

Laboratory assessment of botanicals, bio-control agents and fungicides combating *Exserohilum turcicum*-inducing Turcicum leaf blight in maize

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Abstract The research focuses on the management of Turcicum leaf blight, a foliar disease caused by *Exserohilum turcicum* in maize crops. The disease leads to significant yield losses (25-90%) and is typically managed with fungicides, which pose environmental and toxicity concerns. The study explores alternative methods, including botanicals, bio-control agents, and fungicides. Among eight botanicals tested, extracts from parthenium, onion, neem, and tarvad exhibit effectiveness against *E. turcicum*. Bio-control agents, particularly *Trichoderma harzianum*, showed promising results in inhibiting the pathogen. Among fungicides, carbendazim 12% + mancozeb 63% WP demonstrates 100% inhibition of *E. turcicum* mycelial growth at half of the recommended and recommended concentrations, outperforming other fungicides such as azoxystrobin 18.2% W/W + cyproconazole 7.3% W/W (96.66% and 97.22% respectively) and pyraclostrobin 133 g/l + epoxiconazole 50 g/l SE (85.55% and 88.33% respectively). kresoxim-methyl 44.3% SC exhibits the least inhibitory effect (27.15% and 29.07% respectively). These findings suggest potential alternatives for managing Turcicum leaf blight with reduced environmental impact.

Keywords: Maize · *Exserohilum turcicum* · Biological control · Botanicals · Fungicides

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Introduction

Maize (*Zea mays* L.) is a cereal grain belonging to the family Gramineae/Poaceae. Due to its several uses it also called as ‘Queen of Cereals’. The crop is native of Central America and Mexico by origin (Pursglove, 1972; Dowswell *et al.*, 1996). Maize is a widely cultivated crop and it is grown throughout the world in tropical, sub-tropical and temperate climate under irrigated to semi-arid condition. Maize is considered as a versatile crop as it adapts to the wide range of production environments. Maize grain contains carbohydrates ranges from 63-69%, protein contents ranged from 11–13%, 4-7% oil, (Khan *et al.*, 2014). Maize also contains significant quantities of nicotinic acid, riboflavin and vitamin A with high content of carbohydrates, proteins, fats, vitamins and minerals. It is an important feed and food crop and it ranks third following wheat and rice not only in India but also in the world (Khokar *et al.*, 2021). It is perceived as a major cereal crop having great agro-economic value because of its expanded use in many agro-industries. It provides food, fodder, feed and serves as source of primary raw material for a number of industrial products *viz.*, starch, oil, protein, alcoholic beverages, cosmetics, food sweeteners, bio-fuel, etc. Maize is utilized as staple food by the lower strata of society and also used as a crop of par excellence for industrial use.

During the year 2019-2020, total world production of rice was 509.2 million tonnes, production of wheat was 761.5 million tonnes while that of maize was 1147 million tonnes (Anonymous, 2023). Since pre-historic times, maize has been staple food for majority of the people in Latin America, Mexico and Central America. In the world, important producer of the maize crop is USA (346 million tonnes), China (260.8 million tonnes), Brazil

(102 million tonnes), European Union 27 (66.74 million tonnes), and India (31 million tonnes). India ranks 4th in terms of area with 9.89 million ha land under maize. The USA is the top maize producer followed by China, contributing 36% and 25% of world maize production. However, India remained among the top 10 producers of maize in the World since 1961 and presently ranks 6th with annual output of 31.65 million MT (Anonymous, 2023). Total cultivated area under maize in India is about 9.2 million hectares of total annual production of 27.8 million tons of grain and average yield of 3.02 tonnes per hectare which ranks third in production and contributes to about 2 per cent of the world production along almost 4 per cent share in world harvested area in the year 2018-19. In India, states *viz.*, Karnataka, Andhra Pradesh, Maharashtra, Tamil Nadu, Rajasthan and Uttar Pradesh together contribute to 60 per cent of area and 70 per cent of maize production (Anonymous, 2020). Maharashtra is emerging as a major maize growing state in the country, accounting for 10 per cent of total maize area with 0.92 million hectares equally contributing to the total maize production in the country. Maize cultivation reaches its boom in terms of acreage due adoption of modern crop production practices like, using chemical pesticides, chemical fertilizers and also use of some commercial hybrids. These factors in various ways led the maize crop to become vulnerable to many pests and diseases at the farmer's field. Among the different diseases infecting maize crop, foliar diseases are of significant importance and destroy the leaves of crop and result in great yield reduction.

Maize is prone to about 112 diseases in various parts of the world. These diseases caused by fungi, bacteria, viruses and nematodes, results in extensive damage and yield loss. In India, about 60 diseases have been reported which affects the maize crop (Hooda *et al.*, 2018). On the basis of research studies conducted during the last few years under the All India Coordinated Maize Improvement Project, out of 61 diseases reported in country, about 16 diseases adversely affecting maize crop have been recognized as major diseases. Among all the foliar diseases discovered in maize, the turcicum leaf blight (Northern corn leaf blight) caused by *Exserohilum turcicum* (Pass.) Leonard and Suggs. (syn. *Helminthosporium turcicum* Pass.) is of worldwide importance. Turcicum leaf blight is popularly known as

Northern Corn Leaf Blight (NCLB) in the United States of America. Mild temperature and high humidity favour the disease development (Ullstrup, 1970). Environmental factors like heavy dews, frequent rains and cool temperature are favourable for disease development (Jordan *et al.*, 1983). The disease and pathogen were first reported by Passerini in 1876 from Parma, Italy. In India, this disease was first recorded by Butler *et al.* (1920). The disease is more prevalent in the states *viz.*, Andhra Pradesh, Himachal Pradesh, Karnataka and Maharashtra. Turcicum leaf blight is considered to be one of the most destructive foliar diseases in Karnataka region and results in reduction of grain yield by 28 to 91 per cent (Harlapur, 2005). The pathogen causing turcicum leaf blight overwinters in the crop residues such as infected leaves, corn husks and other plant parts (Smith *et al.*, 2004). The disease is known to affect crop from seedling stage up to harvest. Reduction in grain yield of crop is more if disease occurs at flowering, silking and grain filling stages of crop. The disease causes leaf necrosis and premature death of foliage which reduces the grain and fodder value of the crop. Symptoms of disease appear as a oval, water soaked, small spots on the leaves which gradually grow into long, elongate, elliptical, spindle shaped greyish green lesions ranging from 2.5 to 15 cm in length (Rai *et al.*, 2010).

Use of fungicides for the control of plant diseases is a common practice. However, use of plant extracts in disease management is considered as eco-friendly, eliminating chances of environmental pollution and sustainable approach for disease management. Moreover, frequent use of fungicides in disease management has led to resistance development in various pathogens. No doubt in the past few decades fungicides have protected the plants from diseases, their continuous and over use resulted in some serious ecological problems, like residual effects, hazardous effects on beneficial organisms in soil and resistant strain development in pathogen. Now a day, some combi-fungicide are available in market which is effective in disease control. With this view present investigation was carried out to test newer fungicides, botanicals and bio-control agents against *Exserohilum turcicum* under laboratory conditions with the following objectives, to test the efficacy of various botanicals, biocontrol agents and fungicides against the pathogen under *in vitro* conditions.

Material and methodology

In vitro evaluation of plant extracts against *E. turcicum*

Preparation of aqueous plant extracts by crude extraction method

The experiment was carried out in Plant Pathology laboratory at Department of Plant Pathology and Microbiology, MPKV, Rahuri.

The crude extracts of eight plant spp. were prepared from their plant parts. Plant parts used for extract preparation (leaves, bulb) were collected and thoroughly washed with tap water and air dried. Ten gm of plant material was weighed and then crushed in mortar and pestle by adding 10 ml of sterile water (1:1 w/v). The macerated material was then filtered through muslin cloth and subsequently through Whatman No. 40 filter paper. The supernatant was taken as standard plant extract solution (100%). Further extract was diluted by adding sterilized distilled water to get 5, 10 per cent concentration.

In vitro evaluation of plant extracts against *Exserohilum turcicum*

The aqueous plant extracts were evaluated at 5 and 10 per cent concentration by poisoned food technique for their efficacy in inhibiting the mycelial growth of turcicum leaf blight pathogen i.e. *Exserohilum turcicum*. The plant extracts were tested at two concentrations i.e. 5 and 10% concentration and this was achieved by adding 5 ml and 10 ml supernatant of each plant extract into 95 ml and 90 ml of PDA media in conical flasks, respectively and such conical flasks containing PDA (food) and plant extract (poison) were sterilized by autoclaving at 15 psi for 20 minutes (Sood and Dohroo, 2003). Twenty ml PDA containing plant extract were poured into sterilized Petri plate under aseptic conditions and allowed to solidify. PDA plates containing plant extracts were inoculated aseptically in the centre with 5 mm disc of 10 days old sporulating culture of *Exserohilum turcicum*. Three replications were maintained for each treatment. Petri plates without any plant extract and inoculated with pathogen served as control. All the inoculated petri plates were incubated at 25±1°C in the laboratory. The radial growth of test fungus in the treated plates was measured when pathogen growth in control touched the edges of petri dishes. The per cent

inhibition of fungal growth was evaluated by using the formula given by Vincent (1927).

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

Where, I= Per cent inhibition, C = Colony diameter in control, T= Colony diameter in treatment

In vitro evaluation of bio-control agents against *Exserohilum turcicum*

Bio-control agents were evaluated for their antagonistic potential against pathogen using dual culture technique (Morton and Stroube, 1955). Twenty ml of PDA per petri plate was poured and allowed to solidify. Five mm discs of *E. turcicum* taken from seven days old culture was placed at one end of petri plate and respective antagonistic organism (5 mm) was inoculated at the opposite side of the petri plate. The test pathogen being relatively slow growing was incubated 48 hours prior to *Trichoderma* spp. to cope up with the fast growth of *Trichoderma* spp. In case of bacterial antagonist *E. turcicum* was placed at the one end of petri plate and the bacterial culture was streaked at the other half of the petri plate. Three replications were maintained for each treatment. Control having test pathogen only was kept for comparison. Petri plates were incubated for seven days at 25±1°C. The activity of antagonistic organisms was recorded after 96 hours by measuring colony diameter of test pathogen i.e. *E. turcicum* in each treatment and compared with control. Per cent growth inhibition of the test pathogen over control was calculated according to the formula given by Vincent (1927).

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

Where, I= Per cent inhibition, C = Colony diameter in control, T= Colony diameter in treatment

In vitro evaluation of fungicides against *Exserohilum turcicum*

Seven fungicides consisting of two systematic viz., kresoxim-methyl 44.3 SC, propiconazole 25 EC; one non-systematic viz., mancozeb 75 WP and four combo-products viz., azoxystrobin 18.2 W/W + cyproconazole

7.3 W/W, azoxystrobin 18.2 W/W + difenoconazole 11.4 W/W, pyraclostrobin 133g/l + epoxiconazole 50 g/l and carbendazim 12 + mancozeb 63 WP were assayed for their efficacy against *E. turcicum* under *in vitro* condition. Poisoned food technique was adopted for *in vitro* testing of fungicides (Nene and Thapliyal, 1979). The calculated amount of fungicide was thoroughly mixed in the medium before pouring into the petri plates so as to get the desired concentration of active ingredient of each fungicide separately. Twenty ml of fungicide amended medium were poured in each of 90 mm sterilized petri plates and allowed to solidify. The plates were inoculated centrally with five mm disc of ten days old young sporulating culture of *E. turcicum*. For each treatment three replications were maintained and petridishes without fungicidal treatment along with pathogen were kept as control. The inoculated Petri plates were incubated at $25\pm 1^\circ\text{C}$ in the laboratory. The colony diameter was measured when fungus touched the periphery in control plates. Per cent inhibition of growth were calculated by using formula given by Vincent (1927).

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

Where, I= Per cent inhibition, C = Colony diameter in control, T= Colony diameter in treatment

Statistical analysis

The data represented arithmetical averages of three replications and Completely Randomised Design (CRD).

The results of all the experimental treatments were statistically analysed by the methods of analysis of variance (ANOVA) as described by Panse and Sukhatme (1978).

Result and discussion

In vitro evaluation of different plant extracts @ 5% concentration against *Exserohilum turcicum*

From the data presented in Table 1, it is revealed that all the plant extracts were significantly superior over control in reducing the mycelial growth of *E. turcicum* at 5% concentration. Among all the treatments maximum inhibition of mycelial growth (56.92%) was in *Parthenium hysterophorus* extract with least colony diameter of 38.77 mm and this treatment was followed by *Allium cepa*, *Azadirachta indica* and *Senna auriculata* extracts with 55.11, 51.85 and 49.22 per cent inhibition of mycelial growth respectively. Thus, plant extracts viz., *Parthenium hysterophorus*, *Allium cepa*, *Azadirachta indica* and *Senna auriculata* were at par with each other at 5% concentration in inhibiting the fungal growth. Among all plant extracts evaluated minimum inhibition (29.29%) was recorded with *Vitex negundo* extract. Maximum colony diameter (90.00 mm) of fungus was recorded in control treatment (Figure 1A).

The results given in Table 1 shows that all plant extracts at 10% concentration significantly inhibited the mycelial growth over the untreated control. Among all treatments maximum inhibition of mycelial growth

Table 1. Evaluation of different plant extracts @ 5% and 10% concentration against *Exserohilum turcicum* under *in vitro* condition

Tr. No.	Plant spp.	Botanical name	Mean colony diameter (mm)		Per cent inhibition (%)	
			5%	10%	5%	10%
T ₁	Neem	<i>Azadirachta indica</i>	43.33	31.60	51.85(46.05) *	64.88(53.65) *
T ₂	Ghaneri	<i>Lantana camara</i>	56.17	34.17	37.59(37.81)	62.03(51.96)
T ₃	Tulasi	<i>Ocimum tenuiflorum</i>	58.30	44.83	35.22(36.40)	50.18(45.10)
T ₄	Karanj	<i>Millettia pinnata</i>	60.33	52.50	32.96(35.03)	41.66(40.20)
T ₅	Nirgudi	<i>Vitex negundo</i>	63.63	62.50	29.29(32.76)	30.55(33.55)
T ₆	Onion	<i>Allium cepa</i>	40.40	29.67	55.11(47.93)	67.03(54.95)
T ₇	Parthenium	<i>Parthenium hysterophorus</i>	38.77	28.60	56.92(48.97)	68.22(55.68)
T ₈	Tarvad	<i>Senna auriculata</i>	45.70	33.03	49.22(44.55)	63.29(52.70)
T ₉	Control		90.00	90.00	0.00(0.00)	0.00(0.00)
SE (m)±					0.52	0.42
CDP=0.01					2.01	1.64

*Figures in parenthesis are arc sine transformed values

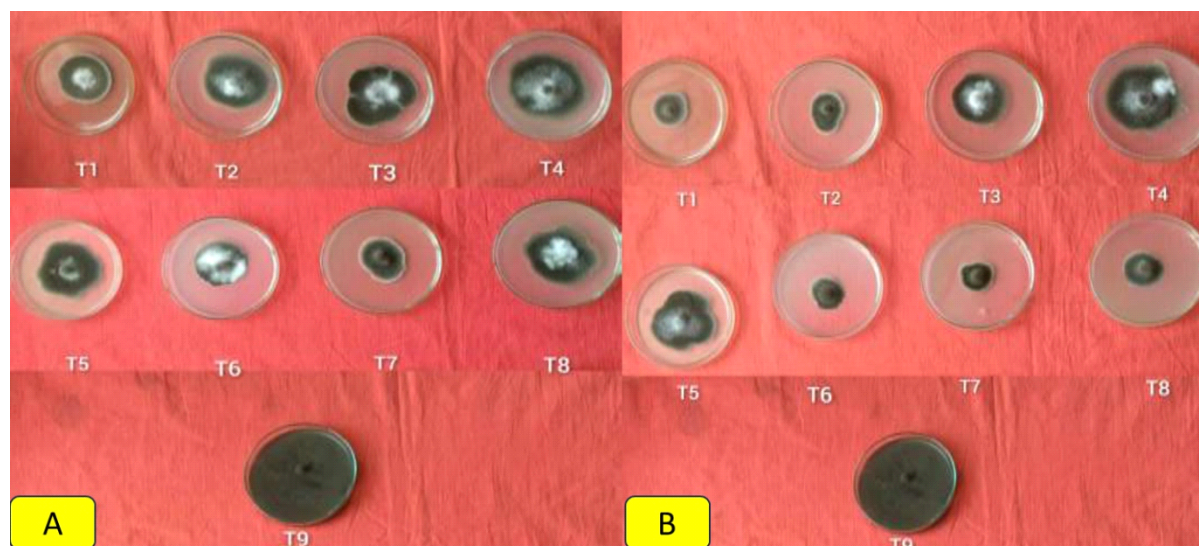


Figure 1. *In-vitro* evaluation of different plant extracts A) @ 5% B) @ 10% concentration against *Exserohilum turcicum*

(68.22%) was found in *Parthenium hysterophorus* with minimum colony diameter of 28.60 mm. It was followed by *Allium cepa* (29.67 mm), *Azadirachta indica* (31.60 mm), *Senna auriculata* (33.03 mm) and *Lantana camara* (34.17 mm) extracts showing 67.03, 64.88, 63.29 and 62.03 per cent inhibition, respectively. Thus, the plant extracts viz., *Parthenium hysterophorus*, *Allium cepa*, *Azadirachta indica*, *Senna auriculata* and *Lantana camara* were at par with each other at the concentration of 10 per cent in recording colony diameter of *E. turcicum*. Among the plant extracts evaluated, minimum inhibition (30.55%) was found in *Vitex negundo* extract with 62.50 mm mean colony diameter. Maximum colony diameter (90.00 mm) was recorded in control treatment (Figure 1B).

In vitro evaluation of bio-control agents against *E. turcicum*

The findings of *in vitro* experiment conducted to know the most effective bio-control agent against *E. turcicum* utilizing dual culture technique are presented in Table 2. From the data presented it is revealed that all bio-control agents were significantly superior to inhibit the fungal growth over control. The per cent inhibition ranged from 47.96 to 77.07. The results revealed that *Trichoderma harzianum* was most effective antagonist exhibiting 77.07 per cent mycelial inhibition of fungus followed by *Trichoderma hamatum* (73.51%). Moreover, *T. harzianum* and *T. hamatum* were at par with each other in inhibiting

Table 2. Evaluation of bio-control agents against *Exserohilum turcicum* under *in vitro*

Tr.No.	Antagonist	Mean colony diameter (mm)	Per cent inhibition (%)
T ₁	<i>T. asperellum</i>	31.36	65.14 (53.81) *
T ₂	<i>T. harzianum</i>	20.63	77.07 (61.38)
T ₃	<i>T. hamatum</i>	23.83	73.51 (59.02)
T ₄	<i>T. konigii</i>	28.5	68.33 (55.75)
T ₅	<i>P. fluorescence</i>	37.16	58.7 (50.01)
T ₆	<i>B. subtilis</i>	46.83	47.96 (43.83)
T ₇	Control	90.00	0.00 (0.00)
SE (m)±			0.81
CD P=0.01			3.42

*Figures in parenthesis are arc sine transformed values

mycelial growth. Next effective antagonists reported were *T. konigii* and *T. asperellum* which gave mycelial inhibition of 68.33 and 65.14 per cent, respectively. Among all the treatments *Bacillus subtilis* exhibiting least mycelial inhibition (47.96 %) with 46.83 mm mean colony diameter of *E. turcicum*.

Evaluation of fungicides against E. turcicum under in vitro conditions

Seven fungicides including two systematic, one non-systematic and four combi-product fungicides at concentration of 50% and 100% recommended were assessed to find out their efficacy in inhibition of mycelial growth of *E. turcicum* using poisoned food technique.



Figure 2. In-vitro evaluation of bio-control agents against *Exserohilum turcicum*

Evaluation of fungicides against *E. turcicum* at 50% concentration under in vitro conditions

Efficacy (*in vitro*) of seven fungicides at 50% concentration evaluated using poisoned food technique is presented in Table 3. The data presented showed that all the test fungicides significantly inhibited the mycelial

growth of *E. turcicum*. Among all treatments carbendazim 12% + mancozeb 63% proved to be most effective fungicide exhibiting maximum mean mycelial growth inhibition of 100 per cent followed by Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC which showed 96.66 per cent mycelial growth inhibition. Next efficacious treatments against *E. turcicum* were pyraclostrobin 133g/l + epoxiconazole 50g/l SE, mancozeb 75% WP and propiconazole 25% EC which gave 85.55, 84.96 and 83.32 per cent inhibition, respectively. Moreover, these three treatments were at par with each other in recording colony diameter. Among the various fungicides evaluated, the least effective was kresoxim-methyl 44.3% SC giving 27.15 per cent inhibition. Maximum colony diameter (90 mm) was recorded in control treatment (Figure 3A).

Evaluation of fungicides against *E. turcicum* at 100% recommended concentration under in vitro conditions

The data given in Table 3 revealed that all fungicides were significantly superior in reducing mycelial growth. Among different fungicides, carbendazim + mancozeb was found most effective exhibiting maximum mean mycelial growth inhibition (100 per cent). Next best treatment was Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC with 97.22 per cent mycelial growth inhibition. It was followed by Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE (88.33%), mancozeb 75WP (87.83%) and propiconazole 25SC (86.66%). Moreover,

Table 3. Evaluation of fungicides against *Exserohilum turcicum* at 50% and 100% recommended concentration under *in vitro*

Tr.No.	Fungicides	Concentration (%)		Mean colony diameter (mm)		Per cent inhibition (%)	
		50	100	50	100	50	100
T ₁	Mancozeb 75% WP	0.125	0.25	13.53	10.9	84.96(67.18)*	87.83(69.58)*
T ₂	Kresoxim-methyl 44.3% SC	0.05	0.1	65.56	63.83	27.15(31.39)	29.07(32.62)
T ₃	Propiconazole 25% EC	0.05	0.1	15	12	83.32(65.90)	86.66(68.58)
T ₄	Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC	0.05	0.1	3	2.5	96.66(79.47)	97.22(80.39)
T ₅	Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC	0.05	0.1	18.5	15	79.44(63.00)	83.33(65.90)
T ₆	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	0.075	0.15	13	10.5	85.55(67.65)	88.33(70.02)
T ₇	Carbendazim 12% + Mancozeb 63% WP	0.05	0.1	0.00	0.00	100.00(90)	100.00(90)
T ₈	Control			90.00	90.00	0.00(0.00)	0.00(0.00)
	SE (m)±					0.53	0.41
	CD P=0.01					2.22	1.70

*Figures in parenthesis are arc sine transformed values

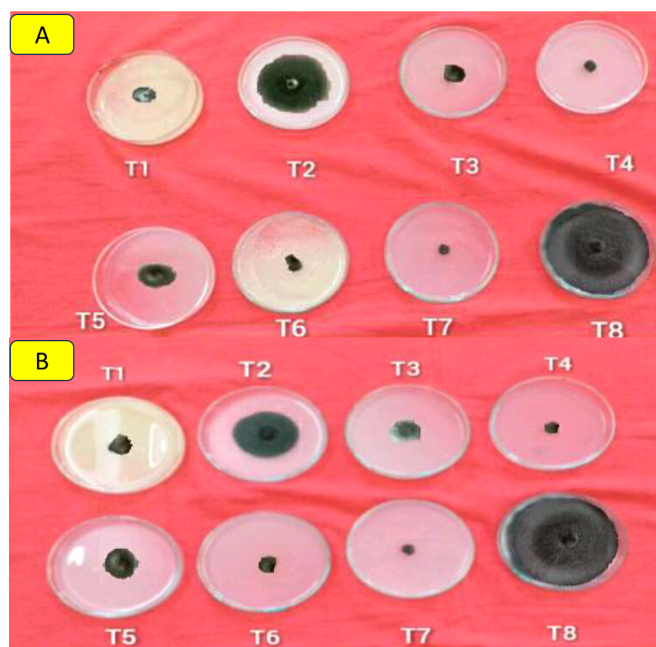


Figure 3. *In vitro* evaluation of fungicides against *Exserohilum turcicum* at A) 50% and B) 100 % recommended concentration

the fungicides pyraclostrobin + epoxiconazole, mancozeb and propiconazole were at par with each other at the recommended concentration in inhibiting mycelial growth of fungus. Least inhibition of mycelial growth was recorded in Kresoxim-methyl 44.3% SC (29.07%).

Discussion

In the present study, *in vitro* evaluation of eight botanicals against *Exserohilum turcicum* was done by poison food technique. Plant extracts viz., parthenium, onion, neem and tarvad were found effective against *E. turcicum* at 5 and 10% concentration. Among the various plant extracts, parthenium exhibited maximum inhibition of pathogen over untreated control. The present results are confirmed with the findings of Manu *et al.* (2017) who found that among the eleven botanicals tested against *E. turcicum*, garlic bulb extract showed maximum inhibition (79.63%) of mycelial growth of *E. turcicum* followed by Parthenium leaf extract (64.14%). Harlapur *et al.* (2007) noted that, neem seed kernel extract @ 10% concentration showed maximum inhibition of mycelial growth (56.64%) of test pathogen followed by *Aloe vera* @ 10% (53.50 %). Similar results on antifungal activity of different aqueous plant extracts have been reported by Meena *et al.* (2003). In present studies, all the botanicals significantly inhibited mycelial growth of test fungus *E. turcicum*. With increase

in concentration of plant extracts, mycelial inhibition of fungus also increased and maximum inhibition was obtained at higher concentration i.e. 10 per cent.

Also, the study on *In vitro* evaluation of bio-control agents against *E. turcicum* showed that *T. harzianum* was most effective antagonist showing 77.07 per cent mycelial inhibition of *E. turcicum* followed by *T. hamatum* (73.51%) and *T. konigii* (68.33%), while, the least inhibition was recorded in *Bacillus subtilis* (47.96%). These results are in line with those reported by Manu *et al.* (2017) who reported maximum inhibition of mycelial growth (98.65%) by *T. harzianum*-2 followed by *T. viride* (98.34%). Among the bacterial antagonists, *Pseudomonas fluorescence*-1 and *Pseudomonas fluorescence*-2 showed the mycelial inhibition of 95.49% and 94.24% respectively. In present study bio-control agents were found effective in controlling the growth of test fungus under *in vitro* conditions. Earlier, Harlapur *et al.* (2007) and Khedekar *et al.* (2012) reported that *Trichoderma harzianum* was effective in inhibiting the mycelial growth. These results are further supported by the results of Singh and Singh (2014).

The study on seven fungicides were evaluated against *E. turcicum* under *in vitro* conditions. It was recorded that among the various fungicides only combi fungicide Carbendazim 12% + Mancozeb 63% exhibited 100 per cent inhibition of mycelial growth of *E. Turcicum* at 50% and 100% recommended concentration. It was followed by Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC and Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE. Least inhibition of mycelial growth was observed in Kresoxim-methyl. The results obtained during present study are in consonance with the findings of Reddy *et al.* (2013) who evaluated seven fungicides against *E. turcicum* under *in vitro* condition and reported that the lowest per cent disease index (PDI) was in treatment mancozeb 75%WP @ 0.25% and combination treatment of carbendazim 12% + mancozeb 63% @ 0.25% with per cent disease control of 73.0 and 72.1%, respectively over control. Kumar *et al.* (2015) found that among the six fungicides tested zineb 75 WP @ 0.25% concentration was most effective in inhibiting the growth of *E. turcicum*. Similarly, mancozeb 63% + carbendazim 12% @ 0.25% was equally effective in reducing disease severity which can be used as an alternative to zineb. Many workers like Veerabhadraswamy *et al.* (2014) and Anand *et al.* (2013) reported that carbendazim 12% + mancozeb 63% and

tebuconazole 50% + trifloxystrobin 25% were effective to inhibit growth of fungus at different concentrations. Similar results were reported by Manu *et al.* (2017) showing that among systematic fungicides, tebuconazole completely inhibited the pathogen at all the concentrations tested, while among contact fungicides, propineb was highly effective inhibiting 83.89 per cent mycelial growth of *E. turcicum* at 500 ppm. Among combi-products tested against *E. turcicum*, only carbendazim 12% + Mancozeb 63% at 500 ppm showed complete inhibition of mycelial growth of *E. turcicum*. During present studies all the tested fungicides at various concentrations significantly inhibited the mycelial growth of *E. turcicum* over untreated control. As the concentration of fungicides was increased, mycelial growth inhibition also increased. Among all the tested fungicides maximum inhibition of pathogen was obtained with carbendazim 12% + mancozeb 63% at 50% and 100% recommended concentration. It was followed by azoxystrobin 18.2% w/w + cyproconazole 7.3% w/w SC and pyraclostrobin 133g/l + epoxiconazole 50g/l SE.

Conclusion

The findings of this study revealed that the under *in vitro* conditions, botanicals such as *Parthenium hysterophorus* and *Allium cepa* demonstrated fungistatic properties against *E. turcicum*, with effective results at concentrations of 5% and 10%. Additionally, among six bio-control agents tested, *Trichoderma harzianum* and *T.hamatum* exhibited superior efficacy in inhibiting the mycelial growth of *E. turcicum*, with 77.07% and 73.51% inhibition, respectively. In the case of fungicides, carbendazim 12% + mancozeb 63% emerged as the most effective, achieving 100% inhibition of mycelial growth at 50% and 100% recommended concentrations under *in vitro* conditions. The study concludes that fungicides, botanicals, and bio-control agents are effective in controlling *E. turcicum*. Botanicals and bio-control agents, in particular, show promise in managing Turcicum leaf blight infection in maize, offering an eco-friendly approach to disease management.

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