In vitro efficacy of different fungicides and bioagents for management wilt of watermelon[*Citrullus lanatus*] incitedby*Fusarium oxysporum*f. sp. *niveum*

Abstract

Fusarium wilt of watermelon caused by *Fusarium oxysporum*f. sp. *niveum* has been emerging as one of the major threats to profitable cultivation ofthe watermelon crop. In the present investigation, seven fungicides,*viz*.,cCarbendazim50%WP, cCoppercOxychloride50%WP, Ttebuconazole50%+tTrifloxystrobin25%WG, cCarbendazim12%+mMancozeb63%(75%WP), cChlorothalonil75%WP, aAzoxystrobin23% SC, tTebuconazole 25.9%EC,and four bioagents namely, *Trichoderma viride*, *Trichodermaharzianum*,*Trichodermakoningii*, and*Trichodermalongibrachiatum*,were evaluated *in vitro* at two different concentrations for their efficacy against the pathogen causing wilt of watermelon. Among the different fungicides evaluated, cCarbendazim 50% WP (0.1 and 0.2% concentration) and cCarbendazim 12% +mMancozeb 63% (0.1 and 0.2% concentration) were inhibiting mycelial growth of *F. oxysporum*f.sp. *niveum*completely.Among the different bioagents evaluated, *Trichodermaharzianum*was found most effective with significantly least mycelial growth (22.50 mm) and highest mycelial growth inhibition (75.00%) of the test pathogen.

Keywords: Watermelon, *Fusarium oxysporum*, Wilt,Bioagents, Fungicides

Introduction:

Watermelon [*Citrullus lanatus* (Thunb.) Matsum and Nakai] is amost widelygrown vegetable crops in the warmer parts of the world**.** It is a well-liked summer vegetable fruit with in the*Cucurbitaceae* family of gourds and has chromosomal number 2n=2x=22(Paris, 2015).It known by various names in different regions of India such as Kkalingad, Kkalindi, and Ttarbuj. The arid areas of Africa, especially the Kalahari Desert, are said to be the origin of watermelon(Strauss, 2015).Among the various fungal diseases, *Fusarium* wilt caused by *Fusarium oxysporum* f. sp. *niveum* is the most severe soilborne disease and is considered as a most important disease in watermelon. The yield loss is around 30–80% or even more, and is presently a major hindrance to watermelon cultivation worldwide (Rahman *et al*. 2021).Initial symptoms often include a dull, gray-green appearance of leaves that precedes a loss of turgor pressure and wilting. Wilting is followed by a yellowing of the leaves and finally necrosis. The wilting generally starts with the older leaves and progresses to the younger foliage. Initial symptoms often occur as the plant is beginning to vine and wilting may occur in only one runner

Comment [A1]: Current sources on the subject can be added to this section. Since it is a comprehensive sentence, more sources can be used.

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leaving the rest of the plant apparently unaffected. Under conditions of sufficiently high inoculum density or a very susceptible host, the entire plant may wilt and die within a short time. Affected plants that do not die are often stunted and have considerably reduced yields. Under high inoculum pressure, seedlings may damp off as they emerge from the soil (Egel and Martyn, 2024).

Comment [A2]: The introduction section is generally lacking in references.

Although there are very general sentences, one research is given.

Materials and Methods

The present study was conducted at the Department of Plant Pathology, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during the years 2023-2024.Seven fungicides namely, c~~C~~arbendazim50%WP, c~~C~~oppero~~O~~xychloride50%WP, t~~T~~ebuconazole50%+t~~T~~rifloxystrobin25%WG, c~~C~~arbendazim12%+m~~M~~ancozeb63%(75%WP), c~~C~~hlorothalonil75%WP, a~~A~~zoxystrobin23% SC, and t~~T~~ebuconazole 25.9%ECwere tested *in vitro* against the pathogen at two different concentrations by applying the "Poisoned Food Technique" (Nene and Thapliyal, 1993) with three replications in Completely Randomized Design. Four bioagents, *viz.*, *Trichoderma viride*, *Trichodermaharzianum*, *Trichodermakoningii*, and *Trichodermalongibrachiatum*, were evaluated *in vitro* for their efficacy against *Fusarium oxysporum* f. sp. *niveum* by applying the "Dual culture technique" (Dennis and Webster, 1971) with four replications in a Completely Randomized Design (CRD). The efficacy of bioagents and fungicides of test fungus was expressed as per cent inhibition of mycelial growth over control and Per cent inhibition was calculated by using the formula given by Vincent (1947).

Comment [A3]: How many petri dishes will there be in each repetition, what is the total number of petri dishes, should be written in detail.

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

Where,

C = Growth (mm) of the test fungus in untreated control plate

T = Growth (mm) of the test fungus in treated plate

Results and Discussion

1. *In vitro* efficacy of fungicides against pathogen of wilt of watermelon

Results from the table 1, plate I (a and b) and fig. 1 revealed that all the fungicides evaluated *in vitro* were significantly effective against *Fusarium oxysporum* f. sp. *niveum*, a causal organism of wilt of watermelon.

1.1 Effect on colony growth

At lower concentration, the fungicides observed radial mycelial growth of the test pathogen from 0.00 mm (Carbendazim 50% WP and Carbendazim 12% + Mancozeb 63 % WP) to 34.00 mm (Azoxystrobin 23% EC) as against 90.00 mm in untreated control. However, Carbendazim 50% WP and Carbendazim 12% + Mancozeb 63 % WP was most effective with least of the mycelial growth (0.00 mm) followed by Tebuconazole 25.9% EC (10.00 mm), Tebuconazole 50 % WG + Trifloxystrobin 25 % WG (15.50 mm), Copper Oxychloride 50 % WP (24.00 mm), Chlorothalonil 75% WP (28.00 mm). Azoxystrobin 23% EC was found comparatively less effective with maximum mycelial growth of 34.00 mm.

At higher concentration, (Table 1, Fig. 1 and plate I) the fungicides observed radial mycelial growth of the test pathogen was ranged from 0.00 mm (Carbendazim 50% WP, Tebuconazole 25.9% EC, Carbendazim 12% + Mancozeb 63 % WP) to 28.50 mm (Azoxystrobin 23% EC), as against 90.00 mm in untreated control. Carbendazim 50% WP, Carbendazim 12% + Mancozeb 63 % WP and Tebuconazole 25% EC was found most effective with least of the mycelial growth (0.00 mm) followed by Tebuconazole 50% + Trifloxystrobin 25 % WG (12.50 mm), Copper Oxychloride 50 % WP (19.50 mm), Chlorothalonil 75% WP (23.00 mm). Azoxystrobin23% EC was shown to be less effective, with the maximum mycelial growth of 28.50 mm.

1.2 Effect on mycelial growth inhibition

At l~~L~~ower concentration, per cent mycelial growth inhibition of the test pathogen ranged from 62.22% (Azoxystrobin23%EC) to 100% (Carbendazim 50% WP and Carbendazim 12% + Mancozeb 63% (75%WP). However, fungicide Carbendazim 50% and Carbendazim 12% + Mancozeb 63% WP was found most effective which was inhibited 100.00%mycelial growth followed by fungicide Tebuconazole 25.9% EC (94.44%), Tebuconazole 50% + Trifloxystrobin 25% WG (82.77%), Copper Oxychloride 50% WP (73.33%), Chlorothalonil 75% WP (68.88%). Azoxystrobin 23% EC was found comparatively less effective with minimum mycelial inhibition per cent of 62.22%.

At h~~H~~igher concentrations, per cent mycelial growth inhibition of the test pathogen ranged from 73.88% (azoxystrobin 23% EC) to 100% (carbendazim 50% WP, tebuconazole 25% EC and carbendazim 12% + mancozeb 63% (75%WP). However, fungicidescarbendazim 50% WP, tebuconazole 25.9% EC, and carbendazim 12% + mancozeb 63% WP ~~was~~ werefound to be most effective, which ~~was~~ inhibited 100.00% mycelial growth, followed by fungicidestebuconazole 50% + trifloxystrobin 25% WG (86.11%), copper oxychloride 50% WP (78.33%),and chlorothalonil 75% WP (73.88%). A~~a~~zoxystrobin 23% EC was found comparatively less effective, with a minimum mycelial inhibition ~~per cent~~ percentage of 68.33%.

Similarly, Parmar (2014) studied the efficacy of six different combination fungicidesat different concentrations against *Fusarium oxysporum* f. sp. *niveum* using poisoned food technique, and results revealed that carbendazim12% + mancozeb 63% WP inhibited growth of *Fusarium oxysporum* f. sp. *niveum* (100%). Gurjar and Shekhawat (2012) also evaluated the *in vitro* efficacy of five fungicides against *Fusarium oxysporum Schlecht* and reported that~~,C~~carbendazim 50% WP was found to be the most effective fungicide in checking mycelia growth. Madhavi & Bhattiprolu (2011) ~~were~~ carried out a similar study on *in vitro* efficacy of six fungicides against *Fusarium solani* by Poisoned Food Technique and showed that a combination of carbendazim 12% +mancozeb 63% was effective in inhibiting mycelial growth, followed by c~~C~~arbendazim alone.

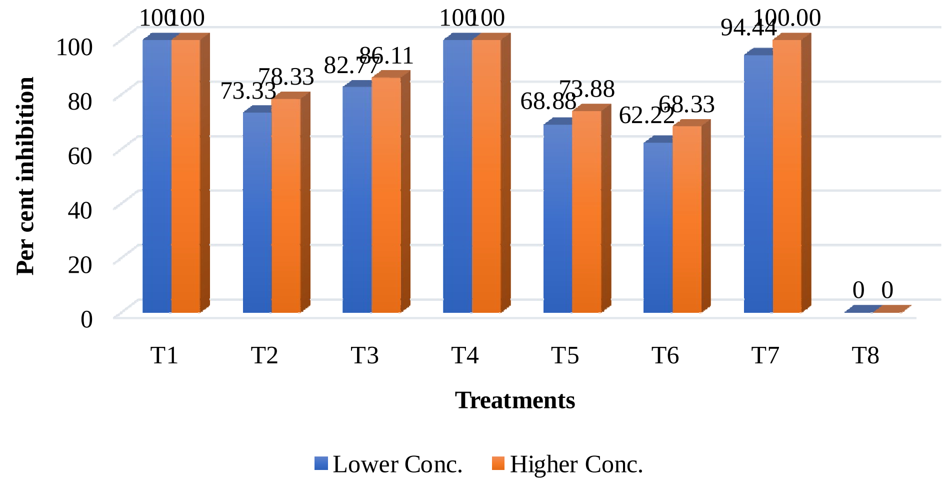
Comment [A4]: The study should not be discussed with a single source. Differences between studies should be clearly stated. In the discussion, there should be more references since the results obtained will be compared with other studies.

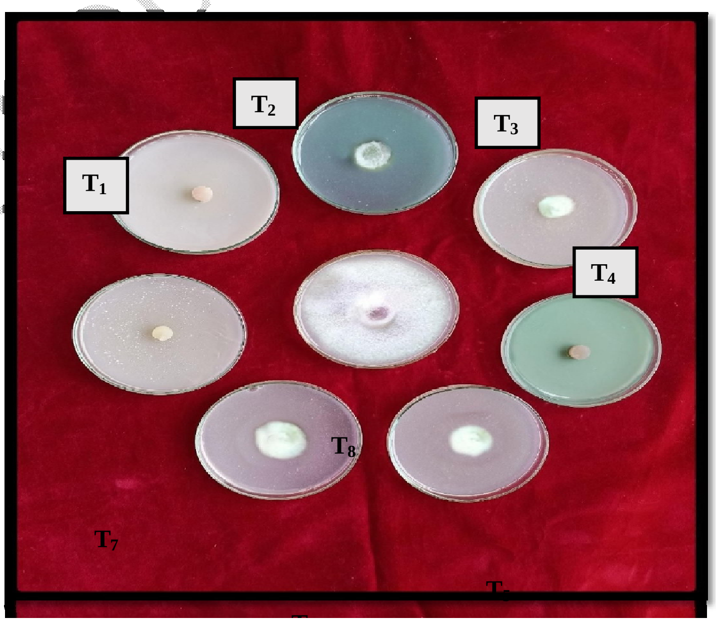
Table 1:*In vitro* efficacy of fungicides against pathogen of wilt of watermelon

Tr. No.	Treatment	Conc. (%)	Mean colony dia. (mm)	(%) Inhibition over control	Conc. (%)	Mean colony dia. (mm)	(%) Inhibition over control
T_1	Carbendazim50%WP	0.1%	0.00	100.00	0.2%	0.00	100.00
T_2	CopperOxychloride50%WP	0.1%	24.00	73.33	0.2%	19.50	78.33
T_3	Tebuconazole50%+ Trifloxystrobin25%WG	0.1%	15.50	82.77	0.2%	12.50	86.11
T_4	Carbendazim12%+Mancozeb 63%(75%WP)	0.25%	0.00	100.00	0.3%	0.00	100.00
T_5	Chlorothalonil75%WP	0.1%	28.00	68.88	0.2%	23.00	73.88
T_6	Azoxystrobin23% SC	0.2%	34.00	62.22	0.3%	28.50	68.33
T_7	Tebuconazole 25.9%EC	0.05%	10.00	94.44	0.1%	0.00	100.00
T_8	Control (Untreated)	-	90.00	0.00	-	90.00	0.00
	S.E. (m) ±		**0.38**			**0.27**	
	C.D. at 1%		**1.57**			**1.11**	

Comment [A5]: Two digits must be given after the decimal dot. This arrangement must be made throughout the table. For example; 99.00%

Fig. 1: In vitro efficacy of fungicides against the *F. oxysporum* f.sp. niveum





Comment [A6]: Decimal numbers must be given with a dot. For example, 100.00

2. *In vitro* efficacy of bioagents against pathogen of wilt of watermelon

The results from Table 2, plate II and fig.2showed that all the bioagents studied *in vitro* were significantly effective in inhibiting the mycelial growth of *Fusarium oxysporum*f. sp. *niveum*. Among the four bioagents,*Trichodermaharzianum*was found to be most effective with significantly least mycelial growth (22.50 mm) and highest mycelial growth inhibition (75.00%) of the test pathogen followed by *Trichodermalongibrachiatum* (23.75 mm and 73.61% respectively), *Trichoderma viride*(27.50 mm and 69.44%, respectively) and *Trichodermakoningii*(35.00 mm and 61.11%, respectively). *Trichodermakoningii*was found comparatively less effective with maximum mycelial growth (35.00 mm) and minimum mycelial growth inhibition (61.11%).

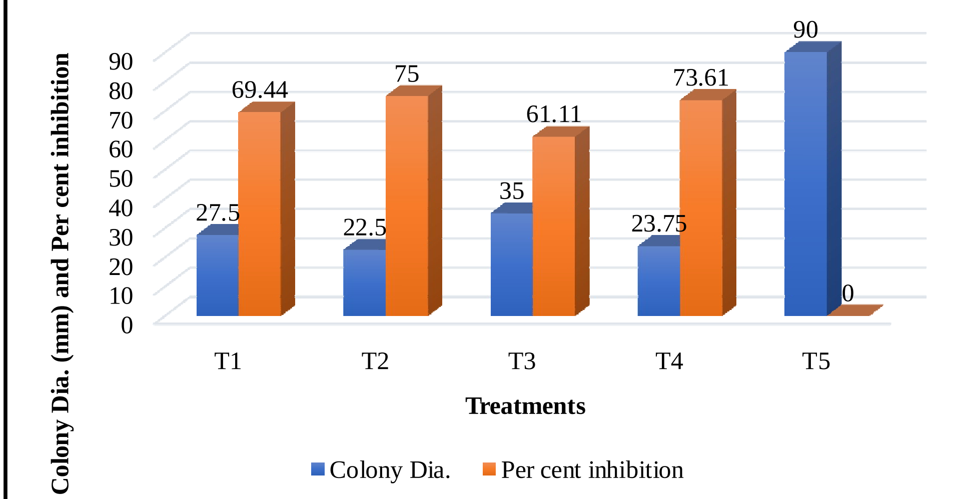
Table 2. *In vitro* efficacyof bioagents againstpathogen of wilt of watermelon.

Tr. No.	Bioagents	Mean colony dia. (mm)	(%) Inhibition over control
T_1	*Trichoderma viride*	27.50	69.44
T_2	*Trichoderma harzianum*	22.50	75.00
T_3	*Trichoderma koningii*	35.00	61.11
T_4	*Trichoderma longibrachiatum*	23.75	73.61
T_5	Control	90.00	0.00
SE(m) ±		**0.47**	
C.D (P=0.01)		**1.97**	

Gurjar and Shekhawat (2012) were carried out similar study on *in vitro* efficacy of four bioagents against *Fusarium oxysporum Schlecht* and reported that, *Trichoderma harzianum* was found to be most effective treatment in checking mycelial growth of the pathogen. Similarly, Patel *et al.* (2023) evaluated *in vitro* efficacy of six different bioagents by dual culture method against the *F. solani*, and reported that, *Trichoderma harzianum* was found most effective treatment in inhibiting mycelial growth of the pathogen. Sharma *et al.* (2022) also evaluated *in vitro* efficacy of bioagents against *Fusarium* wilt of cucumber by using dual culture technique and reported that, *Trichodermaharzianum* was found most effective with 61.08% inhibition of mycelial growth.

Comment [A7]: In the discussion, the results obtained from both other researchers and this study should be compared. The reason for the differences between the studies should be explained. There is a general lack of references in the study.

Fig.2: In vitro efficacy of bioagent against the *F. oxysporum* f.sp. *niveum*



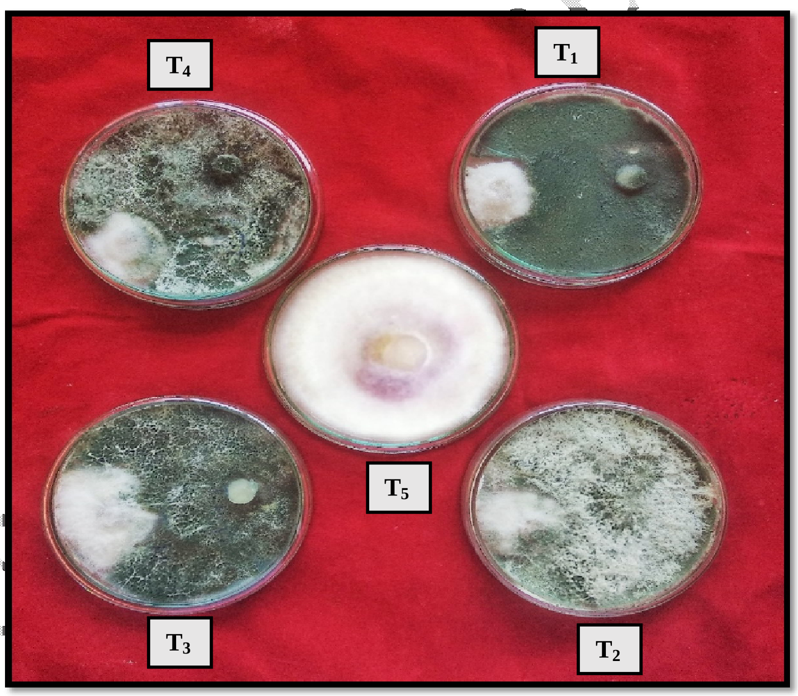


Plate II: *In vitro* efficacyof bioagents against *Fusarium oxysporum* f. sp. *niveum.*

Conclusion

Among the different fungicides evaluated *in vitro*, carbendazim 50% WP (0.1 and 0.2% concentration) and carbendazim 12% + mancozeb 63% (0.1 and 0.2% concentration) were inhibiting mycelial growth of *Fusarium oxysporum*f. sp. *niveum*completely. Similarly, among the bioagents*T. harzianum*was most effective in inhibiting *Fusarium oxysporum*f. sp. *niveum*with 75.00% inhibition followed by *T. longibrachiatum*69.44%.

Comment [A8]: Conclusion should be given more comprehensively

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