International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 481-483

Received: 16-10-2020
Accepted: 24-11-2020

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In-vitro evaluation of fungicides against *Cylindrocladium* spp causing defoliation and die-back in Cashew

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DOI: https://doi.org/10.22271/chemi.2021.v9.i1g.11276

Abstract
Among all the 10 fungicides/ fungicide combinations under study, complete inhibition of the mycelial growth occurred in mancozeb (0.00mm) and metalaxyl in combination with mancozeb. They were followed by zineb plus hexaconazole (12mm), Chlorothalonil (12.33mm), carbendazim (15.67mm), Zineb (17.33mm), Hexaconazole (17.67mm), thiophenate methyl (18.00mm), copper oxy-chloride (26.00mm) and copper hydroxide (27.00mm) respectively. Maximum growth (90.00 mm) was recorded in control.

Keywords: Fungicides, *Cylindrocladium* spp.

Introduction
Anacardium occidentale L. belonging to the family Anacardiaceae is a native to Brazil and was introduced to India five centuries ago (Shanthi and Vittal, 2012) [10]. In India cashew is being grown on an area of 10.27 lakh hectares with a total production of 7.25 lakh MT of raw nuts and productivity of 706 kg/ha. India is the largest producer of raw cashewnut contributing 20 per cent of total global production. In India, Maharashtra ranks first in production and productivity of cashew with an average annual yield of 1262 Kg/ha (Anonymous, 2019) [1].
Cashew is not only a delicious and nutritious but is also a hardy and highly remunerative crop owing to its minimal crop management requirements. Cashew being tropical crop can tolerate higher temperatures but is highly sensitive to frost. The optimum temperature range for successful cultivation is about 20 to 30 ^{0}C. The annual precipitation of 1000 to 2000 mm is ideal for cashew. Coincidence of flowering with high rain fall or excess humidity leads to incidence of pests and diseases (Bhoomika and Sudha Rani, 2018) [2].
Incessant prolonged rain showers coupled with more than 90 per cent humidity during the monsoon season of 2019, resulted in occurrence and quick spread of defoliation followed by die-back in all the cashew pockets along the length and breadth of Konkan region. This situation alarmed an urgent study of the malady to solace the cashew growers with an appropriate and affordable solution to the problem. Therefore; the present investigation was carried out to test different fungicides against *Cylindrocladium* spp. under laboratory conditions.

Material and Methods
Fungicides reported effective against *Cylindrocladium* spp. causing various diseases in different horticultural and agronomical crops, were evaluated *in vitro* by applying Poisoned Food Technique (Nene and Thapliyal, 1993) [7] and using Potato Dextrose Agar as basal medium. The experiment was planned to evaluate *in vitro* efficacy of ten fungicides including systemic, contact and combination product fungicides against the pathogen.
The efficacy of fungicides was expressed as per cent inhibition of mycelial growth as compared to control and was calculated by using the formula given by Vincent (1927) [13]. The data obtained were averaged and analyzed statistically.

$$\text{Per cent Inhibition (I)} = \frac{C-T}{C} \times 100$$

Where
I = Per cent inhibition
C = Growth (cm) of the pathogen in control plate.
T = Growth (cm) in treatment

Results
In this study, ten fungicides were evaluated *in vitro* to judge their efficacy against *Cylindrocladium* spp by poisoned food technique. It was revealed from the data that the effect of different fungicides on growth of *Cylindrocladium* spp was significant. The observations on mycelial growth and per cent inhibition of mycelium were recorded. The results are presented in table 1.

Table 1: *In vitro* evaluation of different fungicides against *Cylindrocladium* spp

Tr. No.	Treatments	Concentration %	Mean Colony Diameter (mm)*	Per cent inhibition compared to control
T1	Carbendazim 50% WP	0.1%	15.67	82.58
T2	Thiophenate methyl 70% WP	0.1%	18.00	80.00
T3	Chlorothalonil 75% WP	0.2%	12.33	86.20
T4	Zineb 78% WP	0.25%	17.33	80.74
T5	Mancozeb 75% WP	0.25%	00.00	100
T6	Copper oxychloride 50% WP	0.25%	26.00	71.11
T7	Copper hydroxide 77% WP	0.2%	27.00	70.00
T8	Hexaconazole 5% SC	0.1%	17.67	80.36
T9	Zineb 68% WP + Hexaconazole 4% WP	0.2%	12.00	86.66
T10	Metalaxyl 4% WP + Mancozeb 64% WP	0.2%	00.00	100
T11	Control	-	90.00	-
S.E.m ±		-	0.036	-
C.D. (P = 0.01)			0.107	

* Mean of three replications

Perusal of data presented in Table -1 revealed that the effect of fungicides on growth of *Cylindrocladium* spp was significant. Among all the 10 fungicides/fungicide combinations under study, complete inhibition of the mycelial growth occurred in mancozeb (0.00mm) and metalaxyl in combination with mancozeb. They were followed by zineb plus hexaconazole (12mm), Chlorothalonil (12.33mm), carbendazim (15.67mm), zineb (17.33mm), hexaconazole (17.67mm), thiophenate methyl (18.00mm), copper oxy-chloride (26.00mm) and copper hydroxide (27.00mm) respectively. Maximum growth (90.00mm) was recorded in control.

Discussion
The *in vitro* studies conducted to evaluate 10 fungicides/ fungicide combination against the pathogen *Cylindrocladium* spp revealed that, manconcozeb 75 WP completely inhibited the mycelial growth of the pathogen. So also, the combination fungicide comprising metalaxyl 4% WP plus mancozeb 64% WP exhibited similar results. Carbendazim ranked fourth in order of merit with 15.67 mm growth and 82.58 per cent inhibition as compared to control.

Sulochana (1980) [12] achieved the best results with carbendazim at the least concentration (250 ppm) and further higher concentrations. Mancozeb was also effective but at higher concentration of 1000 ppm and above. Her results in respect of mancozeb are at par with results of present study but contradictory in respect of carbendazim.

Sharma and Mohanan (1991) [11] while working on five species of *Cylindrocladium* found that among the 22 fungicides tested *in vitro*, only carbendazim provided complete inhibition.

Jayasinghe and Wijesundera (1995) [5], found that benomyl, mancozeb, metalaxyl 8% plus mancozeb 64% and oxadixyl 10% plus mancozeb 56%, were effective against *Cylindrocladium quinqueseptatum*. The findings of this study are at similitude with present results in respect of sole mancozeb and its combination with metalaxyl.

It was also reported by Polizzi and Vitale (2001) [8] that, mycelial growth of six strains of *C. pauciramosa* was completely inhibited by carbendazim at 1000 ppm concentration.

Similarly, Henricot, *et al*. (2008) [4] found that, out of 13 fungicides evaluated against *Cylindrocladium*, carbendazim at 5000 ppm concentration completely inhibited mycelial growth of the pathogen.

Mancozeb both at 500 and 1000 ppm concentration completely inhibited mycelial growth of *Cylindrocladium jatrophae* (Chavan *et al*., 2011).

The results of Safrankova *et al*. (2013) [9] points out that mycelial growth and conidial germination of *C. buxicola* were inhibited up to 96 per cent by mancozeb.

The results of present study are in accordance with those of Chavan *et al*. (2011) and Safrankova *et al*. (2013) [9].

Among the six fungicides tested against *C. quinqueseptatum* the pathogen of leaf blight of clove; Khare *et al*. (2014) [6] found that, the growth as well as sporulation of the pathogen was absolutely inhibited by carbendazim and carbendazim plus mancozeb. These findings are contrary to current findings in respect of carbendazim.

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