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**Parveen G**
Department of Plant Pathology, College of Horticulture, Bengaluru, Karnataka, India

**Ambika DS**
Department of Plant Pathology, College of Horticulture, Bengaluru, Karnataka, India

**Sangeetha CG**
Department of Plant Pathology, College of Horticulture, Bengaluru, Karnataka, India

**Shivapriya M**
Department of Plant Pathology, College of Horticulture, Bengaluru, Karnataka, India

**Chikkanna GS**
Department of Plant Pathology, College of Horticulture, Bengaluru, Karnataka, India

**Corresponding Author:**
**Parveen G**
Department of Plant Pathology, College of Horticulture, Bengaluru, Karnataka, India

# *In-vitro* evaluation of fungicides at different concentrations against *Fusarium* wilt in muskmelon caused by *Fusarium solani* (Mart.) Sacc.

**Parveen G, Ambika DS, Sangeetha CG, Shivapriya M and Chikkanna GS**

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**Abstract**
The present investigation was undertaken to evaluate potential inhibitory effect of indigenous fungicides (Five systemic, five contact and five combination fungicide) against *Fusarium solani* (Mart.) Sacc., a causal organism of wilt disease in muskmelon crop. *In-vitro* screening of fifteen fungicides was carried out by poisoned food technique using potato dextrose agar each at 500, 1000, 1500, 2000, 2500 and 3000 ppm concentrations. Antifungal activity was measured in terms of per cent inhibition. The results showed that tebuconazole 25.9% WW maximum mean inhibition of 97.74 per cent followed by propiconazole 25% EC 97.40 per cent mean inhibition, while least per cent mean inhibition (28.70%) was observed in case of Copper hydroxide 53.8% DF as compared to control.

**Keywords:** Muskmelon, *Fusarium* wilt, fungicide

## Introduction
Muskmelon (*Cucumis melo* L.) is a major vegetable crop that belongs to the Cucurbitaceae family. Iran is considered as the primary muskmelon development center and secondary centers are India, Afghanistan, Persia, China and Southern Russia. It is a significant river bed crop, accounting for roughly 80% of total muskmelon production (Pradhan, 2014) [7]. The crop is prone to be affected by several diseases *viz.*, powdery mildew, downy mildew, damping-off, *Fusarium* wilt, bacterial wilt, anthracnose, *Alternaria* leaf blight and root knot nematode. Among these, *Fusarium* wilt more destructive soil borne disease, causes reduced yield and fruit quality in muskmelon. The pathogen is soil as well as seed-borne in nature and causes vascular wilts by infecting plants through the roots and growing internally through the cortex to the stele (Bowers and Locke, 2000) [1]. The *Fusarium* wilt infected plants show symptom of wilting, followed by chlorosis and subsequently necrosis of the leaf interveinal regions. Plants that were infected early did not set fruit, while those that were infected later produced little, deformed fruits. On sick vines, cracks are common. The central part of the taproot shows a deep red colour (Kim *et al*., 1993, Majdah and Tuwaijri, 2015) [3, 4]. There are numerous disease management strategies available, including cultural techniques, biological control, resistant cultivars, crop rotation and chemical control methods. Use of chemical method is considered as easiest and effective way to control the *Fusarium* pathogen. Hence in this present investigation, an attempt was made to screen fungicides against the *Fusarium* pathogen as well as to develop a disease management strategy.

## Materials and Methods
The *in-vitro* study was carried out under aseptic conditions at Plant Pathology Department, College of Horticulture, Bengaluru.
Efficacy of fifteen fungicides including five systemic, five contact and five combination fungicides were tested against *F. solani* (Mart.) Sacc. At different concentrations by poisoned food technique (Nene and Thaplyal, 1982) [5] *in vitro* conditions. Fifteen test fungicides (as listed in the Table 1) were incorporated aseptically in sterilized potato dextrose agar medium in a quantity to arrive at a final concentration of 500 ppm, 1000 ppm,

1500 ppm, 2000 ppm, 2500 ppm and 3000 ppm of the poisoned medium was poured in each of the sterilized petri plates. These were the inoculated at the center with a 5 mm disc cut with a sterile cork borer from an actively growing 7-day s old culture of *F. solani* (Mart.) Sacc. The inoculated petri plates were inverted and incubated at 25±1 ºC. Each treatment was replicated three times. Suitable control (without fungicide) was also maintained. The radial growth of *F. solani* (Mart.) Sacc. was recorded after complete growth of fungus in control plate. The per cent inhibition of growth of test fungus over control will be determined using the formula given by Vincent (1947) [9].

PI = 100 (C-T)/C

Where,
PI= Per cent inhibition.
C= Growth of the fungus in control.
T= Growth of the fungus in treatment.

**Statistical analysis**

Data obtained in the investigation for various parameters was subjected to ANOVA for *in vitro* following completely randomized block design. The data generated from various experiments were statistically analysed using WASP and OPISTAT software.

**Results and Discussion**

Five systemic fungicides were tested against *F. solani* (Mart.) Sacc., among which tebuconazole 25.9% W/W gave the best result by maximum inhibition of 98.88 per cent at 3000 ppm (Table 2, plate 1a), which was significantly superior to all other fungicides and the least inhibition of the mycelial growth was in azoxystrobin (42.22%). Among the contact fungicides tested, captan recorded considerable highest mycelial inhibition of 64.07, 67.40, 77.77, 82.96, 84.07 and 86.29 per cent inhibition at 500, 1000, 1500, 2000, 2500 and 3000 ppm respectively, followed by zineb of about 55.55, 67.40, 69.63, 71.48, 75.55 and 75.18 per cent inhibition at 500, 1000, 1500, 2000, 2500 and 3000 ppm respectively, while least per cent inhibition was observed in case of chlorothalonil 57.40 per cent inhibition at 3000 ppm (Table 2, plate 1b). Among the combination products, carbendazim 25% + mancozeb 50% showed 86.29, 90.00, 92.22, 93.70, 95.18 and 96.29 per cent inhibition at 500, 1000, 1500, 2000, 2500 and 3000 ppm respectively, followed by captan 70% + hexaconazole 5% WP of about mycelial growth inhibition of 94.44 per cent inhibition at 3000 ppm. The least per cent inhibition of 75.92 per cent was showed by hexaconazole 4% + zineb 68% recorded of at 3000 ppm (Table 2 and Plate 2).

Among all three groups of fungicides, systemic fungicides were found to be more effective than contact and combination fungicides. Among all fungicide tested tebuconazole 25.9% WW maximum mean inhibition of 97.74 per cent followed by propiconazole 25% EC 97.40 per cent mean inhibition, while least per cent mean inhibition (28.70%) was observed in case of copper hydroxide 53.8% DF as compared to control. There was positive correlation between concentration and inhibition of growth of pathogen. It is inferred from the data presented in Table 2 and Fig. 1 that all the fungicides are significantly effective in inhibition of test pathogen. The results of present investigation have similar findings with the earlier records of Ravichandran and Hegde (2015) [8] tested for four systemic fungicides against Fusarium wilt in chickpea and among all fungicides carbendazim and tebuconazole inhibited complete mycelial growth of pathogen followed by hexaconazole (88.61%). Golakiya *et al.* (2018) [2] tested six systemic fungicides against *Fusarium oxysporum* f. sp. *ciceri*. Tebuconazole inhibited highest mycelial growth (89.19%) followed by carbendazim (67.30%). Tebuconazole (97.74% inhibition) belongs to the triazole fungicide. The other scientists like group and produced the best results among all fungicides tested, making it the best fungicide for Fusarium wilt.

The triazoles are effective Tok inhibitors of ergo-sterol synthesis, the pathogen's major membrane sterol. They inhibit the cytochrome P450-dependent enzyme C-14 alpha-demethylase, which is required for the conversion of ianosterol to ergosterol. Nene and Thapliyal (1973) [6] published similar findings on the efficacy of triazoles, which inhibit the sterol biosynthesis pathway in fungi.

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**Table 1:** List of fungicides used for *in vitro* evaluation against *F. solani* (Mart.) Sacc. by poisoned food method

| Fungicides | Sl. No. | Technical name | Trade name | Concentration (ppm) |
|---|---|---|---|---|
| *Systemic fungicides* | 1. | Hexaconazole 5% SC | Contaf plus | 500, 1000, 1500, 2000, 2500, 3000 |
| | 2. | Tebuconazole 25.9% EC | Folicure | 500, 1000, 1500, 2000, 2500, 3000 |
| | 3. | Propiconazole 25% EC | Tilt | 500, 1000, 1500, 2000, 2500, 3000 |
| | 4. | Thiophanate methyl 70% WP | Roko | 500, 1000, 1500, 2000, 2500, 3000 |
| | 5. | Azoxystrobin 23% SC | Amistar | 500, 1000, 1500, 2000, 2500, 3000 |
| *Contact fungicides* | 6. | Captan 50% WP | Captaf | 500, 1000, 1500, 2000, 2500, 3000 |
| | 7. | Chlorothalonil 78% W/W | Kavach | 500, 1000, 1500, 2000, 2500, 3000 |
| | 8. | Copper hydroxide 53.8% DF | Kocide | 500, 1000, 1500, 2000, 2500, 3000 |
| | 9. | Mancozeb 75% WP | Indofil M-45 | 500, 1000, 1500, 2000, 2500, 3000 |
| | 10. | Zineb 75% WP | Indofil Z-78 | 500, 1000, 1500, 2000, 2500, 3000 |
| *Combination fungicides* | 11. | Hexaconazole 4% + Zineb 68% | Avatar | 500, 1000, 1500, 2000, 2500, 3000 |
| | 12. | Metalaxyl 4% + Mancozeb 64% (68% WP) | Redomil gold | 500, 1000, 1500, 2000, 2500, 3000 |
| | 13. | Carbendazim 25% +Mancozeb 50% | Sprint | 500, 1000, 1500, 2000, 2500, 3000 |
| | 14. | Captan 70% + Hexaconazole 5% WP | Toqat | 500, 1000, 1500, 2000, 2500, 3000 |
| | 15. | Tricyclazole 18% + Mancozeb 62% WP | Merger | 500, 1000, 1500, 2000, 2500, 3000 |

**Table 2:** *In vitro* evaluation of fungicides against *F. solani* (Mart.) Sacc. Causing Fusarium wilt

| | Sl. No. | Fungicide | Percent inhibition of mycelial growth | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Concentration | | | | | | |
| | | | 500ppm | 1000ppm | 1500ppm | 2000ppm | 2500ppm | 3000ppm | Mean |
| i. | 1 | Metalaxyl 4%+Mancozeb 64% WP | 60.00 (50.77) | 64.07 (53.16) | 68.51 (55.87) | 74.07 (59.39) | 75.18 (60.13) | 80.37 (63.71) | 70.37 |
| | 2 | Hexaconazole 4% +Zineb 68% | 51.85 (46.04) | 53.33 (46.89) | 55.55 (48.17) | 59.25 (50.35) | 62.96 (52.53) | 75.92 (60.62) | 59.81 |
| | 3 | Captan 70% + Hexaconazole 5% WP | 80.00 (63.74) | 85.18 (67.61) | 88.88 (70.50) | 91.11 (72.71) | 92.22 (74.33) | 94.44 (76.38) | 88.64 |
| | 4 | Tricyclazole 18% + Mancozeb 62% WP | 05.55 (13.17) | 16.66 (23.88) | 25.92 (30.49) | 51.85 (46.04) | 54.07 (47.32) | 88.88 (70.50) | 40.49 |
| | 5 | Carbendazim 25% + Mancozeb 50% | 86.29 (68.31) | 90.00 (71.55) | 92.22 (73.77) | 93.70 (75.45) | 95.18 (77.31) | 96.29 (78.89) | 92.28 |
| ii. | 6 | Captan 50 % WP | 64.07 (53.16) | 67.40 (55.16) | 77.77 (61.86) | 82.96 (65.59) | 84.07 (66.45) | 86.29(68.31) | 77.09 |
| | 7 | Copper hydroxide 53.8 % DF | 07.40 (15.57) | 14.07 (21.98) | 19.63 (26.25) | 28.51 (32.22) | 31.48 (34.09) | 71.11(57.47) | 28.70 |
| | 8 | Chlorothalonil 78% W/W | 12.59 (20.65) | 19.25 (25.96) | 23.70 (28.86) | 50.74 (45.40) | 52.59 (46.47) | 57.40(49.02) | 36.04 |
| | 9 | Mancozeb 75% WP | 10.37 (18.75) | 16.66 (24.01) | 37.77 (37.87) | 51.11 (45.61) | 64.44 (53.41) | 79.63(61.85) | 43.33 |
| | 10 | Zineb 75% WP | 55.55 (48.23) | 67.40 (55.16) | 69.63 (56.54) | 71.40 (57.73) | 75.55 (60.37) | 75.18(60.11) | 72.46 |
| iii. | 11 | Azoxystrobin 23% SC | 21.11 (27.27) | 23.70 (29.07) | 24.07 (29.37) | 29.25 (32.72) | 35.92 (36.80) | 42.22(40.50) | 29.38 |
| | 12 | Tebuconazole 25.9% WW | 96.66 (79.90) | 97.03 (80.19) | 97.40 (80.93) | 97.77 (81.87) | 98.70 (83.46) | 98.88 (83.91) | 97.74 |
| | 13 | Hexaconazole 5% SC | 64.07 (53.16) | 74.07 (59.47) | 74.07 (59.39) | 77.77 (61.96) | 78.88 (62.69) | 79.63(63.19) | 74.75 |
| | 14 | Thiophanate methyl 70% WP | 74.07 (57.18) | 80.00 (60.25) | 82.96 (65.66) | 84.07 (66.46) | 92.96 (74.65) | 98.51(83.07) | 84.44 |
| | 15 | Propiconazole 25% EC | 93.70 (75.45) | 97.40 (78.07) | 97.40 (80.74) | 98.51 (83.07) | 98.51 (83.07) | 98.86 (83.91) | 97.40 |
| | | Mean | 54.22 | 57.35 | 62.37 | 69.48 | 72.85 | 81.58 | |
| | | | S. Em± | | CD @ 1% | | | | |
| | | Fungicide (F) | 0.950 | | 3.461 | | | | |
| | | Concentration (C) | 0.601 | | 2.189 | | | | |
| | | F X C | 2.327 | | 8.477 | | | | |

Values in parenthesis are arc sine transferred values. Whereas i: Combination fungicide ii: Contact fungicide iii: Systemic fungicide

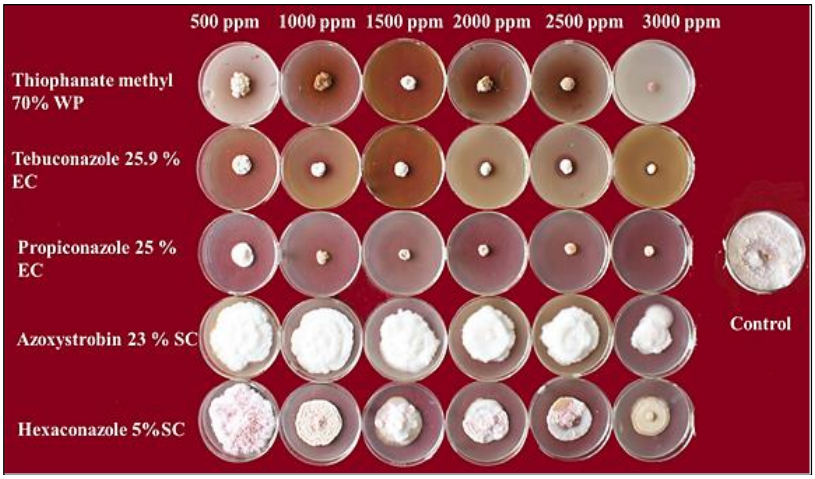


**Plate 1a:** *In vitro* evaluations of systemic fungicides against *F. solani* (Mart.) Sacc.


**Plate 1b:** *In vitro* evaluations of contact fungicides against *F. solani* (Mart.) Sacc.

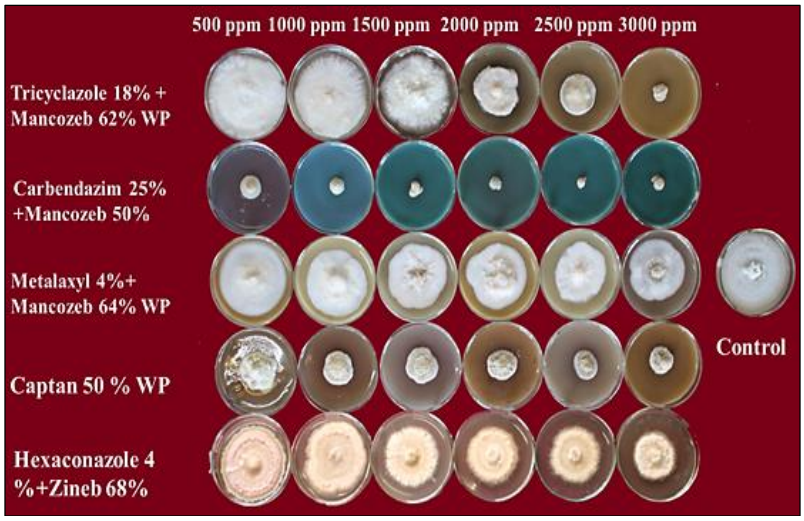


**Plate 2:** *In vitro* evaluations of combination fungicides against *F. solani* (Mart.) Sacc.

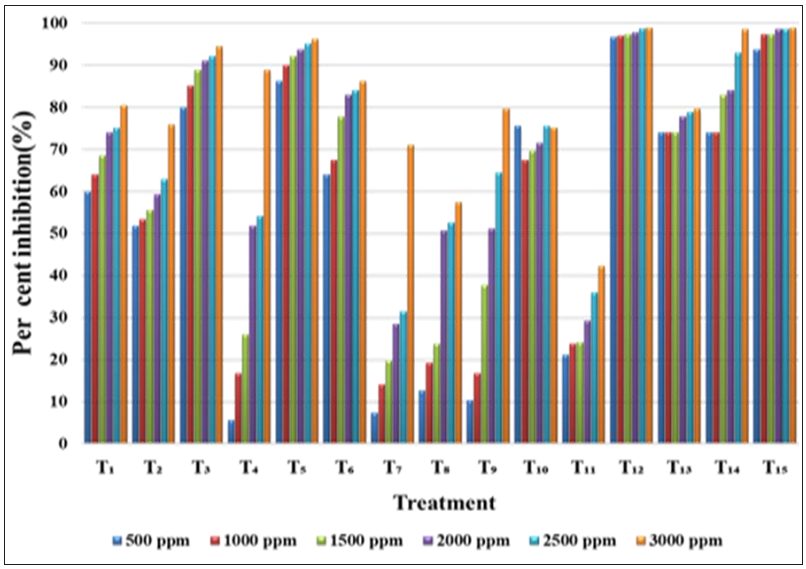


**Fig 1:** *In vitro* evaluation of bio control agents against *F. solani* (Mart.) Sacc.

**Treatments**

$T_1$-Metalaxyl 8% +Mancozeb 64% WP, $T_2$-Hexaconozole 4%+Zineb 68% $T_3$-Captan 70% + Hexaconazole 5% WP, $T_4$-Tricyclazole 18% + Mancozeb 62% WP, $T_5$-Carbendazim 25% +Mancozeb 50%, $T_6$-Captan 50% WP, $T_7$-Copper hydroxide 53.8% DF, $T_8$-Chlorothalonil 78% W/W, $T_9$-Mancozeb 75% WP, $T_{12}$-Tebuconozole 25.9% EC, $T_{13}$-Hexaconazole 5% SC, $T_{14}$-Thiophenate methyl 70% WP, $T_{15}$-Propinconozole 25% EC.

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