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W Tampakleima Chanu
Department of Plant Pathology, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

Bireswar Sinha
Department of Plant Pathology, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

PH Sobita Devi
Department of Plant Pathology, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

PH Ranjit Sharma
Department of Genetics and Plant Breeding, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

N Gopimohan Singh
Department of Agricultural Statistics, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

Correspondence
W Tampakleima Chanu
Department of Plant Pathology, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

In vitro assessment of fungicides against *Fusarium oxysporum* f. sp. *pisi* causing *Fusarium* wilt of pea

W Tampakleima Chanu, Bireswar Sinha, PH Sobita Devi, PH Ranjit Sharma and N Gopimohan Singh

Abstract
The present study was designed to evaluate the antifungal effect of six different fungicides *viz.*, Carbendazim, Copper oxychloride, Captan, Thiophanate methyl, Ridomil, and Carboxin + Thiram. The evaluation was carried out at different concentrations i.e., 0.025%, 0.05%, 0.1%, 0.2% and 0.4% against mycelial growth of *Fusarium oxysporum* f.sp. *pisi* (FOC) by "poisoned food technique". Results obtained on *in vitro* evaluation revealed that all the test concentrations of all fungicides significantly inhibited growth of (FOC) as compared to control. It was observed that the pathogen could not grow at all different concentrations *viz.*, 0.025%, 0.05%, 0.1% and 0.2% in Carbendazim, yielded 100 per cent inhibition of mycelial growth of the pathogen and least inhibition was observed with Copper oxychloride (1.15 per cent) at 0.05% concentration. On the basis of available information and preliminary study, it is suggested that Carbendazim can be used in the management of *Fusarium* wilt of pea.

Keywords: Concentrations, fungicide, *Fusarium oxysporum* f.sp. *pisi*, poisoned food technique

Introduction
Pea (*Pisum sativum)* which is generally known as garden pea belongs to family Leguminosae. It is an important Rabi pulse crop in the North-Eastern region of India. One of the most important aspects of legumes is, the capacity of symbiotic nitrogen fixation by roots, indicating their importance as a source of nitrogen in both natural and agricultural ecosystems. In Manipur, pea production is facing many biotic and abiotic constraints, among them biotic diseases constitute the most important factor that reduces the average yield of the pea crop by direct attack on the grains. Among several soil borne diseases affecting pea production, wilt caused by *Fusarium oxysporum* f.sp. *pisi* is the most important fungal disease which can attack various crops finally leading to drastic yield loss (Basu *et al.,* 1973) [1]. Use of fungicides is the quickest and effective method for *Fusarium* wilt management (Moosa *et al.,* 2016) [4, 6]. Since many years, control of several fungal diseases is managed by employing the potential of fungicides (Bharat *et al.,* 2006) [2]. Based on damage nature and survival capability of the fungus, the use of chemicals for management of pea wilt was considered to be the only economical and practical solution. Therefore, keeping in view, the importance and losses caused by *Fusarium* wilt, present investigation was undertaken to test the efficacy of some promising fungicides for its effective management against wilt of pea under *in vitro*.

Materials and Methods
A virulent isolate (*Fusarium* oxysporum f. sp. *pisi)* among different isolates collected from wilt infested pea plants was used in the present study. The pure culture of isolated fungus was maintained on PDA slants and stored in refrigerator for further investigations and sub-cultured at regular intervals. The present investigation was conducted in the laboratory of the Department of Plant Pathology, College of Agriculture, CAU, Imphal, Manipur.

Effect of fungicides on the growth of *Fusarium* oxysporum f. sp. *pisi in vitro*
In vitro inhibitory action of six fungicides, namely Carbendazim, Thiophenate methyl, Copper oxychloride, Captan, Ridomil and Carboxin + Thiram at different concentrations i.e., 0.025%, 0.05%, 0.1%, 0.2% and 0.4% were evaluated against linear growth of *Fusarium oxysporum* f.sp. *pisi* by poisoned food technique (Nene and Thapliyal, 2000) [7].
Per cent inhibition in mycelial growth was calculated by following formula described by Vincent (1927)

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

Where,
C = linear growth of the fungus in control
T = linear growth of the fungus in treatment

Table 1: *In vitro* efficacy of fungicides on the growth of *Fusarium oxysporum* f.sp. *pisi* at different concentrations

Sl. No	Treatments	Concentrations (%)	Inhibition (%) over control*
1.	Carbendazim (50% WP)	0.025	100.00(10.02)
		0.05	100.00(10.02)
		0.1	100.00(10.02)
		0.2	100.00(10.02)
2.	Copper oxychloride (50% WP)	0.05	1.18(1.29)
		0.1	13.92(3.79)
		0.2	17.06(4.18)
		0.4	19.02(4.40)
3.	Captan (50% WP)	0.05	79.02(8.92)
		0.1	80.59(9.00)
		0.2	84.31(9.21)
		0.4	86.67(9.34)
4	Thiophante methyl (70% WP)	0.025	84.71(9.23)
		0.05	90.19(9.52)
		0.1	93.54(9.70)
		0.2	93.92(9.72)
5.	Ridomil (68% WP)	0.05	18.63(4.37)
		0.1	25.69(5.11)
		0.2	27.64(5.30)
		0.4	35.69(6.01)
6.	Carboxin (37.5% WP) + Thiram (37.5% WP)	0.05	84.90(9.24)
		0.1	86.67(9.34)
		0.2	89.22(9.47)
		0.4	89.61(9.49)
S.E(d)±		-	0.12
C.D. (5%)		-	0.24

*Mean of three replications
Values in parentheses are Square Root Transformed values

Results and Discussions

In-vitro evaluation of fungicides *viz.*, Carbendazim, Copper oxychloride, Captan, Thiophanate methyl, Ridomil, and Carboxin + Thiram was carried out at 0.025%, 0.05%, 0.1%, 0.2% and 0.4% concentrations. The data presented in Table 1 and Figure 1 (Plate A, B, C, D, E and F) clearly indicated that all the six tested fungicides had significant inhibitory outcome on the radial growth of the pathogen at different concentrations against *Fusarium oxysporum* f. sp. *pisi*. Among the six tested fungicides, maximum inhibition was showed with Carbendazim at all different concentrations *viz.*, 0.025%, 0.05%, 0.1% and 0.2% yielded 100 per cent inhibition of mycelial growth of the pathogen respectively, and least inhibition was observed in Copper oxychloride with 1.18 per cent inhibition at 0.1% of concentrations as compared to other treatments.

The results of present study are in agreement observed by Gangwar and Kumar (2012) [3] that Carbendazim, Benomyl, Copper oxychloride, Captan and Mancozeb were effective against *F. oxysporum* f. sp. *pisi in vitro.* The mode of action of Carbendazim is to bind an essential structure of all cells i.e., microtubuli, through interfering with their functions like cell division and intracellular transport etc. Similar findings were observed with by Maheswari *et al.* (2008) who reported that Carbendazim was most effective fungitoxicant for checking the fungal growth followed by Captan. Present findings are also supported by Khan *et al.* (2016) [4, 6] where they tested several fungicides *viz.*, Raxil Ultra (Tebuconazole), Topsin-M (Thiophanate Methyl), Score (Difenconazole), Derosil (Carbendazim), Hombre (Imidacloprid+Tebuconazole) and Divident Star (MetalaxylM+Difenconazole) *in vitro* with significant inhibitory effect on growth of *F. oxysporum* f. sp. *pisi*. Rehman *et al.* (2014) [8] recommended the Topsin-M was the best fungicide among all tested chemicals because of its systemic activity against *F. oxysporum* f. sp. *pisi.* Therefore the present research work reports that almost all fungicide treatments had somewhat showed inhibitory effect on the colony growth of the pathogen as compared to control.

Conclusions

Based on present investigation it could be concluded that among the six fungicides viz., Carbendazim, Copper oxychloride, Captan, Thiophanate methyl, Ridomil, and Carboxin + Thiram, Carbendazim showed the best result with 100.0 per cent inhibition in fungal growth and so, it can be used for control of *Fusarium* wilt of pea. Hence, this finding will be greatly helpful to pea growers by integrating with different management strategies for the purpose of control of *Fusarium* wilt of pea in field condition which may impart positive impact.

Acknowledgement

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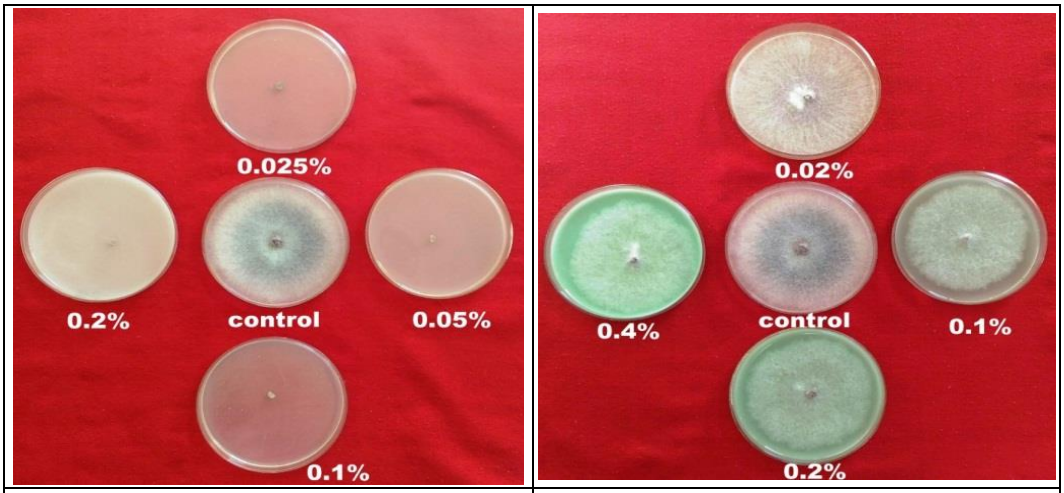

Plate A: Carbendazim at 0.025%, 0.05%, 0.1% and 0.2% of concentrations.

Plate B: Copper oxychloride at 0.05%, 0.1%, 0.2% and 0.4% of concentrations.

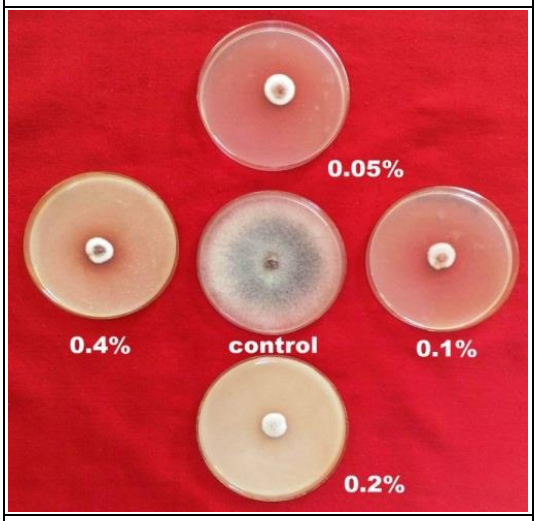

Plate C: Captan at 0.05%, 0.1%, 0.2% and 0.4% of concentrations.

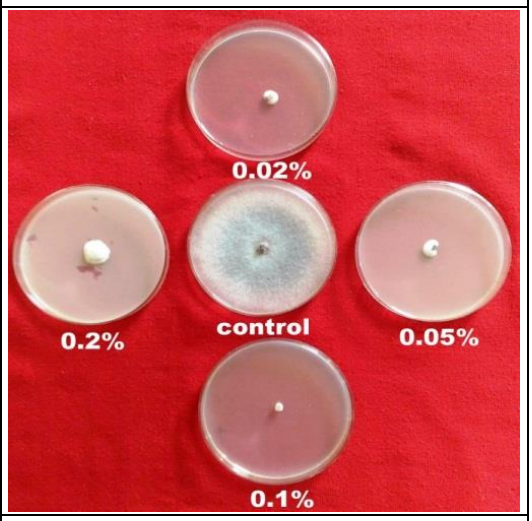

Plate D: Thiophenate methyl at 0.025%, 0.05%, 0.1% and 0.2% of concentrations.

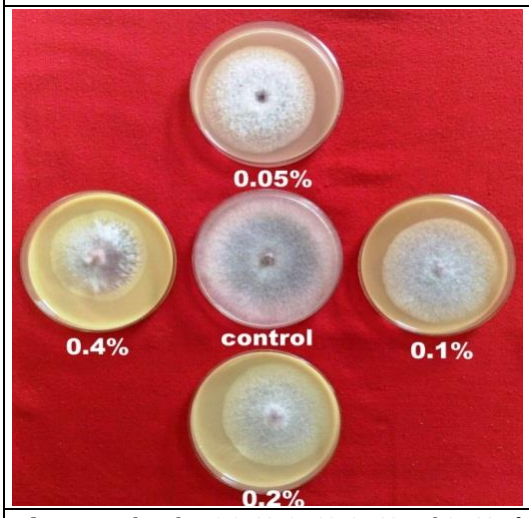

Plate E: Ridomil at 0.05%, 0.1%, 0.2% and 0.4% of concentrations.

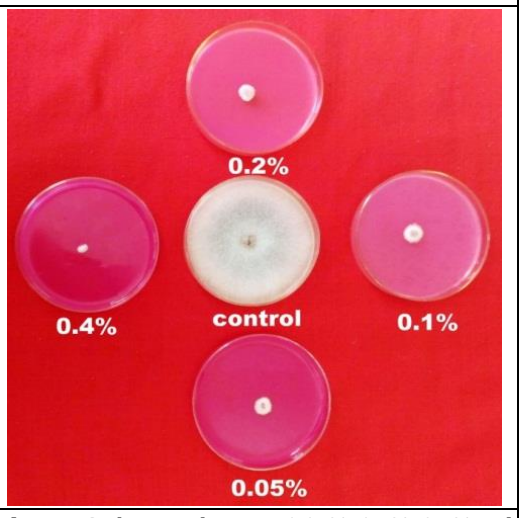

Plate F: Carboxin+Thiram at 0.05%, 0.1%, 0.2% and 0.4% of concentrations.

Fig 1: *In vitro* efficacy of different fungicides on growth of *Fusarium oxysporum* f. sp. *pisi.*

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