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EFFICACY OF DIFFERENT FUNGICIDES AGAINST FUSARIUM WILT AND THEIR IMPACTS ON HEIGHT AND YIELD OF TOMATO CROP UNDER THE TUNNEL FARMING CONDITION

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ABSTRACT

Tomato (*Lycopersicon esculentum* Mill.) is attacked by various disease causing micro-organisms. Among them Fusarium wilt is the major destructive disease of tomato. This study was conducted to test the efficacy of different fungicides i.e. metalaxyl+mancozeb, copper oxychloride, benalaxyl+mancozeb, carbendazim and mancozeb at different concentrations (2, 2.5, 3, 3.5, 4 g/litre water) against the fusarium wilt of tomato caused by *Fusarium oxysporum* f. sp. *lycopersic*i and also to observe the impacts of fungicides on plant height and yield under tunnel condition. The result revealed that copper oxychloride was significantly effective in all its doses to control the Fusarium wilt of tomato, the most effective dose was 3 g/l where the disease severity was recorded 6.2 percent only, followed by metalaxyl+mancozeb (4g/l) in which the disease severity was recorded 9.6 percent, other fungicides also showed good result but mancozeb alone was not effective, however it had synergistic effect and can be used as a base with the other fungicides for controlling the fusarium wilt. Two of the fungicides proved to be the most appropriate chemicals having no severe impacts on plant height and yield. The highest plant height was recorded 10.96 and 9.38 feet whereas the highest yield per plant was recorded 3.97 and 3.67 kg in case of copper oxychloride and metalaxyl+mancozeb respectively.

Keywords: Tomato, tunnel, fusarium wilt, fungicides, height, yield

INTRODUCTION:

Tomato (*Lycopersicon esculentum* Mill.) is the second most important *solanaceous* vegetable crop after potato and it is one of the most vital vegetables economically in the world including Pakistan. It is sensitive to various fungal diseases which bring huge losses to its production. Fusarium wilt of tomato that is caused by *Fusarium oxysporum* f. sp. *lycopersici* is one of the most severe diseases of tomato under favorable weather conditions, particularly the susceptible varieties are noticeably damaged which bring huge loses to its growers (Hanaa *et al.* 2011). Fusarium wilt is a disorder that carries gigantic economic losses to tomato crop (Agrios 2005). It is a serious problem in tomato which brings 25% reduction in tomato production worldwide (Fravel *et al*., 2005; Walker, 1971). In Pakistan, 49.5% yield reduction due to this disease has been reported by FAO, 2015. Even though *Fusarium oxysporum* of tomato has been reported to widely spread through soil, however Reis *et al.* (2007) studied that the contaminated seeds of tomato are also the main source for the spread of this disease. The fungus establishes its colony on the xylem of the host plant, and consequently breakdown and blockage of the xylem take place and later on the symptoms of wilt start appearing i.e. leaf yellowing and wilting, and ultimately the death of the plant (Hanaa *et al.* 2011; Bennett, 2008). The Fusarium diseases cause vascular wilts by infecting the plants via roots and growing internally through the cortex to the stele (Bowers and Locke 2000). Getting rid of wilt disease of tomato depends on proper management of *Fusarium oxysporum* is needed, as this microorganism and its numerous unique forms affect many economic variety of crops.

There are certain fungicides used to effectively control this disease. Sultana and Abdul (2013). used the fungicides, aliette, benlate and carbendazim, mancozeb, ridomil, topsin-m and vitavax *in-vitro* and *in-vivo* to control *Fusarium oxysporum*, and found that these fungicides were effective against the pathogen. Nedelcu and Alexandri (1995) *in vitro* evaluated copper oxychloride on *F. oxysporum* f. sp. *lycopersici* and found that the fungicide had a strong effect to control tomato diseases.

There are number of chemicals they control the diseases but leave negative impacts on plant height and yield, thus this study was conducted to record the efficacy of the fungicides against the Fusarium wilt of tomato cv. APCL that is susceptible to *F. oxysporum*, and as well as to observe the negative impacts of fungicides on the plant height and yield under the tunnel condition..

MATERIALS AND METHODS

Fungal pathogen growth: The contaminated parts of tomato were gathered in the tunnels and kept in polythene packs, labeled appropriately and then taken to the Laboratory of Plant Pathology, Directorate of Vegetable Seed Production, Agriculture Research Institute, Quetta, Pakistan in 2019. The fungus from tomato branches with necrotic tissues was isolated. Measuring 3 to 5 cm in length portion of stems of tomato plant having vascular staining were cut and flushed altogether in tap-water and then they were superficially sterilized in 5% sodium hypochlorite for about two min. After that those cut pieces were again flushed in distilled water for multiple times, sterile filter papers were used to dry them and then they were plated onto the most utilized medium potato-dextrose-agar (PDA) that was already adjusted with streptomycin sulfate (250 mg/l). The plated pieces in petri dishes were placed in incubator for about 2 weeks at 24 to 28°C. The isolates of fungus were cleaned up by sub-culturing and chosen by single spore isolation technique on dried agar culture. To identify the concerned species of Fusarium, Gerlach and Nirenberg (1982) keys and findings were followed. Isolates of *F. oxysporum* utilized in the current experiment were raised on potato-dextrose agar at 24 to 28°C for about fourteen days. To obtain a suspension of $1x10^6$ spores/ml, spores from the surface of the 14 days old culture were removed carefully by adding sterile distilled water. Afterward, using a haemocytometer the suspension of spores was refined by a muslin cloth folded in two layers to obtain the desired concentration of spores.

Plant material: Tomato seeds of cv. APCL were superficially cleaned in 0.5 percent sodium hypochlorite solution for two to three minutes, washed in distilled water 3 times preceding sowing. The washed seeds were sown in trays (seedling plug size 3.4/5 cm, 64 plugs) containing standardized medium-sand and soil (80:20). Then the trays were kept in a glasshouse at 24 to 28°C maintaining 60 to 70% relative humidity, 16 hours light and 8 hours darkness.

Pathogenicity tests and race determination: Pathogenicity tests using root-dip inoculation was tested on six-week-old tomato seedlings at the three-true-leaf stage. For ten minutes the seedling roots were kept in the suspension of conidia ($1x10^6$ spores/ml) of tested isolate, later the concerned seedlings were moved into plastic high tunnel (Amini, 2009).

Efficacy of different fungicides against Fusarium wilt of tomato under the tunnel farming condition:

Five fungicides: metalaxyl+mancozeb, copper oxychloride, benalaxyl+mancozeb, carbendazim, and mancozebat different concentrations (2,2.5,3,3.5,4 g/litre water) were applied by soil drench method individually seven days after inoculation to assess their effects against the fusarium wilt of tomato under tunnel condition. Plants in the control in the similar way were treated with the distilled water and then the concerned pathogen was inoculated in them (with-out fungicides). The experiment was arranged in a completely randomized design having 5 replications for every treatment. The disease infestation was measured after 50 days as a total per-cent age seedlings with certain Fusarium wilt symptoms (leaf yellowing and falling, vascular staining, and the loss of height). Followed by Bhatti et al. 2021

Disease severity assessment: The disease index (Grattidge and O'Brien 1982) was established to measure the disease infestation 50 days after inoculation using the given scales: 0, (0-24%) of yellowed and wilted leaves; 1, (25-49%) of yellowed and wilted leaves; 2, (50-74%) of yellowed and wilted leaves; 3, (75-99%) of yellowed and wilted leaves; 4, (100%) dead plant.

Data analysis: All of the experiments were organized in a completely randomized design. At p=0.05, the least significant difference (LSD) test was used to compare mean values. To compare means, Duncan's multiple Range test was used with a p=0.05 significance level. All statistical work was carried out with the help of (Statistix 8.1).

RESULTS AND DISCUSSIONS

Fungal isolate and pathogenicity tests: Pathogenicity test of the isolate was affirmed on tomato cv. APCL (Susceptible to Fusarium species). Two weeks after inoculation, the symptoms of the disease started to appear on the plants infected with the pathogen. The pathogen isolate used, showed typical symptoms of Fusarium wilt and it was found to be highly virulent against cv. APCL. Yellowing and drooping of lower leaves were the first signs of the disease. The symptoms appeared on one side of the infected plant or on one of the shoots. Finally, diseased plants showed stunting and brownish vascular staining, and death (Fig.1). Therefore, pathogenicity of tested isolate on tomato cultivar

APCL was clearly distinct. The same fungus species was re-isolated from the discolored vascular tissue of diseased plants stem.

Identification of Fusarium species and race determination: The morphological criterion used to identify *F. oxysporum* f. sp. *lycopersici* were concentrated on Gerlach and Nirenberg (1982) sources. The mycelium of the pathogen ranged in colour from cottony white to pink, with a purple shade in the medium. Micro-conidia were abundant, oval-ellipsoid, straight to bent, 4-12x2.1-3.5 µm, and born on simple phialides occurring laterally. Macro-conidia were thin-walled, three to five septate, fusoid-subulate, and pointed at both ends with a pedicellate base, and were born on branched conidiophores or on the surface of sporodochia. The presence of three septate spores was more usual. Smooth and rough-walled chlamydospores were common, and they evolved terminally. There was no indication of sexual stage. The race determination results showed that APCL susceptible to Fusarium species wilted four weeks after inoculation. The outcomes of the recent experiment on race determination pointed out that all the isolates were linked to *F. oxysporum* f. sp. *lycopersici*.

Efficacy of different fungicides against Fusarium wilt of tomato under the tunnel farming condition:

Symptoms started to appear on untreated plants within a month after inoculation; the initial symptoms were yellowing and wilting of the leaves. All the five fungicides metalaxyl+mancozeb, copper oxychloride, benalaxyl+mancozeb, carbendazim and mancozeb were significantly (P =0.0000) effective against the fusarium wilt of tomato under tunnel condition (Fig.2 and 3). Among all the fungicides copper oxychloride was significantly effective in all its doses, the disease severity of fusarium wilt of tomato was recorded 6.2 and 6.4 percent when applied @ 3 and 3.5 g/l water respectively, followed by metalaxyl+mancozeb with 9.6 percent disease severity when applied @ 4 g/l. All the other fungicides were effective in reducing the disease severity with the highest doses; however mancozeb alone did not show considerable effectiveness against the pathogen but it had synergistic effect and can be used as a base with the other fungicides for controlling the Fusarium wilt. The disease severity was recorded 18.4 and 19.0 percent when applied carbendazim and benalaxyl+mancozeb @ 4 g/l respectively (Table.1). The results are with accord to Ramaiah and Garampalli (2015) found that copper oxychloride was most effective in inhibiting the Fusarium wilt of tomato; they also observed that carbendazim and mancozeb also showed good result controlling the test fungus. Nedelcu and Alexandi (1995) also found the copper oxychloride an effective fungicide against the concerned pathogen. Dahal and Shrestha (2018) studied that carbendazim was an effective fungicide against the *Fusarium oxysporum*. Amini and (Sidovish 2010; Akrami and Yousefi, 2015) studied the effectiveness of some fungicides in greenhouse and found that that carbendazim was not as effective as prochloraz and bromuconazole to control the *Fusarium oxysporum* f. sp. *lycopersici.*

Fig.1

Fig.2

Fig. 3

Table-1: Efficacy of different fungicides against Fusarium wilt of tomato under the tunnel farming condition

Fungicides	Doses (g/ litre water)	Disease Severity %
Metalaxyl+Mancozeb	2	42.0 cde
	2.5	18.0 ghij
	3	15.6 hijk
	3.5	15.0 hijk
	4	9.6 ijk
Copper oxychloride	2	27.2 fg
	2.5	13.4 hijk
	3	6.2 k
	3.5	6.4 k
	4	7.4 jk
Benalaxyl+Mancozeb	2	44.6 cd
	2.5	27.2 fg
	3	22.0 gh
	3.5	20.0 ghi
	4	19.0 ghi
Carbendazim	2	52.6 bc
	2.5	33.2 ef
	3	22.2 gh
	3.5	22.0 gh
	4	18.4 ghi
Mancozeb	2	56.6 b
	2.5	49.6 bcd
	3	42.0 cde
	3.5	40.6 de
	4	33.2 ef
Control	0	76.6 a
LSD (p<0.05)		P = 0.0000

Impacts of different fungicides on plant height and yield of tomato under the tunnel farming condition: Copper oxychloride proved to be most appropriate fungicide having no severe impacts on plant height and yield followed by metalaxyl+mancozeb. The highest plant hei-ght was recorded 10.96 and 9.38 feet in case of copper oxychloride and metalaxyl+ manco-zeb respectively. The impacts of other fungi-cides almost had minor differences while mancozeb left a severe impact on the plant height, recorded to be the smallest after cont-rol. Whereas the highest yield per plant was recorded 3.97 and 3.67 kg in case of copper oxychloride and metalaxyl+mancozeb resp-ectively, while the lowest yield was recorded by mancozeb after control (Table.2, Fig.3). The results are with close agreement to (Ali *et al.* 2020; Nizamani *et al*., 2020); Poussio et al. 2021) found that the highest plant height and yield of cv. APCL were 9.72 feet and 4.29 kg respectively.

Table-2: Impacts of different fungicides on plant height and yield of tomato under the tunnel farming condition

Fungicides	Plant Height (feet)	Yield per plant (kg)
Metalaxyl+Mancozeb	9.38 b	3.67 a
Copper oxychloride	10.96 a	3.97 a
Benalaxyl+Mancozeb	7.60 c	3.10 b
Carbendazim	6.20 d	2.92 bc
Mancozeb	5.10 e	2.64 c
Control (No fungicide)	3.00 f	1.60 d
LSD (p<0.05)	P = 0.0000	

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