thisnecessitates the use of integrated disease management (IDM) strategies to minimise the infection rate. Chemical management is one of the modules in IDM for effective management of brown root disease. The bio-efficacy of new fungicide molecules were evaluated against fungal pathogen *Phellinus noxius* isolated from coffee, results of the experiment was deliberated in the following paragraphs.

Culture morphology of Phellinus noxius isolated from brown root disease infected coffee plant

The brown root disease pathogen *Phellinus noxius* was isolated by plating infected tissues of coffee on PDA plates. Growth characteristics of the colony on PDA plate varied from white initially after 5 to 7 days of isolation/inoculation later from eighth day onwards it turns to light brown to dark brown colour with flat to raised fluffy and smooth regular to a coarse irregular margin.Arthrospores arranged in chain were observed under microscope. Similar cultural morphology of *Phellinus noxius* has been described earlier.

Evaluation of fungicide molecules against pathogen Phellinus noxius

At present brown root disease is managed by adopting integrated disease management practices which includes drenching of the fungicide carbendazim 50 WP @ 8 g/L. The present recommended fungicide might have acquired resistance against the pathogen and of late ineffectiveness of the fungicide has been observed

Table1. Efficacy of fungicide molecules against brown root disease pathogen *Phellinus noxius* (*Fomes noxius*)under *in-vitro conditions*

Treatments		Concentration (ppm)			Mean
		1000	2000	3000	
T_1	Carbendazim 50 WP	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
T_2	Propiconazole 25 EC	100.00 (90.04)	100.00 (90.04)	100.00 (90.04)	100.00
T_3	Tebuconazole 430 SC	100.00 (90.04)	100.00 (90.04)	100.00 (90.04)	100.00
T_4	Difenoconazole 25% EC	100.00 (90.04)	100.00 (90.04)	100.00 (90.04)	100.00
T_5	Azoxystrobin 23% SC	66.30 (54.53)	73.70 (59.17)	76.30 (60.89)	72.10
T_6	Propiconazole 13.9% + difen oconazole 13.9% EC	100.00 (90.04)	100.00 (90.04)	100.00 (90.04)	100.00
T_7	Azoxystrobin 18.2% + difenoconazole 11.4% SC	98.15 (82.21)	100.00 (90.04)	100.00 (90.04)	99.38
T_8	Trifloxystrobin 25% + tebuconazole 50% WG	100.00 (90.04)	100.00 (90.04)	100.00 (90.04)	100.00
T_9	Fluxapyroxad 167 g/L + pyraclostrobin 333 g/L	100.00 (90.04)	100.00 (90.04)	100.00 (90.04)	100.00
T_{10}	Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
					CD @ 1%
Fungicide (F)					2.29
Concentration (C)					1.25
F x C					3.97

*Figures in parentheses are arc sine values.

both *invitro* and *invivo.* As the fungicide carbendazim is included in draft order of banned pesticides list. Therefore, it is felt to explore an alternative fungicide is need of the hour. In this context, laboratory bioassays were carried out to find substitute fungicide for the management of brown root disease.

Results indicated that, Propiconazole 25% EC, Tebuconazole 25.9% EC, Difenoconazole 25% EC, Propiconazole 13.9% + Difenoconazole 13.9% EC, Trifloxystrobin 25% + Tebuconazole 50% WG and Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L were highly effective and recorded 100 % mycelial inhibition in all the concentrations tested. Whereas, Azoxystrobin 18.2% + Difenoconazole 11.4% SC recorded inhibition of 99.38% followed by azoxystrobin 23% SC (72.10%).However, there was luxurious growth of *Phellinus noxius* mycelium carbendazim 50 WP at all the tested concentrations. Details are furnished in Table 1 and Fig 1.

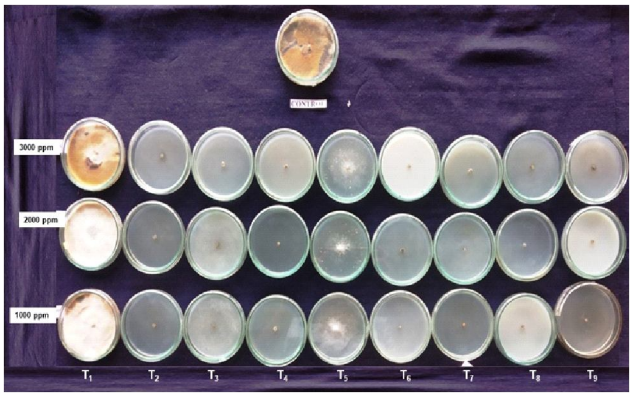

Fig. 1. Mycelial growth of *Phellinus noxius* on PDA media envenomed with different fungicide molecules

Systemic fungicides triadimefon, prochloraz, and mepronil were found to be nonphytotoxic and effective in reducing disease incidence under *in vitro* as well as in glass house conditions.Ranjini *et al.* (2017) revealed that fungicide molecules Tebuconazole 50% + Trifloxystrobin 25% WG and Tebuconazole 25% EC recorded 100% inhibition of the mycelial growth of coffee red root disease fungus *Poria hypolateritia*. Whereas, Propiconazole 25% EC showed inhibition of 99.02% and Carbendezim 50% WP could inhibit the fungal growth only up to 6.10% under *in vitro* conditions.Fungicides hexaconazole and propiconazole at 100 ppm concentration managed the brown root rot disease of tea both *in vitro* and in nursery conditions. Besides root disease management, it was also found that the tea plants treated with these fungicides showed positive response in growth (Morang *et al.*2016).

CONCLUSION

Present study has indicated an ample scope to find analternative fungicidesfor effective management of brown root disease of coffee which can be studied further as large field experiment for healthy upkeep of coffee plantations.

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