Eco. Env. & Cons. 28 (December Suppl. Issue) : 2022; pp. (S47-S52)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i08s.008

The efficacy of various fungicides against tomato *Fusarium* wilt (*Fusarium oxysporum* f. sp. *lycopersici*)

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(Received 2 June, 2022; Accepted 24 August, 2022)

ABSTRACT

The tomato is one of the most popular vegetables farmed worldwide. One of the most harmful tomato disease is *Fusarium* wilt, which is a disease that the fungus *Fusarium oxysporum* f.sp. *lycopersici* causes. Disease causes about 30% to 40% losses in yield. The poisoned food technique was used to assess the fungi-toxic activity of the fungicides Blitox 50, Aliette, Roko, Amistar, Avtar, and Cabrio Top at the plant pathology department of the college of agriculture at LPU, Punjab, throughout the years 2021-2022. Six different fungicides were tested in the lab at various concentrations such as 50, 100, and 150 ppm. Thiophanate Methyl (Roko) show the best result in laboratory. Same fungicides were checked at field. Among this fungicides Copper Oxychloride (Blitox 50) shows the best result in field condition.

Key words: *Tomato, Fusarium wilt, In-vitro, In-vivo, Fungicide, Control.*

Introduction

The second-most significant crop in the world after potatoes is the tomato (*Solanum lycopersicum* Mill.). It originated in tropical America and is now one of the most widely grown Solanaceous vegetables worldwide (Thompson and Kelly, 1957). In India 2019-20, the tomato was cultivated in 818 thousand ha area and its production was 205.50 Lakh tonnes. The largest production was in Andhra Pradesh (2667.43 thousand tonnes); Madhya Pradesh (2655.29 thousand tonnes); Karnataka (2163 thousand tonnes); Tamil Nadu (1592.31 thousand tonnes); Gujarat (1378.78 thousand tonnes) (Indian horticulture database 2020). In many regions, tomatoes are affected by a number of diseases brought on by nematodes, viruses, bacteria, fungi, and other organisms (Mark *et al.*, 2006). *Fusarium* wilt is a prevalent tomato disease that affects both greenhouse and field -grown tomatoes worldwide (Amini *et al.*, 2010; Abdel-Monaim, 2012). According to Mui-Yun (2003), the pathogen is soil-borne and may survive in contaminated soil for up to ten years. Temperatures of 28 °C in the soil and air are perfect for infection. The pathogen will expand into the lower sections of the stem if soil temperatures are optimal but air temperatures are not, but the plants will not show any visible symptoms.

Agrios (1988) discovered thatchlamydospores, macroconidia andmicroconidia are the three forms of asexual spores produced by *Fusarium oxysporum.* Gerlach and Nirenberg, (1982) and Upadhyay and Rai, 1987 investigated the details of *Fusarium oxysporum* f. sp. *lycopersici*. Macro-conidia are fusiform, hyaline, with two to three septates and measuring 2.5-3.3 x 3.5-5.5 µ. Microconidia are one celled, hyaline, ovoid to ellipsoidal, and range in size from 2.5- 4 x 6-15 µ. Chlamydospores develop in older mycelium. Pathogenic *F. oxysporum* strains induce two types of symptoms: vascular wilting and, in rare circumstances, rotting. The fungus that causes vascular wilting enters the host roots and colonises the xylem vessels, causing the plant to progressively yellow and wilt. (Olivain and Alabouvette, 1999). Amutha *et al.,* (2017) reported that Yellowing of a single leaflet or stalk, or slight wilting and drooping of the lower leaves on a single stem are indications of tomato *Fusarium*wilt. Leaves or entire branches may become yellow and dry out, yet they remain attached to the plant (yellow-flagging appearance) by blocking xylem vascular bundles and reducing water transmission, browning of the vascular system produces severe wilting in plants. The fungus infects the epidermal tissues of the roots, travels to the vascular bundles, forms mycelia and/or spores in the vessels, and kills the plants. A leaf or branch may be damaged in half while the other half looks to be unharmed. The vascular tissue of damaged branches has a dark discoloration. Nirmaladevi *et al.* (2016) and Gupta *et al.* (2018) conclude that almost completely destroys the roots, resulting in production losses ranging from 30% to 40%, and it may even reach 90%.

Crop rotation, resistant cultivars,biological control, cultural techniques, and chemical control are some of the disease management measures available according to Kamal *et al.* (2009). Fungicides such as prochloraz-Mn, thiram, imazalil, captafol, and benomyl suppressed root rot and *Fusarium* crown on tomatoes inconsistently, leaving troublesome residues in fruit tissues (Jarvis, 1992; Jarvis, 1988; Marois and Mitchell, 1981). Tomatoes with root rot and *Fusarium* crown were also treated with methyl bromide and chloropicrin (Mc Govern and Vavrina, 1998). Copper chloride, ferric chloride, and manganese sulphate, according to Mandal and Sinha (1992), In order to control *Fusarium* wilt pathogen, resistant tomato plants were developed. Fungicides can boost a crop's genetic potential while also reducing disease-related yield loss. Fungicides used to prevent spore germination and penetration are effective, although the pathogen can develop resistance to them. As a result, fungicides must be treated at regular intervals and in appropriate amounts (Kirk *et al.,* 2005; Kankwatsa *et al.,* 2003).

This study's main objective was to compare the *In-vitro* and *In-vivo* performance of various fungicides against tomato *Fusarium* wilt at various doses. The fungicides known by trade names Blitox 50 W (Copper Oxychloride 50% WP), Aliette (Fosetyl Aluminium 80% WP),Roko (Thiophanate Methyl 70%WP), Amistar (Azoxystrobin 23 % SC), Avtar (Zineb 68 % + Hexaconazole 4 % WP) and Cbrio Top (Metiram 55 % + Pyraclostrobin 5 % WG) were commonly used to control *Fusarium* wilt diseases of tomato crops at Lovely Professional University in Paghawara, Punjab during the years 2021-2022.

Materials and Methods

In-vitro analysis of several fungicides against the tomato *Fusarium* wilt

The effectiveness of six fungicides against *Fol* at three concentrations was evaluated using the poisoned food approach (Falck, 1907). As per the treatment details, fungicides were applied to the PDA medium priorsterilisation. A five-mm disc of *Fusarium oxysporium* f. sp. *lycopersici* was obtained from a seven-day-old culture and put in the Petri dish's middle. The activity of fungicides was measured and compared to control by measuring the colony diameter of *Fusarium oxysporium*f. sp. *lycopersici* in each treatment. In this experiment, six fungicides (Metiram 55% + Pyraclostrobin 5% WG, Zineb 68% + Hexaconazole 4%WP, Azoxystrobin 23%SC, Thiophanate Methyl 70%WP, Fosetyl Aluminium 80% WP, Copper Oxychloride 50% WP) were tested for effectiveness at three different concentrations, 50, 100, and 150 ppm.

The percent suppression of fungal mycelium growth was estimated using Vincent's method (1927).

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

Where,
I = Inhibition percentage
C = Controlled radial growth
T = Treated radial growth.

In-vivo analysis of several fungicides against the tomato *Fusarium* wilt

During Rabi 2021–2022, field tests on the effectiveness of fungicides were done at Lovely Professional University. With seven treatments and three replications, the experiment was created using the Randomized Block Design method. INDUS-1207 tomato variety was used for experiment. The fungicides and its dose were Copper Oxychloride 50% WP @ 2 g, Fosetyl Aluminium 80% WP @ 1g, Thiophanate Methyl 70%WP @ 1gm, Azoxystrobin 23%SC @ 1 ml, Metiram 55% + Pyraclostrobin 5% WG @ 2 g, Zineb 68% + Hexaconazole 4% WP @ 2 g. The first drenching was applied when the first symptoms of wilt was observed in the field, and the second and third drenching were applied 15 days later. Data on disease intensity was collected before the first application, 15 days after the first, second, and third application. A disease rating scale from 0 to 4 was used to compute the Percent Disease Intensity (PDI) (Song *et al.*, 2004) on 10 plants chosen at random in each replication of the treatment.

In 1981, Datar and Mayee's suggested method for calculating the severity of the *Fusarium* wilt of tomato disease was employed.

$$\text{Disease intensity} = \frac{\text{Sum of individual disease ratings}}{\text{Total number of plants inspected} \times \text{Maximum Number of disease rating}}$$

Table 1. *Fusarium* wilt disease rating scale description (Song *et al.*, 2004)

Rating	Reaction Description
0	No wilt symptoms
1	Slightly severity, Plants with leaf wilting (25%)
2	Moderate severity, Plants with leaf wilting (50%)
3	Extensive severity, Plants with leaf wilting (75%)
4	Complete severity, Plants with leaf wilting (100 %)

Results and Discussion

In-vitro analysis of several fungicides against the tomato *Fusarium* wilt

According to the observations, all six fungicides

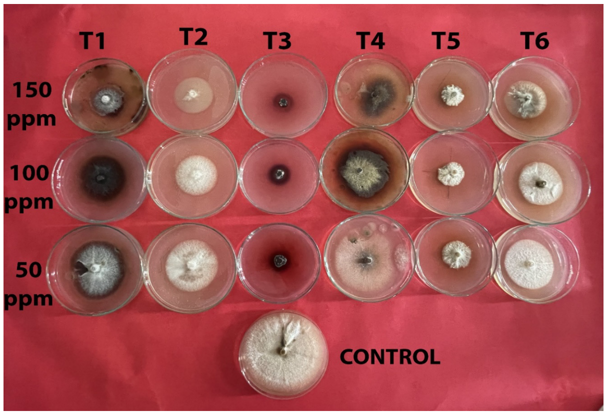
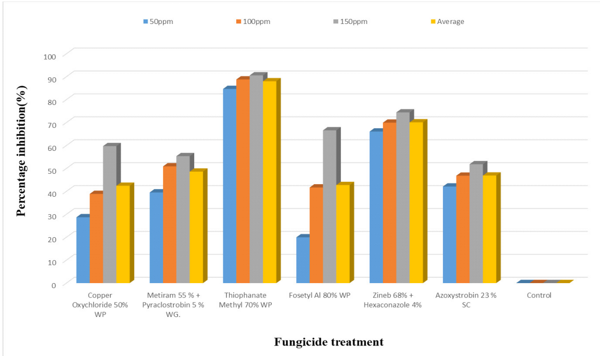


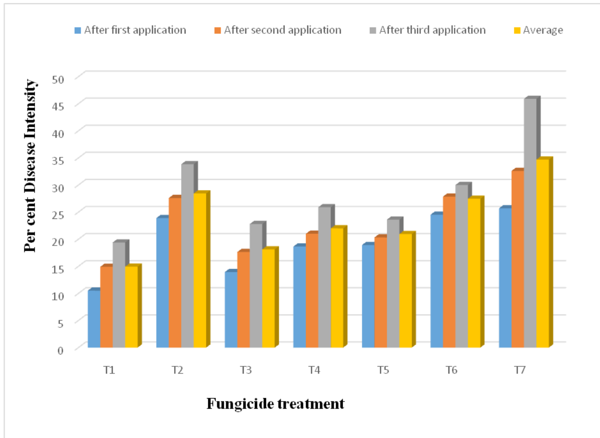
Fig. 1. In-vitro analysis of several fungicides against Folby Poisoned Food Technique

tested at concentrations of 50 ppm, 100 ppm, and 150 ppm prevented this pathogen's mycelial development. Control did not prevent the pathogen's mycelial development. Mycelial growth of *Fol* is inhibited when fungicide concentration rises, which results in a reduction in *Fusarium oxysporium* f. sp. *lycopersici* growth.



Graph 1. *In-vitro* analysis of several fungicides against Fol by Poisoned Food Technique

The fungicides Copper Oxychloride 50% WP and Fosetyl Aluminium 80% WP were less effective as their percent inhibition were very less, i.e. 42.44% and 42.75%. Metiram 55% + Pyraclostrobin 5% WG and Azoxystrobin 23 % SC were moderate effective as their percent inhibition were 48.6% and 46.9% as compared to Thiophanate Methyl 70% WP and Zineb 68% + Hexaconazole 4% WP as their percent inhibition were 88.01% and 70.1%. However, mycelial growth of all the fungicide were also recorded at 50 ppm, 100 ppm and 150 ppm. It was observed that



Graph 2. *In-vivo* analysis of several fungicide on Percentage disease intensity tomato *Fusarium* wilt

the least average mycelial growth was observed in Thiophanate Methyl 70% WP, i.e. 10.75 mm followed by Zineb 68% + Hexaconazole 4% WP, i.e. 26.83 mm, Metiram 55% + Pyraclostrobin 5% WG, i.e. 46.18 mm, Azoxystrobin 23 % SC, i.e. 47.7mm, Fosetyl Aluminium 80% WP, i.e. 51.46 mm and Copper Oxychloride 50% WP, i.e. 51.7 mm (Table 2). Similar kind of result was observed by Gul *et al.* (2021) concluded that the Thiophanate Methyl 70% WP gave highest mycelial percent inhibition in their experiment. Ashish Patiya *et al.* (2020) and Kaushal *et al.* (2019) also reported similar kind of effectiveness of fungicides against *Fol*.

In-vivo analysis of several fungicides against the tomato *Fusarium* wilt

Fungicides were used to determine their efficacy under field condition. Percentage disease intensity (PDI) data at an early stage were recorded regular time intervals of 15 days after drenching. All of the fungicides were shown to be substantially more effective than the control in terms of disease reduction. Copper Oxychloride 50% WP was found more significant according to average, i.e. 14.93% and control was 34.7% followed by Thiophanate Methyl 70% WP, i.e. 18.12%, Metiram 55 % + Pyraclostrobin 5 % WG, i.e. 20.94%, Azoxystrobin 23 % SC, i.e. 22

Table 2. *In-vitro* analysis of several fungicides against Fol by Poison Food Technique

Treatment no.	Treatment	Colony diameter (mm)* 50 ppm	100 ppm	150 ppm	Mean of colony diameter (mm)	Percent Inhibition* 50 ppm	100 ppm	150 ppm	Mean of Percent Inhibition
T1	Copper Oxychloride 50% WP	64.15	54.97	36.2	51.7	28.71	38.89	59.73	42.44
T2	Metiram 55 % + Pyraclostrobin 5 % WG.	54.4	44	40.16	46.18	39.54	50.9	55.36	48.6
T3	Thiophanate Methyl 70% WP	13.8	10	8.46	10.75	84.66	88.8	90.58	88.01
T4	Fosetyl Al 80% WP	72	52.4	30	51.46	19.96	41.7	66.61	42.75
T5	Zineb 68% + Hexaconazole 4%	30.5	27	23	26.83	66.1	69.96	74.43	70.1
T6	Azoxystrobin 23 % SC	52.1	47.8	43.3	47.7	42.11	46.83	51.84	46.9
T7	Control	90	90	90	90	0	0	0	0
	C.D.	0.231	0.448	0.309		0.298	0.39	0.229	
	SE(m)	0.075	0.146	0.101		0.097	0.127	0.075	
	SE(d)	0.107	0.207	0.143		0.138	0.18	0.106	
	C.V.	1.816	3.802	2.893		2.849	3.367	1.814	

*= Mean of three replications

Table 3. *In-vivo* analysis of several fungicide on Percentage disease intensity of tomato *Fusarium* wilt

Treatment no.	Treatment	Per cent Disease Intensity (%) After first application	After second application	After third application	Average
T1	Copper Oxychloride 50% WP	10.5(18.09)*	14.9(22.70)	19.4(26.13)	14.93(22.73)
T2	Fosetyl Aluminium 80% WP	23.9(29.26)	27.6(31.69)	33.83(35.56)	28.44(32.22)
T3	Thiophanate Methyl 70% WP	13.94(21.92)	17.64(24.83)	22.8(28.52)	18.12(25.19)
T4	Azoxystrobin 23 % SC	18.65(25.58)	21(27.27)	25.9(30.59)	22(27.97)
T5	Metiram 55% + Pyraclostrobin 5% WG	18.92(25.78)	20.32(26.79)	23.6(29.06)	20.94(27.23
T6	Zineb 68% + Hexaconazole 4%WP	24.52(29.68)	27.86(31.85)	30(33.21)	27.46(31.60)
T7	Control	25.7(30.46)	32.6(34.81)	45.9(42.64)	34.7(36.09)
C.D.	4.802				
SE(m)	1.541				
SE(d)	2.18				
C.V.	11.225				

*Arc sine converted values are shown in parentheses.

%, Zineb 68% + Hexaconazole 4% WP, *i.e.* 27.46% and Fosetyl Al 80% WP, *i.e*. 28.44%. Blitox 50 W, Roko and Cbrio Top were more effective over control than other, *i.e.* Azoxystrobin 23% SC, Zineb 68% + Hexaconazole 4% WP and Fosetyl Al 80% WP. Similar kind of result observed by Adnan Baloch *et al.* (2021) reported that Copper Oxychloride 50% WP was the most effective fungicide against wilt disease. Gayatri Biswal and Dinesh Singh (2020) and Amini and Sidovich (2010) also reported similar kind of effectiveness of fungicides against Fuasrium wilt of tomato.

Conclusion

Under this investigation, we came to the conclusion that Roko fungicide was most efficient at inhibiting mycelium growth of *Fol* in *In-vitro* conditions. Furthermore, Blitox fungicide shown to be the most efficient in *In-vivo* conditions when used to treat *Fusarium oxysporum* f. sp. *lycopersici.*

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