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Evaluation of Different Fungicides against *Fusarium* Wilt Pathogen of Bottle Gourd

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Bottle gourd (*Lagenaria siceraria* Mol.Standl.), a prominent member of the *cucurbitaceae* family, stands as a significant vegetable crop. However, it faces a formidable challenge in the form of Fusarium wilt, attributed to *Fusarium oxysporum* f. sp. *lagenariae*, a fungal pathogen. This disease poses a substantial threat to bottle gourd cultivation, affecting its vascular system and leading to symptoms like wilting and yellowing, ultimately endangering the plant's survival. The research was conducted on evaluation of fungicides against F. oxysporum of bottle gourd at department of plant pathology, S. D. Agricultural University during 2018-2020. Four systemic, four non-systemic and four combined fungicides at different concentration were tested against F. oxysporum through poison food technique. Among systemic fungicides, carbendazim found much effective and it recorded the highest growth inhibition (99%) at higher concentration, followed by propiconazole

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(98%) at 500 ppm. Among non systemic fungicides, propineb recorded the highest growth inhibition (99.50%) at higher concentration, followed by chlorothalonil (73.83%) at 2000 ppm. Among combined fungicides, carboxin + thiram recorded the highest growth inhibition (99.50%) at higher growth inhibition at 1000 ppm.

Keywords: Fusarium; fungicides; poisoned food; systemic; non systemic; combined.

1. INTRODUCTION

Bottle gourd (*Lagenaria siceraria* Mol.Standl.), a prominent member of the *Cucurbitaceae* family, holds a significant position among vegetable crops. It boasts a variety of names including birdhouse gourd, trumpet gourd, calabash gourd, and white flowered gourd, known as "dudhi" in India. This versatile plant, characterized by its climbing or trailing habit, bears fruits of bottle, oval, or dumb-bell shapes.

Bottle gourd thrives as a warm-season crop, flourishing in warm, humid climates while remaining highly susceptible to frost. While adaptable to various soil types, it achieves optimal growth in fertile sandy loam soils abundant in organic matter, devoid of hard layers, and equipped with efficient irrigation and drainage systems. Widely cultivated across India, its fruits grace markets year-round. Rajasthan, Punjab, Uttar Pradesh, West Bengal, Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, and Tamil Nadu stand as major bottle gourd-growing states in the country.

The production of bottle gourd is affected by a many diseases caused by fungi, bacteria and viruses. Some of the fungi reported from seeds of bottle gourd are *Alternaria alternata*, *Aspergillus flavus*, *A. niger*, *Botryodiplodia theobromae* and *Fusarium* spp. Fusarium wilt, induced by *Fusarium oxysporum* f. sp*. lagenariae*, stands out as a economically significant threat to bottle gourd cultivation, particularly in protected environments, where it can lead to substantial losses in fruit yield. This disease isn't confined to bottle gourd alone; it also impacts other cucurbitaceae crops such as melon, squash, cucumber, and pumpkin, further exacerbating its economic impact across various agricultural sectors.

The manifestation of wilt symptoms is contingent upon several variables, encompassing the density of inoculum in the soil, prevailing environmental conditions, nutrient availability, and the inherent susceptibility of the host plant. Initial wilting is succeeded by a yellowing of the leaves, culminating in necrosis. Typically, wilting initiates in the older leaves and advances to affect younger foliage. In circumstances characterized by either a dense inoculum or a highly susceptible host, the entire plant may succumb to wilting and perish swiftly. Thus, the current investigation aims to generate scientific insights into this pathogen, addressing the need for comprehensive understanding and management strategies.

2. MATERIALS AND METHODS

The *in vitro* efficacy of different fungicides was studied by using poisoned food technique [1]. “The measured quantities of different fungicides were incorporated separately in conical flasks containing 100 ml of melted sterilized PDA medium aseptically to obtain desired concentrations of the fungicides at the time of pouring the medium. The medium was shaken well to give uniform dispersal of the fungicides and then poured into sterilized Petri-plates under aseptic condition. The Petri-plates were inoculated in the centre by placing 5 mm seven days old mycelial disc and then incubated at 27 ± 2°C temperatures for seven days. Simultaneously, the control was also maintained by growing the fungus on fungicide free PDA medium. Three Petri-plates were maintained for each treatment” [2].

The observations on radial growth in each Petri-plates were measured periodically and final observations were recorded when the control plate was fully covered with the growth of test pathogen.

The per cent growth inhibition of the fungus in each treatment in comparison to control was calculated by the following equation [3].

$$PGI = \frac{C - T}{C} \text{ x } 100$$

Where,

PGI = Per cent growth inhibition
C = Colony diameter in control (mm)
T = Colony diameter in treatment (mm)

3. RESULTS AND DISCUSSION

The experiment was conducted under *in vitro* conditions through the randomized complete block design.

The systemic, non-systemic and combined fungicides (four each) at different concentrations were tested *in vitro* for their comparative efficacy against *F. oxysporum* through poisoned food technique (Tables 1, 2 and 3).

Among all the four systemic fungicides, the carbendazim was found more effective, it recorded 99.00 per cent growth inhibition at the highest concentration (500 ppm) and 96.00 per cent growth inhibition at the lowest concentration (50 ppm), followed by propiconazole which recorded 98.00 per cent growth inhibition at the highest concentration (500 ppm) and 70.92 per cent growth inhibition at the lowest concentration (50 ppm).

Table 1. Per cent growth inhibition of *F. oxysporum* by systemic fungicides *in vitro*

Sr. No.	Systemic fungicides	Per cent growth inhibition* Concentration (ppm)				Mean
		50	100	250	500	
1	Difenoconazole 25 EC	58.49**^{fg} (72.66)*	59.85^{f} (74.75)	73.94^{c} (92.31)	81.87^{a} (98.00)	68.54^{c} (84.43)
2	Propiconazole 25 EC	57.38^{g} (70.92)	70.43^{d} (88.64)	74.27^{bc} (92.62)	81.87^{a} (98.00)	70.99^{b} (87.54)
3	Azoxystrobin 23 SC	40.57^{i} (42.33)	52.11^{h} (62.36)	58.52^{fg} (72.71)	63.38^{e} (79.90)	53.65^{d} (64.32)
4	Carbendazim 50 WP	78.46^{ab} (96.00)	80.02^{a} (97.00)	81.87^{a} (98.00)	84.26^{a} (99.00)	81.15^{a} (97.50)
Mean		47.04^{d} (70.48)	52.54^{c} (80.69)	57.78^{b} (88.91)	62.33^{a} (93.72)	-
		Fungicide		**Concentration**		**Fungicide × Concentration**
S. Em. ±		**0.39**		**0.35**		**0.78**
C.D. at 5 %		**1.15**		**1.03**		**2.30**
C.V. %		**2.54**				

**Average of three replications*
*** Arc-sin transformed values*
**Figures in parentheses are original values*
Treatment means with the letter/letters in common are not significant by Duncan's New Multiple Range Test

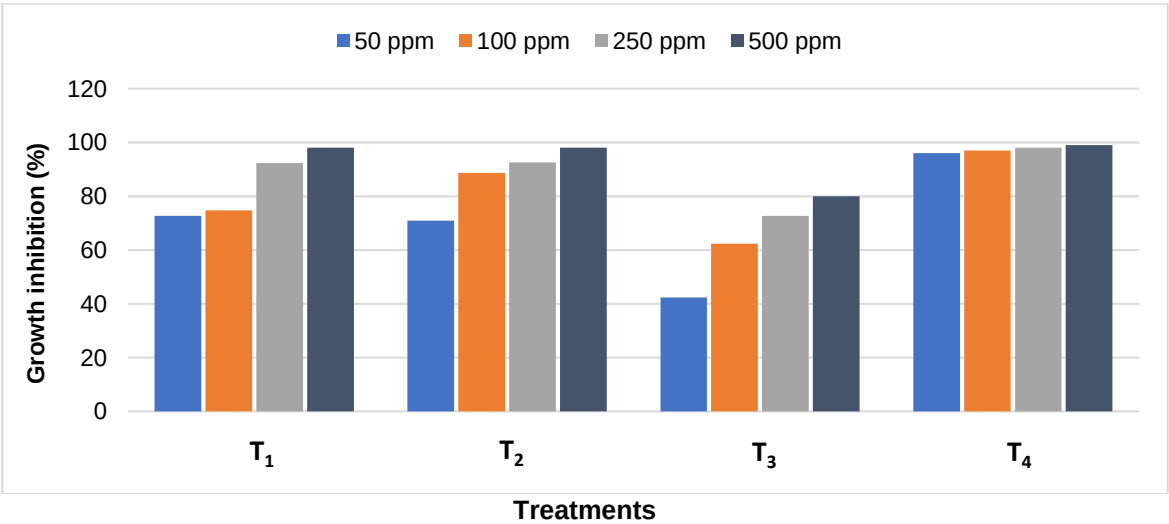

Fig. 1. Growth inhibition of *F. oxysporum* by systemic fungicides *in vitro*
T_1 – Difenoconazole T_3 - Azoxystrobin
T_2 – Propiconazole T_4 – Carbendazim

Among all the four non systemic fungicides, the propineb was found more effective, it showed 99.50 per cent growth inhibition at the highest concentration (2000 ppm) and 55.31 per cent growth inhibition at the lowest concentration (500 ppm), followed by chlorothalonil which showed 73.83 per cent growth inhibition at the highest concentration (2000 ppm) and 37.51 per cent growth inhibition at the lowest concentration (500 ppm).

Table 2. Per cent growth inhibition of *F. oxysporum* by non systemic fungicides *in vitro*

Sr. No.	Non systemic fungicides	Per cent growth inhibition* Concentration (ppm)				Mean
		500	1000	1500	2000	
1	Mancozeb 75WP	31.58**^{ij} (27.44)*	33.20^{hi} (30.02)	39.64^{g} (40.70)	46.65^{e} (52.88)	37.77^{d} (37.76)
2	Chlorothalonil 75WP	37.76^{g} (37.51)	53.94^{d} (65.34)	56.04^{cd} (68.77)	59.25^{b} (73.83)	51.75^{b} (61.36)
3	Propineb 70WP	48.05^{e} (55.31)	54.84^{d} (66.84)	57.93^{bc} (71.79)	85.94^{a} (99.50)	61.69^{a} (73.36)
4	Copper Oxychloride 50WP	29.34^{j} (24.05)	35.25^{h} (33.33)	42.98^{f} (46.48)	85.94^{a} (99.50)	48.38^{c} (50.84)
Mean		29.40^{d} (36.08)	35.50^{c} (48.88)	39.37^{b} (56.93)	55.61^{a} (81.43)	-
		Fungicide		**Concentration**		**Fungicide × Concentration**
S. Em. ±		**0.38**		**0.34**		**0.75**
C.D. at 5 %		**1.12**		**1.00**		**2.25**
C.V. %		**3.40**				

**Average of three replications*
*** Arc-sin transformed values*
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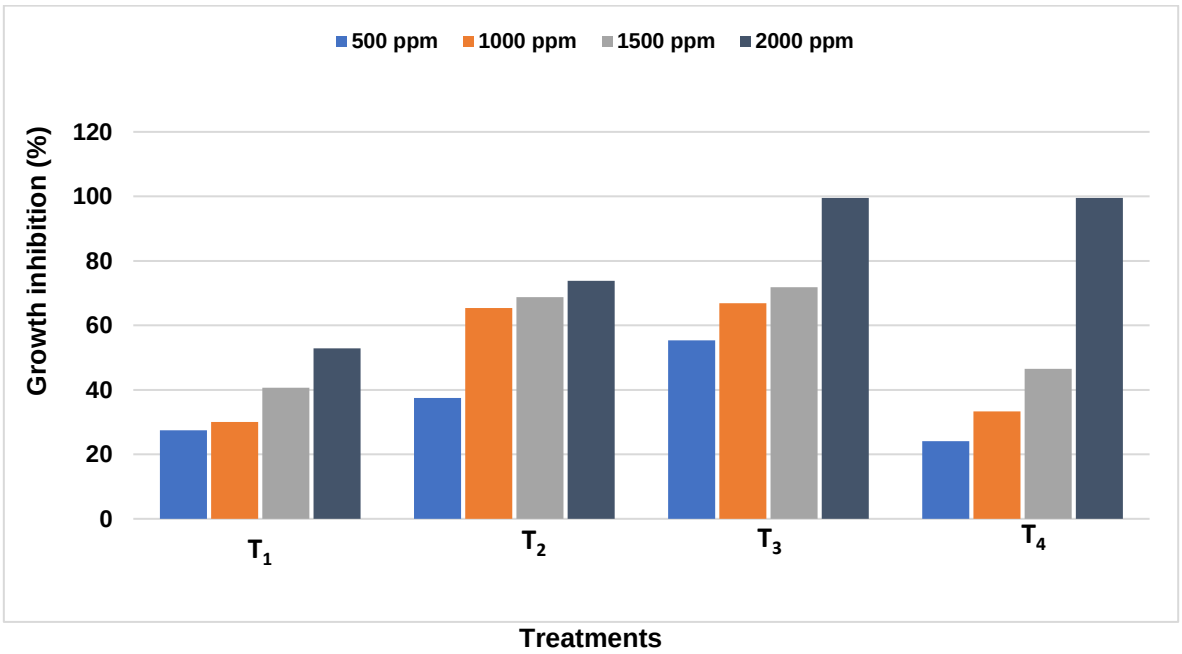

Fig. 2. Growth inhibition of *F. oxysporum* by non systemic fungicides *in vitro*
T_1 - Mancozeb T_3 - Propineb
T_2 - Chlorothalonil T_4 - Copper oxychloride

Of all the combined fungicides tested, carboxin + thiram exhibited the highest efficacy. At the highest concentration (1000 ppm), it achieved an impressive 99.50 per cent growth inhibition, and even at the lowest concentration (100 ppm), it still attained a notable 98.50 per cent growth inhibition. Following closely behind, azoxystrobin + tebuconazole demonstrated significant effectiveness, with 99.50 per cent growth inhibition at the highest concentration (1000 ppm) and 96.67 per cent growth inhibition at the lowest concentration (100ppm).

Table 3. Per cent growth inhibition of *F. oxysporum* by combined fungicides *in vitro*

Sr. No.	Combined fungicides	Per cent growth inhibition* Concentration (ppm)				Mean
		100	250	500	1000	
1	Carbendazim 12WP + Mancozeb 63WP	46.37**^{e} (52.41)*	58.24^{d} (72.29)	80.51^{bc} (97.24)	81.87^{abc} (98.00)	66.75^{c} (79.98)
2	Metalaxyl 8WP + Mancozeb 64WP	28.44^{h} (22.70)	36.66^{g} (35.67)	36.93^{g} (36.12)	45.12^{f} (50.21)	36.79^{d} (36.17)
3	Carboxin 37.5WS + Thiram 37.5WS	82.96^{abc} (98.50)	84.26^{ab} (99.00)	85.94^{a} (99.50)	85.94^{a} (99.50)	84.77^{a} (99.12)
4	Azoxystrobin 11SC + Tebuconazole 18.3SC	79.60^{c} (96.67)	80.64^{abc} (97.35)	81.87^{abc} (98.00)	85.94^{a} (99.50)	82.01^{b} (97.88)
Mean		47.53^{d} (67.57)	52.02^{c} (76.08)	57.10^{b} (82.71)	59.83^{a} (86.80)	-
		Fungicide	**Concentration**		**Fungicide × Concentration**	
S. Em. ±		**0.25**	**0.21**		**0.48**	
C.D. at 5 %		**0.70**	**0.62**		**1.40**	
C.V. %		**1.56**				

**Average of three replications*
***Arc-sin transformed values*
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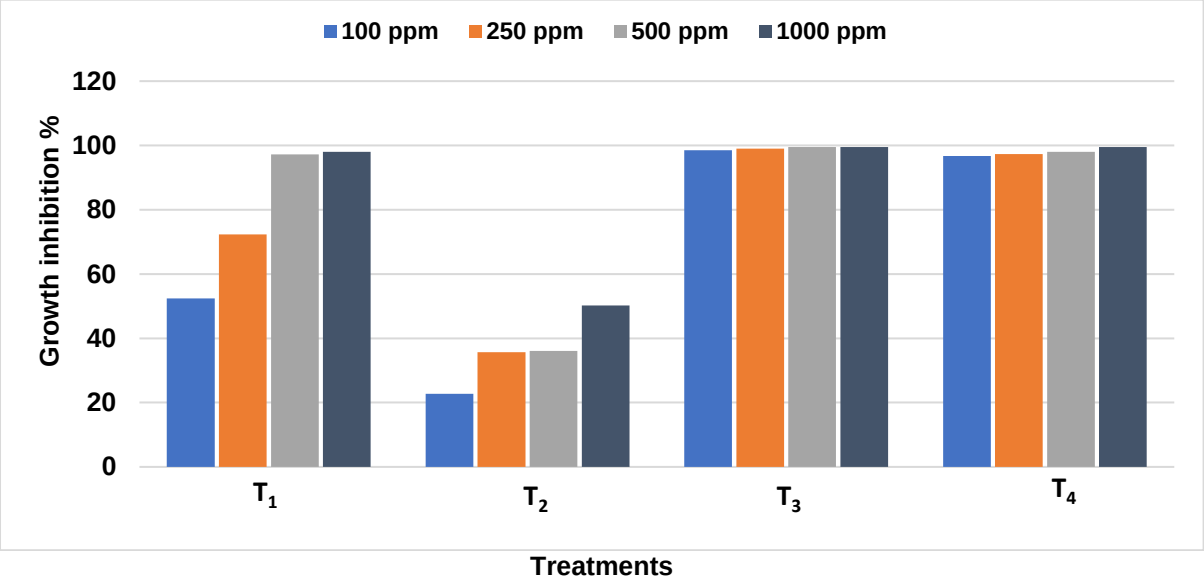

Fig. 3. Growth inhibition of *F. oxysporum* by combined fungicides *in vitro*

T_1 : Carbendazim 12WP + Mancozeb 63WP
T_2 : Metalaxyl 8WP + Mancozeb 64WP
T_3 : Carboxin 37.5WS + Thiram 37.5WS
T_4 : Azoxystrobin 11SC + Tebuconazole 18.3SC

Gurjar and Shekhawat [4] evaluated five fungicides against Fusarium wilt of muskmelon under *in vitro* conditions and observed complete inhibition of mycelial growth of the fungus with carbendazim at all the concentrations tested and difenoconazole and propiconazole at 200 and 500 ppm concentrations.

The efficacy of three fungicides *viz*., carbendazim, carboxin + thiram and propineb were studied under *in vitro* conditions against wilt of chickpea caused by *F. oxysporum* f. sp. *ciceri*. All the test fungicides inhibited the mycelial growth of the fungus. The fungitoxicity of carbendazim was significantly superior as compared to carboxin + thiram and propineb [5].

Bashir et al., [6] evaluated *in vitro* efficacy of different fungicides against wilt of chilli caused by *F. oxysporum* f. sp. *capsici* and found significant reduction in fungal growth with carbendazim at 700 ppm concentrations.

In vitro evaluation was conducted to test the efficacy of seven different fungicides *viz*., azoxystrobin, propineb, thiophanate methyl, difenoconazole, mancozeb, mancozeb + thiophanate methyl, boscalid + pyraclostrobin against wilt of mungbean caused by *F. oxysporum*. Mancozeb + thiophanate methyl (0.15%) was found to be the best which completely inhibited the growth and sporulation of the test fungus, followed by propineb, mancozeb, boscalid + pyraclostrobin and difenoconazole. The least inhibition was recorded with azoxystrobin (55.8%) [7].

Sharma, et al., [8] reported that carbendazim was found most effective against the pathogen with 100% mycelial growth inhibition followed by hexaconazole with 90.77% mycelial growth inhibition whereas, captan and mancozeb were least effective with 32.83% and 55.3% mycelial growth inhibition, respectively.

Different eleven fungicides were tested against *Fusarium oxysporum* of pomegranate in laboratory conditions. Among the tested fungicides propiconazole 25% EC, hexaconazole 5% EC, tricyclazole 75% WP and carbendazim 50% WP significantly inhibited mycelium growth of test pathogen (100%) and noted to be at par with each other [6].

The fungicides evaluated in vitro against Fusarium oxysporum f. sp. lycopersici were effective and reduced the mycelial growth significantly. Among that Carbendazim 50% WP, Copper oxychloride 50% WP and Carbendazim 25% + Mancozeb 50 % WS were found most effective with maximum growth inhibition (100%, 65.22% and 100%) respectively [3].

Sumana *et al* [9] reported that two aggressive isolates (2 Fo and 4 Fo) were taken for the study. The screening was carried out through poisoned food technique using potato sucrose agar (PSA), each at 0.1, 0.2, 0.3 and 0.4% concentrations. The results showed that Carbendazim, Thiophenate methyl, Dithane M-45, Score and Tilt inhibited mycelial growth of both the isolates upto 100% followed by Kocide- 27.7, 16.6%; Calixin – 33.3, 33.3%; Ridomil – 41.5, 53.77% and Bayleton – 83.3, 77.7% respectively.

Four different fungicides namely, carbendazim 50% WP (bavistin), hexaconazole 5% EC (contaf plus), propiconazole 25% EC (Tilt) and thiophanate methyl 70% WP (Roko) at 0.10, 0.15 and 0.20% were evaluated in vitro against Fusarium wilt of chickpea. Carbendazim and propiconazole proved the most effective exhibiting mean mycelial growth inhibition of 100% at all concentrations followed by hexaconazole and thiophanate methyl inhibit mycelial growth of 78.35 and 77.25% at 0.20% respectively [10-12].

The current findings align with previous research, which also recognized carbendazim as an effective fungicide. Consistently, in this study, carbendazim among systemic fungicides, and propineb among non-systemic fungicides, demonstrated high efficacy against F. oxysporum. Notably, among compound fungicides, carboxin + thiram emerged as the most effective in inhibiting the growth of the test fungus.

4. CONCLUSION

In this study, various systemic, non-systemic, and combined fungicides (four of each type) were tested in vitro using the poisoned food technique to assess their efficacy against *F. oxysporum*. The results indicate that carbendazim, among systemic fungicides, and propineb, among non-systemic fungicides, exhibited high effectiveness against *F. oxysporum*. Additionally, carboxin + thiram emerged as the most effective compound fungicide in inhibiting the growth of the test fungus. These findings provide valuable insights for future researchers and students, aiding in the

development of effective management strategies for wilt disease in field conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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