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Epidemiology and *in vitro* management of web blight of strawberry caused by *Rhizoctonia solani* (Kuhn.)

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Abstract
An attempt was made to study a leaf blight disease caused by *Rhizoctonia solani,* which is considered as one of the major problem in strawberry cultivation causing considerable damage. Thus an investigation was programmed at Regional Agricultural Research Station, Ambalavayal, Wayanad and conducted to study the epidemiological parameters that lead to the disease and to find a better management strategy against the disease using fungicides and bio-control agents. Fungicides *viz.,* carbendazim 12% + mancozeb 63% (Saaf), carbendazim 50WP (Bavistin), propineb 70WP (Antracol) and Bordeaux mixture inhibited the pathogen by cent per cent and cymoxanil 8% + mancozeb 64% (Curzate M8) at all concentrations recorded a per cent inhibition of 77 to 80. Biocontrol agent *Trichoderma asperellum* completely inhibited the pathogen by overgrowth mechanism and *Pseudomonas fluorescens* exhibited 55.56 per cent inhibition.

Keywords: Fungicides, *P. fluorescens,* Rhizoctonia, strawberry, *T. asperellum*, web blight

Introduction
Strawberry is one of the sweetest fruit crop chosen by many of the people for its unique smell and taste. It has also gained its importance even in India and is widely being cultivated in many temperate as well as tropical regions. Kerala is also emerging as a good producer occupying fourth in production. Though strawberry cultivation is a profitable business, occurrence of various fungal foliage diseases limits its productivity. Among them a severe pathogen confined to the leaves and stalks was reported by Lele and Phatak (1965) [5] from India caused by *Rhizoctonia bataticola*. As no relevant studies have been conducted in Kerala to document this leaf blight disease, a study was programmed and carried out to document the web blight disease caused by *Rhizoctonia* sp and to find measures for managing the pathogen.

Materials and Methods
Assessment of disease severity and correlation with climatic parameters
Three purposive samplings surveys were conducted at Regional Agricultural Research Station, Ambalavayal, Wayanad to collect infected leaf samples of strawberry. Obtained samples were taken for isolation and Per cent disease severity (PDS) was calculated. Correlation with climatic parameters was carried out using PDS and was assessed following a standard score chart of 0-5 scale depicted below

Table 1: Score chart for assessing the severity of foliage diseases

Grade	Description
0	No symptom
1	≤1 per cent leaf area infected
2	>1-10 per cent leaf area infected
3	>10-25 per cent leaf area infected
4	>25-50 per cent leaf area infected
5	>50 per cent leaf area infected

PDS was calculated using the formula

$$\text{Per cent disease severity (PDS)} = \frac{\text{Sum of all numerical ratings}}{\text{Total no. of leaves observed x Maximum disease grade}} \times 100$$

In vitro management of the pathogen

Nine fungicides like copper hydroxide 77WP (Kocide), cymoxanil 8% + mancozeb 64% (Curzate M8), propineb 70WP (Antracol), copper oxychloride 50 WP (Fytolan), carbendazim 12% + mancozeb 63% (Saaf), difenoconazole 25 EC (Score), Bordeaux mixture, carbendazim 50WP (Bavistin) and Potassium phosphonate (Akomin 40) at three different concentrations (recommended, lower and higher) were chosen chosen for evaluation against the pathogen by poison food technique (Zentmeyer, 1955) [18]. Respective concentrations were made into 100 ml molten cooled PDA in conical flasks and plated on Petri dishes. Each treatment was replicated thrice and a control was also maintained. *Trichoderma asperellum* and *Pseudomonas fluorescens* [reference bio control agent from Kerala Agricultural University (KAU)] was used the isolated fungal pathogen by dual culture method suggested by Skidmore and Dickinson (1976) [14]. *T. asperellum* and the fungal pathogen was placed on Petri plate containing PDA 2cm away from the periphery and *P fluorescens* was streaked on both sides the plate with fungal pathogen at the centre. The per cent inhibition of mycelial growth in each treatment was calculated using the formula given by Vincent (1947) [17].

$$\text{Per cent inhibition of growth} = \frac{C-T}{C} \times 100$$

C= Growth of fungus in control (mm)
T= Growth of fungus in treatment (mm)

The antagonistic reaction of *T. asperellum* against the fungal pathogen was assessed by following the method of Purkayastha and Bhattacharya (1982) [9].

- Homogenous -Free intermingling of hyphae
- Overgrowth -Pathogen overgrown by test pathogen
- Cessation of growth -Cessation of growth at line of contact
- Aversion - Development of clear zone of inhibition

Results and Discussion

Disease severity and correlation with climatic factors

Leaf blight disease (LBW-1) caused by *Rhizoctonia solani* was observed as the devastating disease at Ambalavayal causing significant economic losses. Leaf blight was observed on mature leaves of nursery plants where the symptoms initiated as small reddish black spots all over the leaf lamina which later coalesced to develop a purplish discoloration which were observed on veins also (Plate 1). Correlation study revealed that the disease had a negative influence with relative humidity and rainfall, however it was found non-significant with temperature. Maximum severity of 25.2 per cent was recorded during December-January at a temperature of 21.92°C, RH of 74.24 per cent and rainfall of 59.6mm with a subsequent reduction in other seasons. Rainfall and relative humidity showed an upturn reaching upto 466.5 mm and 88.81 per cent in July-August. De Los Santos *et al*. (2003) [3] studied the conditions favourable for web blight of strawberry and revealed that high levels of soil moisture with high relative humidity and temperature is highly congenial for disease development which is contradictory to the present findings. Similarly, the results presented by Bharadwaj *et al*. (2003) [2] indicated a positive correlation with mean temperature, relative humidity and rainfall in case of web blight caused by *Rhizoctonia solani* in strawberry where they noticed that high relative humidity, soil moisture and temperature along with high rainfall during July-August is most conducive for disease spread which was found not comparable with the present results where the least severity of disease was recorded during July – August.

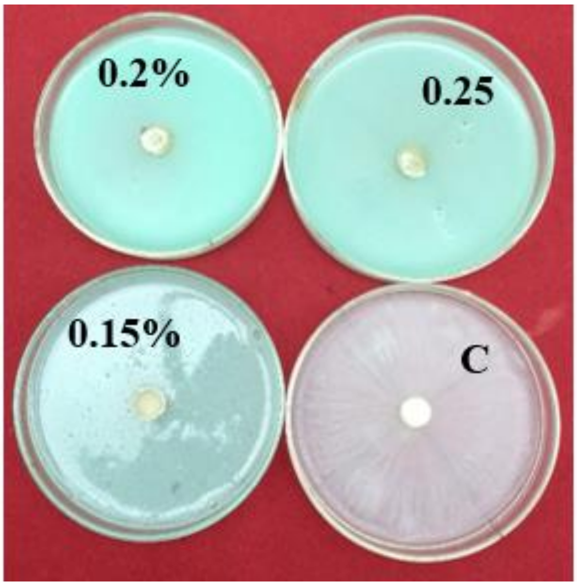
Plate 1: Natural symptom of leaf blight

In vitro evaluation of fungicides and bio-agents

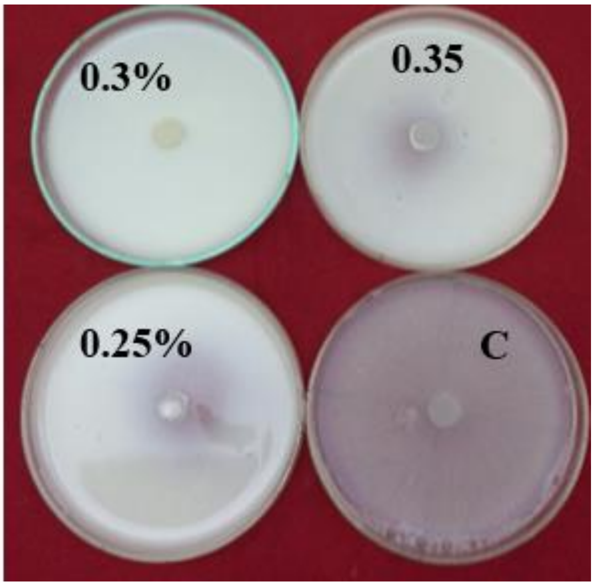
In the case of *Rhizoctonia solani* (LBW-1) causing leaf blight isolated from Wayanad, carbendazim 12% + mancozeb 63% (Saaf), carbendazim 50WP (Bavistin), propineb 70WP (Antracol) and Bordeaux mixture were found cent per cent effective (Plate 2a, b, c and d). Dutta and Kalha (2011) [4] recorded cent per cent inhibition of *Rhizoctonia solani* by Saaf (Carbendazim 12% + Mancozeb 63%) and 98.8 per cent efficacy with carbendazim alone in paddy. Seema *et al*. (2010) [13] also pointed out the efficacy of Bavistin (Carbendazim 50% WP) and Companion (Carbendazim 12% + Mancozeb 63% WP) on *Rhizoctonia solani* affecting tobacco. Cymoxanil 8% + mancozeb 64% (Curzate M8) at 0.2 and 0.25 per cent recorded 78.88 to 80 per cent inhibition of the pathogen (Plate 2e). Copper hydroxide 77WP (Kocide) and difenoconazole 25 EC (Score) (Plate 2f) at higher concentrations were equally effective against the pathogen by 72 to 75 per cent, whereas copper oxychloride 50WP (Fytolan) showed comparatively less inhibition of 25.55 to 36.67 per cent efficacy. Contrary to the above observations, Pawar *et al*. (2015) [8] noticed difenoconazole to be cent per cent effective against *Rhizoctonia solani* in rice. The study supports the findings of Ray and Kumar (2008) [11] where they reported 100 per cent sensitivity of pathogen towards carbendazim and propiconazole and 18.82 per cent inhibition with copper oxychloride against *Rhizoctonia solani* in soyabean. However, Srinivas *et al*. (2013) [15] recorded 70.89 per cent inhibition with copper oxychloride against *Rhizoctonia solani* in rice which is not in agreement with the findings of present study. Parallel to the observations made above, Raj *et al*. (2016) [10] pointed out cent per cent efficiency against *Rhizoctonia solani* with Saaf in chilli. Among the fungicides tested Potassium phosphonate (Akomin-40) showed the least per cent inhibition of the pathogen at all concentrations.

In vitro studies of *T. asperellum* with *Rhizoctonia solani* (LBW-1) recorded cent per cent inhibition of the pathogen, whereas, the bacterial antagonist *Pseudomonas fluorescens* exhibited 55.56 per cent efficacy over control (Plate 3a and b). Amin and Razdan (2010) [1] and Parizi *et al*. (2012) [7] noticed 63.52 and 71.4 per cent control over pathogen with

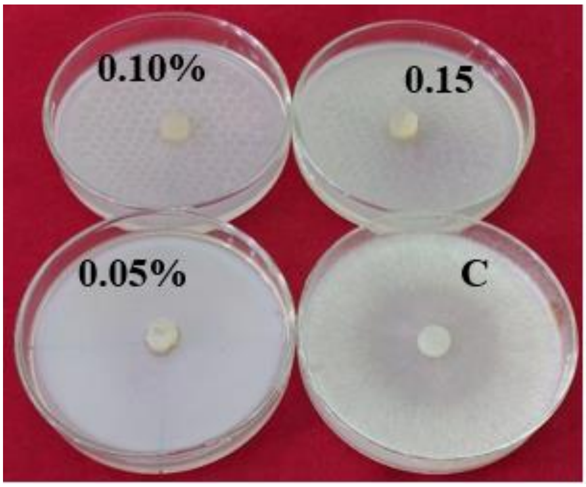
Trichoderma viride against *Rhizoctonia solani* infecting tomato and Rosselle. Seema and Devaki (2012) [12] and Srinivas *et al*. (2013) [15] also proved *Trichoderma viride* to be 67 and 72.65 per cent efficacious against *Rhizoctonia solani* in tobacco and rice. Mezeal (2014) [6] in tomato noted a higher inhibition of 81.30 per cent with *P. fluorescens* against *Rhizoctonia solani.* But, Tapwal *et al*. (2015) [16] reported an inhibition of only 1.45 per cent and 5.10 per cent with *T. viride* and *T. harzianum* against *Rhizoctonia solani*.



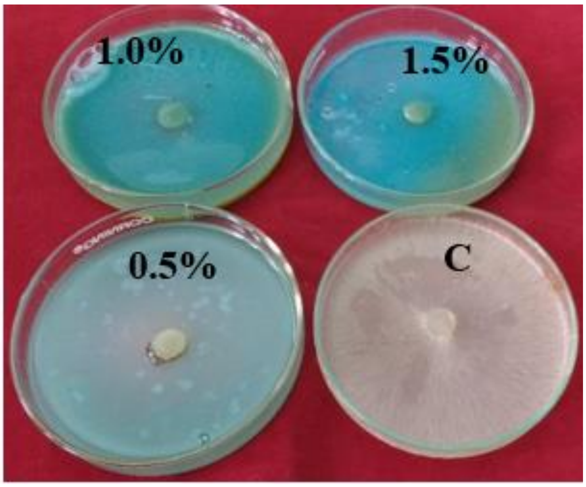
a) Carbendazim 12%+mancozeb 63%



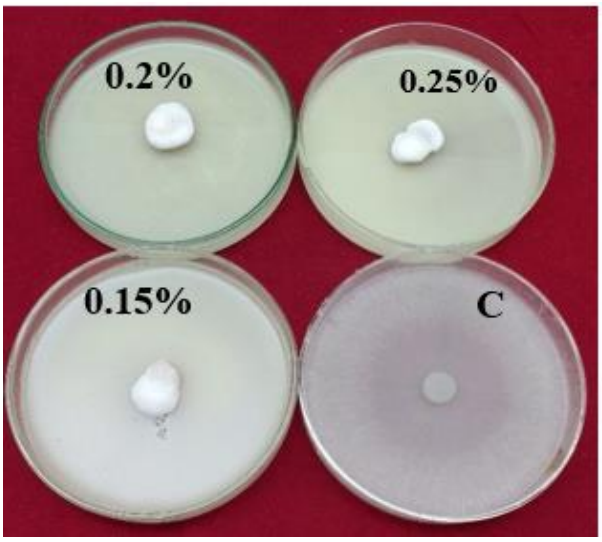
b) Propineb 70WP



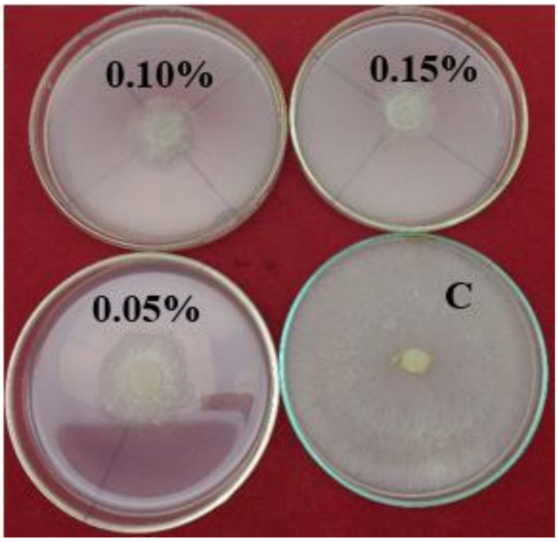
c) Carbendazim 50WP



d) Bordeaux mixture

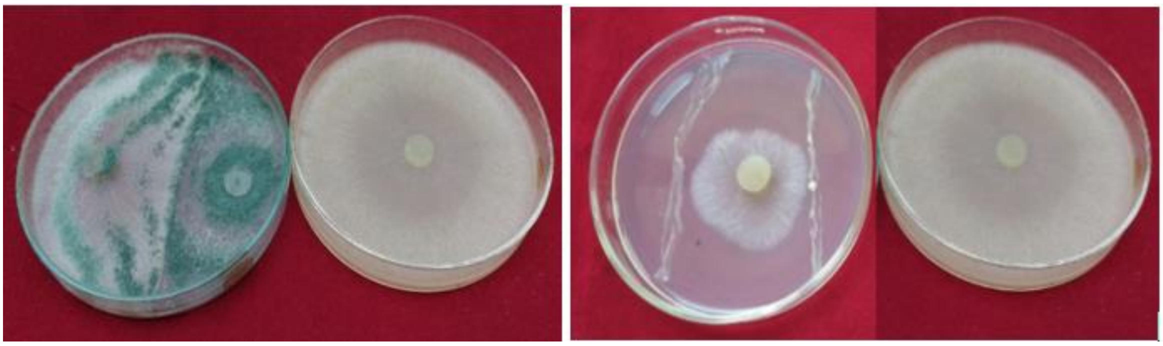


e) Cymoxanil 8%+mancozeb 64%



f) Difenconazole 25EC

Plate 2: *In vitro* evaluation of fungicides against *Rhizoctonia solani*



a) *T. asperellum* b) *P. fluorescens*

Plate 3: *In vitro* evaluation of bioagents against *Rhizoctonia solani*

Table 2: *In vitro* evaluation of fungicides against *Rhizoctonia solani*

Sl. No.	Fungicide	Conc (%)	Per cent inhibition over control
1.	Carbendazim 12% + Mancozeb 63% (Saaf)	0.15	100(10)[a]
		0.20	100(10)[a]
		0.25	100(10)[a]
2.	Cymoxanil 8% + Mancozeb 64% (Curzate M8)	0.15	77.77(8.79)[d]
		0.20	78.88(8.88)[c]
		0.25	80(8.94)[b]
3.	Copper hydroxide 77WP (Kocide)	0.10	65(8.1)[h]
		0.15	69.44(8.38)[g]
		0.20	72(8.52)[f]
4.	Copper oxychloride 50WP (Fytolan)	0.20	25.55(5.12)[l]
		0.25	36.67(5.87)[k]
		0.30	39(6.07)[g]
5.	Propineb 70WP (Antracol)	0.25	100(10)[a]
		0.30	100(10)[a]
		0.35	100(10)[a]
6.	Carbendazim 50WP (Bavistin)	0.05	100(10)[a]
		0.10	100(10)[a]
		0.15	100(10)[a]
7.	Difenoconazole 25EC (score)	0.05	57.77(7.64)[i]
		0.10	72.22(8.56)[f]
		0.15	75(8.66)[e]
8.	Potassium phosphonate (Akomin 40)	0.25	0
		0.30	0
		0.35	0
9.	Bordeaux Mixture	0.50	100(10)[a]
		1.0	100(10)[a]
		1.50	100(10)[a]
	CD (0.05)		0.047

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