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Chemical control of cowpea anthracnose caused by (*Colletotrichum lindemuthianum*)

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Abstract
The pulse crop is very much known as poor man's meat. One such crop is cowpea which has all the nutritional requirements that meets the demand of poverty trodden people. But, its bumper production is significantly hampered due to the anthracnose disease caused by Colletotrichum lindemuthianum. Prior to application of fungicides in the crop for the management of pathogen, tests were conducted by taking 13 different contact and systemic fungicides to find out their effectiveness in controlling the growth of mycelium of the test fungus in five different concentrations i.e. 0.05, 0.10, 0.15, 0.20, 0.25 and 0.30%. Difenoconazole proved to be fatal against the mycelial growth of the pathogen at 0.10% while other fungicides such as Thiophanate methyl at 0.15% followed by copper hydroxide, carbendazim and penconazole proved their efficacy at 0.25% but others influenced least.

Keywords: *Colletotrichum lindemuthianum*, anthracnose, mycelium, fungicides

Introduction

The cowpea (*Vigna unguiculata* L.) is an important food legume and an essential component of cropping systems of the drier regions of the tropics covering parts of Asia, Middle East, Southern Europe, Africa, Southern USA and Central and Southern America. Besides being a fast growing crop, cowpea curbs erosion by covering the ground, fixes atmospheric nitrogen and its decaying residues contribute to the soil fertility. Cowpea diseases induced by different pathogens belonging to various pathogenic groups (fungi, bacteria, viruses and nematodes) constitute one of the most important constraints to the profitable cowpea production.

Anthracnose is one of the most dreaded fungal diseases of cowpea incited by *Colletotrichum lindemuthianum* (Sacc and Magn) Scribber affecting all parts of the plant throughout the growth season of the crop. This causes economic loss in tropical regions of Africa especially Nigeria, Latin America and Asia where conditions are wet and humid for the main part of the growing season (Satpathy *et al*.,2020) [8].

In vitro fungicide testing is important investigation for preliminary screening and evaluation of the effectiveness of fungicides to control a specific fungal pathogen. Laboratory evaluation allows researchers to distinguish effective from ineffective fungicides and thus, select appropriate candidate fungicides for field tests. *In vitro* fungicide testing is also important to determine the minimum or effective dose required to control the fungus, as well as to detect fungicide resistance. *In vitro* tests have been widely implemented in previous studies to determine the efficacy of fungicides towards *Colletotrichum* spp. causing anthracnose on various types of crops, e.g., *C. truncatum* on chilli (Gopinath *et al*. 2006) [3], *C. gloeosporioides* on mango (Kumar *et al*. 2007) [5], and *C. acutatum* on tomato (Chapin *et al*. 2006) [1].

Materials and Methods

Thirteen different contact and systemic fungicides such as Thiophanate methyl, Fixed Copper, Copper Hydroxide, Chlorothalonil, Ziram, Mancozeb, Azoxystrobin, Carbendazim, Difenoconazole, Captan (heterocyclic nitrogen compound), Propiconazole, Penconzole and Tricyclazole were tried in seven different concentrations of 0.01, 0.05, 0.10, 0.15, 0.20, 0.25 and 0.30% in order to find out the efficacy of these chemicals against *C. lindemuthianum* by the filter paper disc plate method (Loo *et al*., 1945) [6]. All the details of chemicals have been mentioned in Table: 1. the sterilized filter paper discs of 10mm diameter were soaked with the fungicidal solution at desired concentration. The disc was placed at the center of petriplates (one disc per plate) containing 20 ml of Richard's Agar medium. Five inoculum discs were cut from the margin of a 10 days old culture of the test fungus and placed equidistantly from each other along with filter paper discs along the periphery of each petriplates. All the petriplates were incubated at 28 $\pm$ 1^0 C for 8 days. Each treatment was replicated thrice. A control check without fungicide was maintained. The activity was measured in terms of inhibitory zone of *C.lindemuthianum* in each concentration of individual fungicide and was compared with control checks. The per cent inhibition of mycelial growth under each concentration of the fungicide was worked out by the following formulae:

$$I = \frac{dc - dt}{dc} X\,100$$

Where
I = Inhibition percentage of diameter growth.
Dc = diameter growth of fungal colony in control.
Dt = diameter growth of fungal colony in treatment.

The commercial name, chemical name, active ingredient and formulation of different fungicides used in the present investigation are given in Table 1.

Table 1: Chemical name, commercial name, active ingredients and formulations of test fungicides

Chemical Name	Commercial Name	Active Ingredient	Formulation
Thiophanate methyl	Topsin-M	1, 2-bis (3-methoxy carbonyl -2 thioureido benzene) thiophanate methyl.	70% WP
Fixed Copper	Blitox-50	Copper oxy-chloride	50% WP
Copper Hydroxide	Kocide	Copper Hydroxide	77% WP
Chlorothalonil	Chlorothalonil	Tetrachloroisophthalonitril	75% WP
Ziram	Cuman-L	Zinc dimethyl dithiocarbamate	27% WP
Mancozeb	Indofil-M-45	Manganese ethylene bis-dithio carbamate + Zn^{++}	75% WP
Azoxystrobin	Azoxystrobin	Methyl(E)-2-{2-[6-(2-cyanophenoxy)pyrimidin-4-yloxy]phenyl}-3-methoxyacrylate	70% WP
Carbendazim	Bavistin	2-(methoxy-carbamoyl) benzimidazole	50% WP
Difenoconazole	Score	cis, trans-3-chloro-4-[4-methyl-2-(1H-1, 2, 4-triazol-1-ylmethyl)-1, 3-dioxolan-2-yl]phenyl 4-chlorophenyl ether	10% WP
Heterocyclic Nitrogen Compound	Captan	(N-Trichloromethylthio)-4-cyclohexene-1, 2-dicarboximide	75% WP
Propiconazole	Tilt	1-[[2(2, 4-Dichlorophenyl)-4-propyl-1, 3-dioxolan-2-yl]methyl]1-H-1, 2, 4-triazole	25% EC
Penconazole	Topas	1-(2, 4-dichloro-b-propylphenethyl)-1H-1, 2, 4-triazole	80% WP
Tricyclazole	Beam	5-methyl-1, 2, 4-triazolo[3, 4-*b*][1, 3]benzothiazole	75% WP

Table. 2: Percent inhibition of mycelial growth of *C.lindemuthianum* at different concentrations of test fungicides.

Fungicides	0.01%	0.05%	0.10%	0.15%	0.20%	0.25%	0.30%
Thiophanate methyl	75.5 (60.3)*	82.6 (65.6)	94.0 (75.9)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)
Fixed Copper	15.6 (23.2)	26.5 (30.9)	42.3 (40.5)	56.5 (48.7)	62.4 (52.1)	84.5 (66.8)	100 (90.0)
Copper Hydroxide	52.8 (46.6)	73.4 (59.0)	82.4 (65.1)	95.0 (77.0)	100 (90.0)	100 (90.0)	100 (90.0)
Chlorothalonil	25.0 (30.0)	40.2 (39.3)	52.5 (46.4)	71.4 (57.6)	75.0 (60.0)	86.5 (68.4)	88.0 (69.7)
Ziram	28.2 (32.0)	32.4 (34.6)	45.0 (42.1)	55.5 (48.1)	69.0 (56.5)	75.5 (60.3)	86.5 (68.4)
Mancozeb	52.6 (46.4)	64.4 (53.3)	76.4 (58.9)	82.5 (65.2)	90.6 (72.1)	98.4 (82.7)	100 (90.0)
Azoxystrobin	25.0 (30.0)	32.6 (34.8)	44.5 (41.8)	58.2 (49.7)	65.3 (53.9)	72.4 (58.3)	82.4 (65.2)
Carbendazim	50.4 (45.2)	70.0 (56.7)	82.4 (65.1)	96.5 (79.2)	100 (90.0)	100 (90.0)	100 (90.0)
Difenoconazole	72.4 (58.3)	86.5 (68.4)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)	100 (90.0)
Captan	26.5 (30.9)	38.4 (38.3)	42.6 (40.7)	58.5 (49.8)	60.4 (51.0)	72.3 (58.2)	86.5 (68.4)
Propiconazole	20.0 (26.5)	24.5 (29.6)	36.8 (37.3)	40.6 (39.5)	52.3 (46.3)	58.5 (49.8)	62.4 (52.1)
Penconazole	68.3 (55.7)	75.2 (60.1)	80.6 (63.8)	92.4 (74.0)	100 (90.0)	100 (90.0)	100 (90.0)
Tricyclazole	21.4 (27.5)	32.5 (34.7)	40.0 (39.2)	45.6 (42.4)	60.5 (51.0)	66.5 (54.6)	72.5 (58.3)
SEm ± C.D(0.05)	(0.351) (1.025)	(0.392) (1.145)	(1.004) (2.932)	(0.602) (1.759)	(0.959) (2.80)	(0.569)(1.661)	(0.334) (0.975)

* Figures in the parentheses are the angular transformed values

Results and Discussion

It may be seen from the Table 2 that there were significant inhibition of mycelial growth of *C.lindemuthianum* in difenoconazole, thiophanate methyl, copper hydroxide, carbendazim and penconazole in different concentrations. At 0.05% concentration, thiophanate methyl and difenoconazole caused inhibition by more than 80%. But, at 0.10%, the reduction in mycelial growth was remarkable with thiophanate methyl, copper hydroxide, carbendazim, difenoconazole and penconazole. Mancozeb was effectively inhibiting at 0.15% onwards but at 0.30% totally stops mycelial growth. Chlorothalonil was significantly effective at a concentration of 0.25%. But at 0.30%, almost all were effective in inhibiting the mycelial growth. As difenoconazole totally inhibited mycelial growth at 0.10% onwards, thiophanate methyl at 0.15% onwards and copper hydroxide, carbendazim and penconazole at 0.20% onwards, these fungicides were found to be most efficacious against the test fungus as indicated by the laboratory tests.

Bioassay studies of thirteen fungicides on seven different concentrations were tested against *C.lindemuthianum* (Table 2). It was revealed that complete inhibition of mycelial growth occurred at 0.15% conc. of Thiophanate methyl, 0.20% conc. of Copper hydroxide, Carbendazim and Propiconazole, and at 0.10% conc. of Difenoconazole. Copper oxychloride and Mancozeb both at 0.30% conc. were found effective against the test fungus. The efficacy of carbendazim against the anthracnose disease has also been proved in rose-scented geranium and also in chilli by Sattar *et al*. (2003) [9] and in chilli by Ekbote (2005) [2] which are in agreement with the present findings. However, in the present investigation, difenoconazole was found to be the most promising fungicide for inhibition of mycelial growth of *C. lindemuthianum*. Nuraini and Latiffah (2019) [7] reported similar effects by the application of systemic fungicide propiconazole where mycelium growth was inhibited in *Colletotrichum* spp. causing anthracnose in chilli. Jayalakshmi *et al*., 2013 [4] working on *C. gleosporioides*, the causative of pomegranate anthracnose noted the complete inhibition of mycelial growth by applying carbandazim + Mancozeb and propiconazole. Similar conclusions were made by Sashikumara *et al*. (2020) [10] while working on *C. truncatum* observed the efficacy of carbandazim + Mancozeb and propiconazole as complete fungi static but the individual action of carbendazim could inhibit the mycelial growth by 73% only. But, Propiconazole and tricyclazole were not proved fungi static in this experimentation.

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