

## Evaluation of Fungicides and Biocontrol Agents against *Fusarium* wilts of Safflower Caused by *Fusarium oxysporum* f. sp. *carthami* Under *In Vitro* Condition

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### ABSTRACT

*In vitro* evaluation was conducted to evaluate the efficacy of fungicides and biocontrol agents against *Fusarium* wilt of Safflower caused by *Fusarium oxysporum* f. sp. *carthami* at the Department of Plant Pathology, College of Agricultural Sciences, Dharwad, Karnataka, during 2021. The research was laid out in a Complete Randomized Design, and eight treatments of fungicides were evaluated by following the Poisoned Food Technique, and four treatments of biocontrol agents, which were received from the Institute of Organic Farming, were evaluated by following the dual inoculation method against *F. oxysporum* f. sp. *carthami* under *in vitro* conditions. The results revealed that among all the fungicides evaluated, Carboxin 37.5 % + thiram 37.5 % and Carbendazim 25 % + mancozeb 50 % inhibited the mycelial growth completely at all the tested concentrations viz., 500 ppm, 1000 ppm, 2000 ppm and 3000 ppm, followed by Tebuconazole 2 DS (93.57 %) and Carbendazim 50 WP (92.33 %). Among the different concentrations of fungicides evaluated against *F. oxysporum* f. sp. *carthami*, the least inhibition of the mycelial growth was observed at 500 ppm (87.39 %), and the significantly highest inhibition was recorded at 3000 ppm (91.44 %), followed by 2000 ppm (89.89 %) and 1000 ppm (87.39 %). In comparison with all the concentrations, the least inhibition of mycelial growth of the fungus was observed in the case of Captan 50 WP (68.16 %) at 500 ppm. Among all the tested biocontrol agents, highest inhibition of mycelial growth of pathogen was found in case of *Trichoderma harzianum* (76.60 %) followed by *Neofusicoccum parvum* (71.39 %) and *Pseudomonas fluorescens* (69.10 %) and least inhibition of mycelial growth of the pathogen was observed in case of *Bacillus subtilis* (64.84 %) as compared to pathogen in control (i.e., where no antagonists were inoculated with pathogen) which has covered the maximum radial growth of 90 mm.

**Keywords:** Biocontrol agents, Fungicides, *Fusarium*, *In vitro*, Safflower, Wilt.

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## INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is an oilseed crop of the post rainy season, mainly cultivated in *Vertisol* in the Deccan region of India. In the world, India is the largest producer of Safflower, occupying 0.56 lakh hectares and an average yield of 640 kg ha<sup>-1</sup> (Anon, 2021). Safflower is a *rabi* crop and it is tolerant to drought, salt and saline water. In India, Safflower is grown for its vegetable oil and fodder purposes, and also the orange-red dye (carthamin) is derived from its florets. In India, Safflower is mainly cultivated for cooking purposes as the seed contains 24-36 per cent oil with linoleic acid of 78 per cent, which is helpful in reducing blood cholesterol levels.

Wilt of Safflower caused by *Fusarium oxysporum* f. sp. *carthami* Klisiewicz and Houston is an important soil borne disease occurring mainly in poorly drained areas of Karnataka and Maharashtra, causing considerable yield losses. Wilt of Safflower is a soil and seed borne disease, and therefore, efforts were made to control the disease and to reduce the yield losses. Therefore, the present

studies were carried out to evaluate the efficacy of fungicides and biocontrol agents against *Fusarium oxysporum* f. sp. *carthami*, causing wilt of Safflower under *in vitro* conditions.

## MATERIALS AND METHODS

A laboratory study was conducted to evaluate the efficacy of fungicides and biocontrol agents against *Fusarium* wilt of Safflower caused by *Fusarium oxysporum* f. sp. *carthami* at the Department of Plant Pathology, College of Agricultural Sciences, Dharwad, Karnataka, during 2021-22. The research was laid out in a Complete Randomized Design and evaluated eight treatments of fungicides by following the Poisoned Food Technique (Nene & Thapliyal, 1973). The antagonistic microorganisms such as *Pseudomonas fluorescens*, *Trichoderma harzianum*, *Bacillus subtilis* and *Neofusicoccum parvum* received from the Institute of Organic Farming (IOF) were evaluated for their antagonistic effect against *F. oxysporum* f. sp. *carthami* under *in vitro* conditions by following the dual culture technique.

**Table.1 Details of all the treatments imposed are mentioned below**

Sl. No.	Common name	Trade name	Concentration (ppm)
T <sub>1</sub>	Captan	Captaf 50 WP	500, 1000, 2000 and 3000
T <sub>2</sub>	Carbendazim	Bavistin 50 WP	500, 1000, 2000 and 3000
T <sub>3</sub>	Tebuconazole	Raxil 2DS (2 % w/w)	500, 1000, 2000 and 3000
T <sub>4</sub>	Carboxin 37.5 % + thiram 37.5 %	Vitavax Power	500, 1000, 2000 and 3000
T <sub>5</sub>	Carbendazim 25 % + mancozeb 50 %	Sprint	500, 1000, 2000 and 3000
T <sub>6</sub>	Thiophanate methyl 45% + pyraclostrobin 5 % FS	Xelora	500, 1000, 2000 and 3000
T <sub>7</sub>	Penflufen 13.28% w/w + trifloxystrobin 13.28 % w/w FS	EverGol Xtend	500, 1000, 2000 and 3000

The efficacy of a fungicide was expressed as per cent inhibition of radial growth over the control, which was calculated by using the formula given by Vincent (1947).

$$PI = \frac{C - T}{C} \times 100$$

Where,

PI = Per cent inhibition,

C = Colony diameter (mm) of the test fungus in the control and

T = Colony diameter (mm) of the test fungus in treatment

## RESULTS AND DISCUSSION

The results revealed that among the fungicides evaluated under *in vitro* conditions against *F.*

*oxysporum* f. sp. *carthami*, Carboxin 37.5 % + thiram 37.5 % and Carbendazim 25 % + mancozeb 50 % inhibited the mycelial growth

completely at all the tested concentrations, followed by Tebuconazole 2 DS (93.57 %) and Carbendazim 50 WP (92.33 %). It was found that, as the concentration of the fungicides increased, its efficacy also increased. Tebuconazole 2 DS (2 % w/w) was highly effective at 3000 ppm (94.62 %) concentration, followed by 2000 ppm (93.77 %), 1000 ppm (93.44 %) and 500 ppm (92.49 %). Carboxin 37.5 % + thiram 37.5 % and Carbendazim 25 % + mancozeb 50 % both were significantly superior over all the fungicides evaluated at different concentrations viz., 500 ppm, 1000 ppm, 2000 ppm and 3000 ppm. Comparison of inhibition of mycelial growth evaluated at different concentrations of fungicides indicated that the least inhibition of mycelial growth was observed at 500 ppm (87.39 %) and the significantly highest inhibition was recorded at 3000 ppm (91.44 %), followed by 2000 ppm (89.89 %) and 1000 ppm (87.39 %). In comparison with all the concentrations, the least inhibition of mycelial growth of the fungus was observed in the case of Captan 50 WP (68.16 %) at 500 ppm. Similarly, the findings of Sastry and Jayaraman (1993),

Chavan et al. (2003), Pawar et al. (2013), and Maitlo et al. (2014) confirmed the efficacy of Carbendazim against *Fusarium* wilt disease. (Table 2, Fig. 1, Plate 1).

Among all the tested antagonists, the highest inhibition of radial growth of pathogen was found in the case of *Trichoderma harzianum* (76.60 %) followed by *Neofusicoccum parvum* (71.39 %) and *Pseudomonas fluorescens* (69.10 %) and least inhibition of radial growth of the pathogen was observed in case of *Bacillus subtilis* (64.84 %), as compared to pathogen in control (i.e., where no antagonists were inoculated with pathogen) which has covered the maximum radial growth of 90 mm (Table 3, Fig. 2, Plate 2). It was concluded that the antagonists effectively suppress the pathogen growth by covering it within a short time by means of mycoparasitism and multiplying at a faster rate than the pathogen. The earlier research findings of Liu and Baker (1986), Sastry and Chattopadhyay (1997), Pathibanda & Prasad (2004) and More & Parate (2016) also reported such antagonists against *F. oxysporum*.

**Table 2. : In vitro evaluation of fungicides against *F. oxysporum* f. sp. *carthami* causing wilt of Safflower**

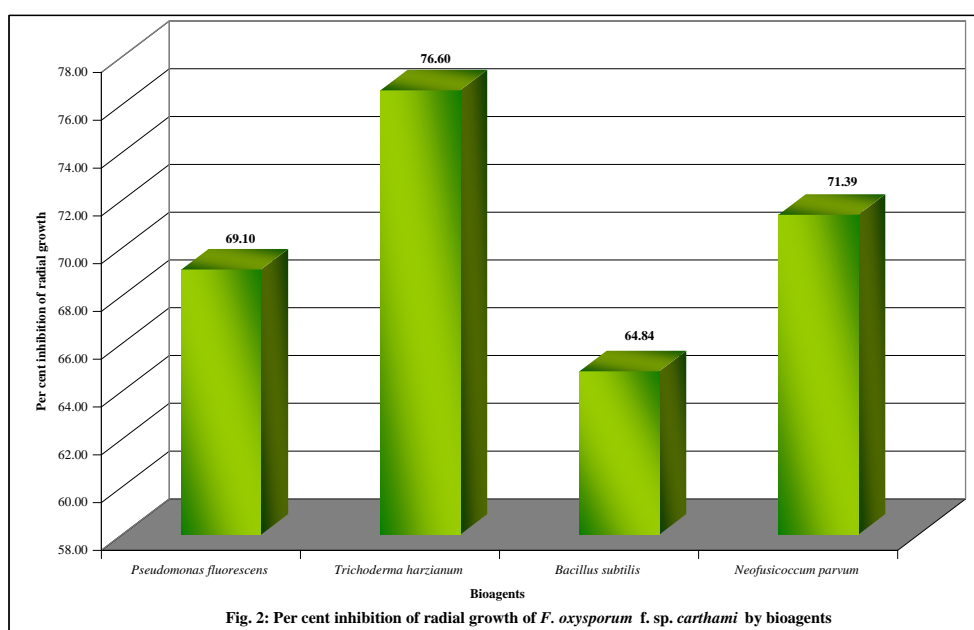
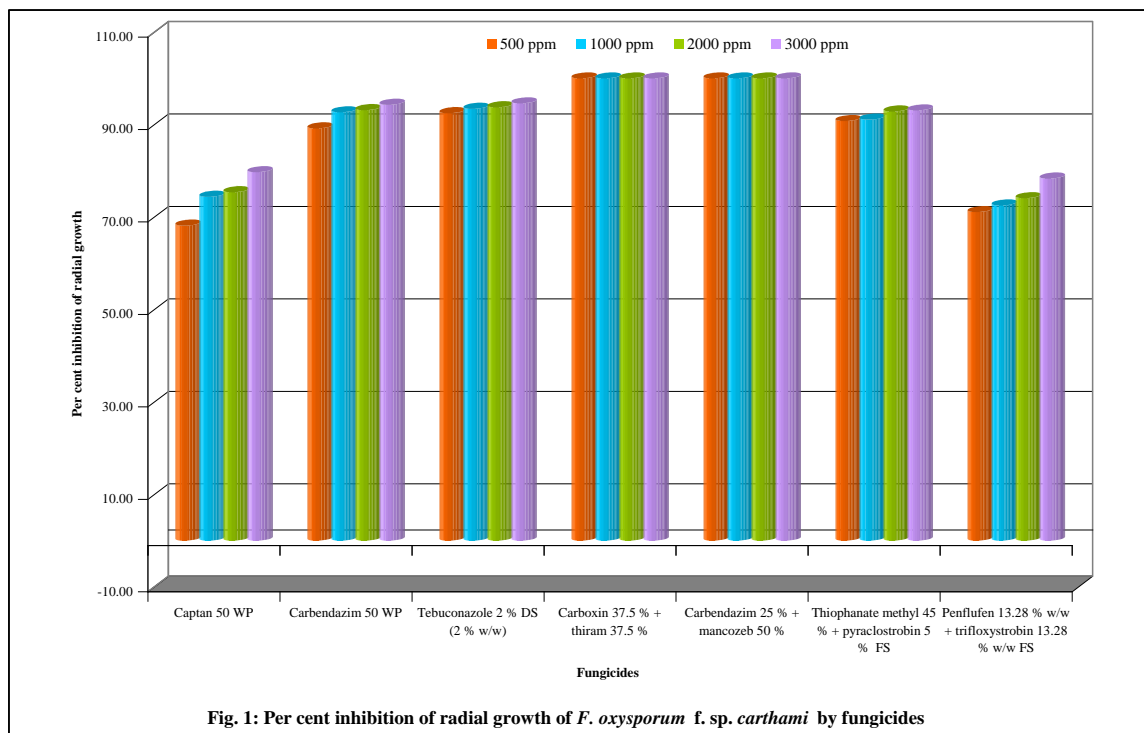
Treatments	Fungicides	Per cent inhibition of mycelial growth				
		Concentration (ppm)				Mean
		500	1000	2000	3000	
T <sub>1</sub>	Captan 50 WP	68.16 (55.65)*	74.40 (59.61)	75.38 (60.25)	79.73 (63.25)	74.41 (59.69)
T <sub>2</sub>	Carbendazim 50 WP	89.20 (70.82)	92.68 (74.31)	93.15 (74.83)	94.31 (76.21)	92.33 (74.04)
T <sub>3</sub>	Tebuconazole 2 DS (2 % w/w)	92.49 (74.11)	93.44 (75.16)	93.77 (75.55)	94.62 (76.60)	93.57 (75.36)
T <sub>4</sub>	Carboxin 37.5 % + thiram 37.5 %	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
T <sub>5</sub>	Carbendazim 25 % + mancozeb 50 %	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
T <sub>6</sub>	Thiophanate methyl 45 % + pyraclostrobin 5 % FS	90.80 (72.44)	91.10 (72.65)	92.86 (74.51)	93.10 (74.85)	91.96 (73.61)
T <sub>7</sub>	Penflufen 13.28 % w/w + trifloxystrobin 13.28 % w/w FS	71.10 (57.49)	72.53 (58.39)	74.10 (59.42)	78.35 (62.27)	74.01 (59.39)
<b>Mean</b>		87.39 (72.93)	89.16 (74.30)	89.89 (74.94)	91.44 (76.17)	89.47 (74.58)
Source		Fungicides (F)		Concentration (C)		F x C
S. Em. ±		0.23		0.17		0.46
C. D. at 1%		0.65		0.49		1.31

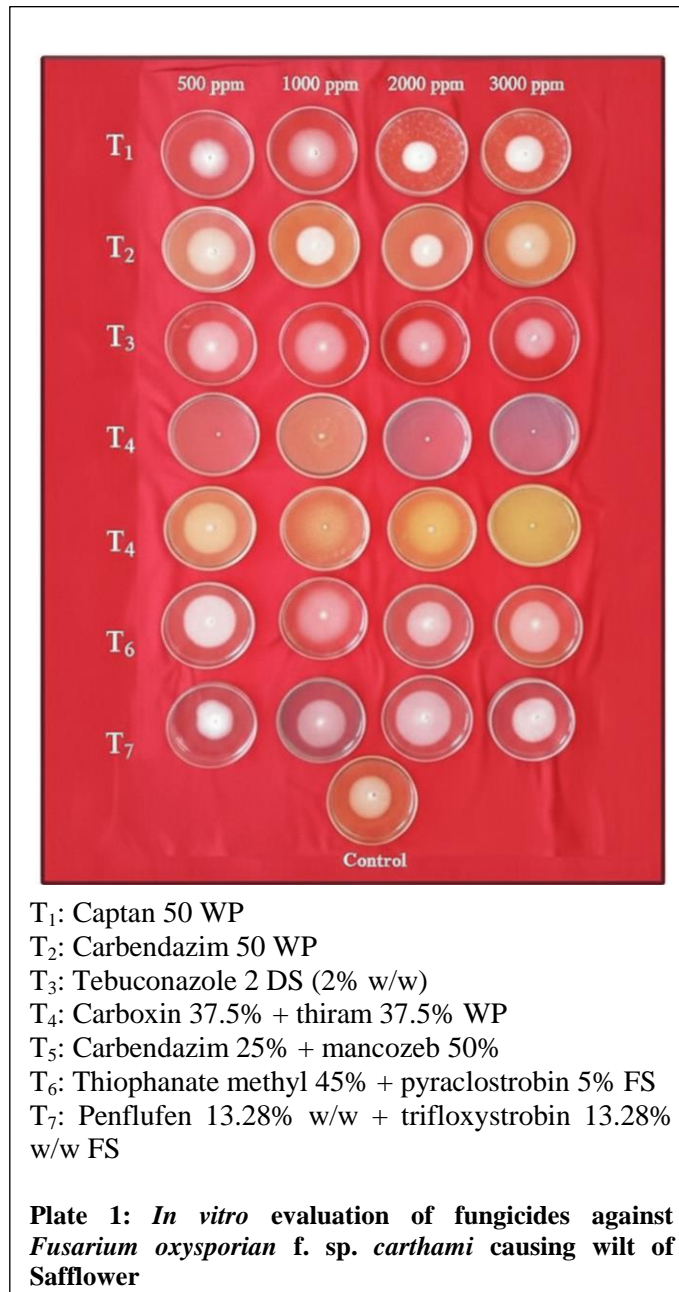
\* Figures in parenthesis indicate arcsine values

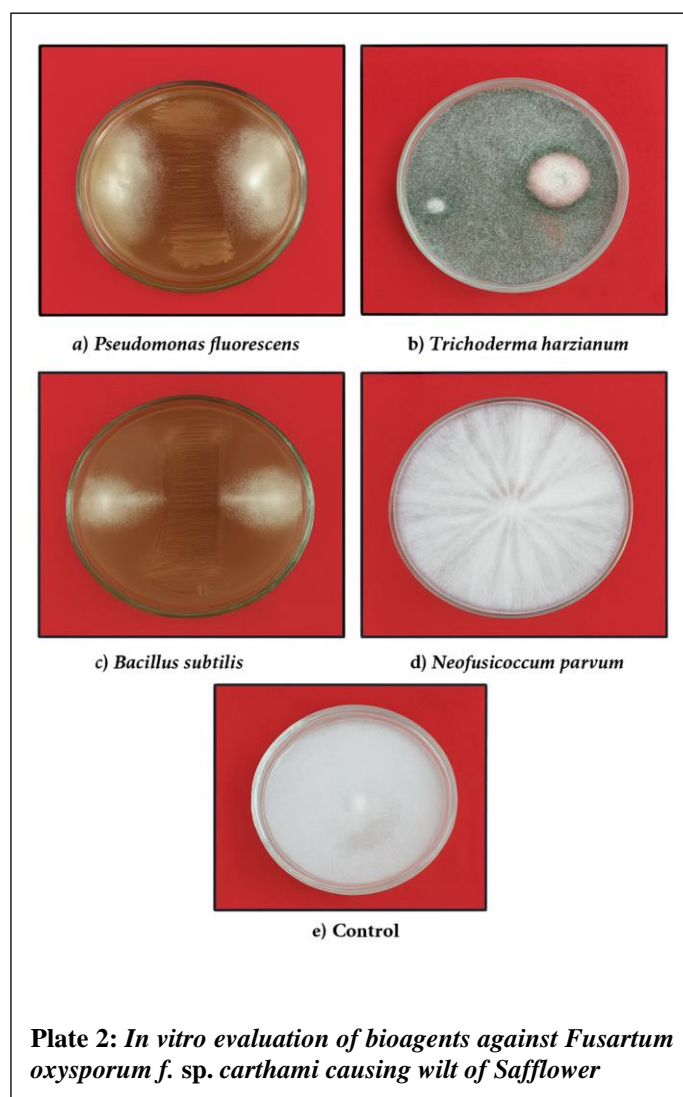
**Table3. In vitro evaluation of biocontrol agents against *F. oxysporum* f. sp. *carthami* causing wilt of Safflower**

Biocontrol agents	Per cent inhibition of mycelial growth
<i>Pseudomonas fluorescens</i>	69.10 (56.23)*
<i>Trichoderma harzianum</i>	76.60 (61.08)
<i>Bacillus subtilis</i>	64.84 (53.63)
<i>Neofusicoccum parvum</i>	71.39 (57.67)
Em. $\pm$	0.41
C. D. at 1%	1.29
C. V. (%)	1.44

\* Figures in parenthesis indicate arcsine values







## CONCLUSION

In the evaluation of the various fungicide concentrations against *F. oxysporum f. sp. carthami*, the minimal inhibition of mycelial growth was documented at 500 ppm (87.39%), while the most significant inhibition was observed at 3000 ppm (91.44%), with intermediate values recorded at 2000 ppm (89.89%) and 1000 ppm (87.39%). Comparatively, the lowest inhibition of mycelial growth of the fungus was noted with Captan 50 WP (68.16%) at 500 ppm. Among the biocontrol agents assessed, *Trichoderma harzianum* exhibited the highest level of inhibition of pathogen mycelial growth (76.60%), succeeded by *Neofusicoccum parvum* (71.39%) and *Pseudomonas fluorescens* (69.10%). The least inhibition of mycelial growth of the pathogen was recorded

with *Bacillus subtilis* (64.84%) relative to the control scenario (i.e., where no antagonistic organisms were inoculated alongside the pathogen), which demonstrated the greatest radial growth of 90 mm.

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### Conflict of Interest:

There is no such evidence of conflict of interest.

### Author Contribution:

All authors have participated in critically revising of the entire manuscript and approval of the final manuscript.

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