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RESEARCH ARTICLE

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Efficacy of Different Fungicides against Leaf Blight of Carrot Caused by *Alternaria alternata* (Fr.) Keissler

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ABSTRACT

Background: Leaf blight disease is painful nerve to carrot growing farmer because it causes huge economic loss to the farmer every year. Leaf blight of carrot is seed and soil borne disease causes by *Alternaria alternata.* Hence management of the disease by fungicides is the best alternative. Therefore, in the present investigation, our main emphasis was to identify best fungicide for management of leaf blight of carrot.

Methods: Seven fungicides were tested against leaf blight pathogen (*Alternaria alternata*) in lab as well as in cage house condition. The experiment was conducted at Cage house of department of Plant Pathology, COA, Jodhpur during *Rabi*-2020-21.

Result: Among all the fungicides used in the present investigation, difenoconazole 25% inhibited the 100% mycelial growth at all the concentrations. The next best treatment was tebuconazole 50%+trifloxystrobin 25% inhibited the 99.02% mycelial growth and Minimum mycelial growth inhibition was observed in mancozeb 75% WP followed by carbendazim 12%+mancozeb 63% 61.58% and 77.70%, respectively; along with control plate was showed 100% mycelium growth. The superior treatments under *in vitro* carry forward *in vivo* condition. When applied as foliar application under cage house condition, difenoconazole 25 EC at 0.25 ml/lit (11.17%) was observed lowest disease incidence.

Key words: *Alternaria alternata*, Carrot, Fungicide, *In vitro, In vivo,* Leaf blight.

INTRODUCTION

Carrot (*Daucus carota* L.), out of the most important vegetables root crop belonging to *Apiaceae* family, is cultivated worldwide. It is well distributed throughout the temperate, tropical and subtropical parts of the world (Bose and Som, 1990) and extensively cultivated in Europe, Asia, North Africa and North and South America (Thompson and Kelly, 1957). Afghanistan is the main centre of origin, from where the carrot originated for cultivation purpose, Mackevic (1929) and Banga (1976). The carrot introduced from Persia to India, according to Shoemaker (1947). The carrot is used for medicinal purposes including stomach ulcers, abscesses, bladder, liver and kidney problems, to aid in childbirth and even as aphrodisiacs. Cultivation of roots for consumption dates back to 600 A.D. when purple root types were grown in the area currently known as Afghanistan (Sangeetha and Shanthakumar 2016). The carotene in one medium-sized carrot supplies our daily requirement of Vitamin A (Rubatzky, *et al*., 1999). The edible part of carrot is the stored taproot. Carrot contains high amount of carotene (10 mg/100 g), thiamine (0.04 mg/100 g) and riboflavin (0.05 mg/100 g) and also serves as source of carbohydrate, protein, fat, minerals, vitamin C and calories (Yawalker, 1985). Carrot is an excellent source of alpha and beta carotene, the forerunner of vitamin A, the edible portion of carrot root (per 100 g) contains carbohydrate (10.6 g), fibre (1.2 g), moisture (86 g) and carotene (1890 µg) (Bose *et al*., 1986). The foliar diseases of carrot, Alternaria leaf blight is major one, which occurs worldwide. Strandberg (1992); Tulek and Dolar (2015) reported that even *A. alternata, A. tenuissima and A. radicina* also causes leaf blight disease of carrot. Alternaria blight of carrot was first reported in 1855 from Germany (Chupp and Sherf, 1960) and later from many countries of temperate and Mediterranean regions of the world Belgium, Holland, USA, Denmark, Israel, France and India (Farrar *et al.,* 2004, Jensen *et al.,* 2004). The pathogen attacks both root and seed crop but losses are more in case of seed crop in nature. The disease appears as brownish water soaked lesions on the margins and tips of older leaflets which gradually extend to become deep brown and blighted. As the spot increase in number, the inter-veinal tissue dies until the entire leaflet is killed. In moist weather disease spread

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rapidly. On leaf petioles, elongated dark spots appeared and the entire leaf dies without spots on the foliage. It also causes damping-off of seedlings, blight of seed stalk and black decay of roots. Under heavy infection conditions leaves are entirely destroyed and harvesting becomes difficult which results in 40-60 per cent yield losses (Vintal *et al.,* 1999; Farrar *et al.,* 2004; Yadav *et al*. 2021). The fungus *A. alternata* produced profuse mycelium on Potato Dextrose Agar (PDA) with an average width of 4.42 µm in diameter, conidiophores, conidia and intercalary chlamydospores measured as 42.26×4.29 µm, 47.16×13.49 µm and 7.22 µm in diameter, respectively. Initially, the mycelium was hyaline that turned to grey-brownish, multicelled, septate and irregularly branched. Conidia were born in chains upto 10 or more on conidiophores. They were light olivaceous to dark brown in colour, varied in shape from obclavate to mostly ellipsoidal, muriform having tapered apex with 1 to 3 longitudinal and 2-10 transverse septa (Nagrale *et al.,* 2013). The productivity of carrot in Rajasthan is very less as compared to India. It may be due to several reasons. Among them, the diseases might be out of the major limiting carrot prodaction. The fungal disease, particularly leaf blight was observed as severe disease of carrot (Soyal *et al*., 2016).

MATERIALS AND METHODS

Efficacy of fungicides were tested against *Alternaria alternata* both in lab as well as in cage house condition.

Evaluation of the efficacy of fungicides *in vitro*

Evaluation the efficacy of seven fungicides along with control (Table 1) was studied against mycelia growth of *Alternaria alternata* by poisoned food technique (Nene and Thapliyal, 1971) Required quantity of each fungicide (Table 1) was added aseptically to 100 ml of sterilized PDA medium in 150 ml flask separately so as to get four different concentrations (250, 500, 750 and 1000 ppm). The medium was supplemented with streptomycin sulphate @ 50 ppm to prevent bacterial contamination. The flasks were shaken to ensure proper and uniform distribution of the fungicides. The medium was poured separately in sterilized petri plates and allowed to solidify. For each treatment three replications were taken and medium without fungicides served as check. Each plate was inoculated with 5 mm diameter mycelial bit

Table 1: List of fungicides evaluated against A. alternata by Poison Food Technique (in vitro).

Fungicide	Tradename	in vitro conc. (ppm)			
Kresoximmethyl 44.3 SC @ 0.044%	Ergon	250	500	750	1000
Mancozeb 75% WPIndofil M-45	250	500	750	1000	
Pyraclostrobin133G/L+Epoxiconazole50G/L SE	Opera	250	500	750	1000
Difenconazole 25% Score	250	500	750	1000	
Carbendazim 12%+Mancozeb 63%	Saaf	250	500	750	1000
Captan 70%+Hexaconazole 5%	Supermat/Taqat	250	500	750	1000
Trifloxystrobin 25 %+Tebuconazole 50%	Nativo	250	500	750	1000
Control -	-	-	-	-	

Table 2: Effect of different fungicides against *A. alternata* under *in vitro.*

Treatment	Per cent inhibition of mycelial growth*				
	Concentration (ppm)				
	250	500	750	1000	Mean
Kresoxim methyl 44.3 SC @ 0.044%	91.72 (73.27)	95.94 (78.38)	100 (90.00)	100 (90.00)	96.91 (82.89)
Mancozeb 75% WP	41.61 (40.15)	57.64 (49.38)	69.66 (56.56)	77.43 (61.62)	61.58 (51.92)
Pyraclostrobin 133 G/L+ Epoxiconazole 50 G/L SE	92.36 (74.02)	100 (90.00)	100 (90.00)	100 (90.00)	98.0 (85.98)
Difenoconazole 25 EC	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
Carbendazim 12%+Mancozeb 63	73.93 (59.27)	76.11 (60.72)	78.69 (62.54)	82.34 (64.91)	77.76 (61.89)
Captan 70%+Hexaconazole 5%	83.37 (65.91)	88.07 (69.78)	100 (90.00)	100 (90.00)	92.86 (78.91)
Trifloxystrobin 25%+Tebuconazole 50%	96.11 (78.88)	100 (90.00)	100 (90.00)	100 (90.00)	99.02 (87.14)
Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Factor	S.Em±			CD (p = 0.05)	
Fungicide (F)	0.28			0.80	
Concentration (C)	0.20			0.57	
Interaction (F×C)	0.57			1.61	

*Average of three replications

Figures in parentheses are angular transformed values of the fungus. Inoculated plates were incubated at 25±1°C for 7 days. The linear growth of test fungus was recorded and per cent growth inhibition was calculated by Vincent's (1947) formula.

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

Where:

I = Inhibition per cent.

C = Colony diameter (mm) in control plate.

T = Colony diameter (mm) in treated plate.

Evaluation of the efficacy of fungicides *in vivo*

The management of *Alternaria alternata* in cage house condition was studied with fungicides found effective in *in-vitro* studies. Five treatments including control were evaluated for their efficacy by foliar spray against *A. alternata.* Experiment was conducted in the cage house during *Rabi* season 2020 - 2021. The seeds of K-4 cultivar were sown with three replications in earthen pots 9″×12″. The fungicides were tested by applying as foliar spray on 60 days old plants after 10 days of inoculation of the pathogen. For comparison inoculated control was maintained without fungicidal application. Observations of the disease intensity were recorded 10 days after foliar spray. Observations on disease intensity were recorded on 5 plant selected in each pot by using disease rating scale given by Jaiman *et al*. (2013) with slight modifications and per cent disease intensity was calculated. The percent disease intensity (PDI) was calculated by using the formula of Wheeler, 1969.

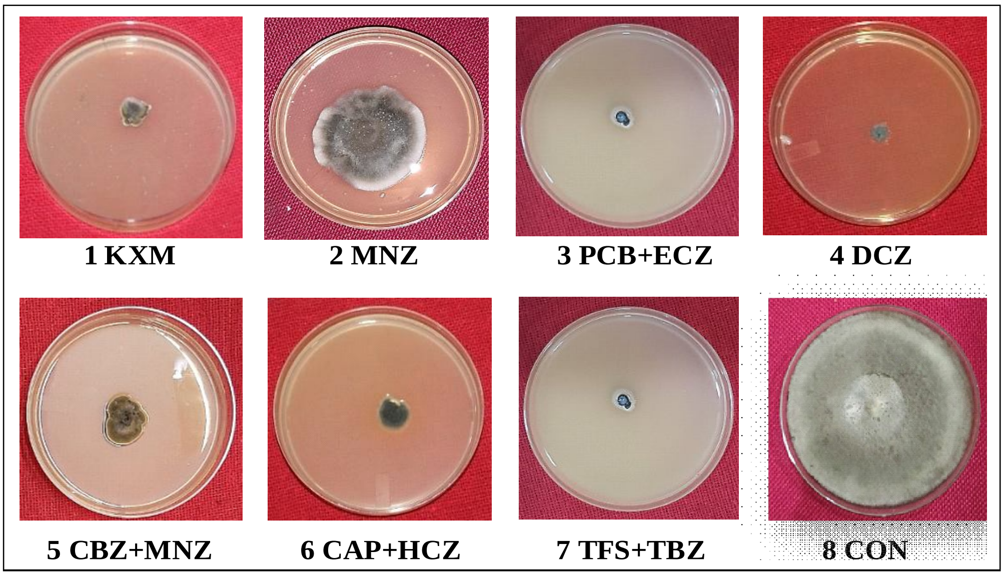

Plate 1a: Efficacy of fungicides against *A. alternata in vitro* (250 ppm)

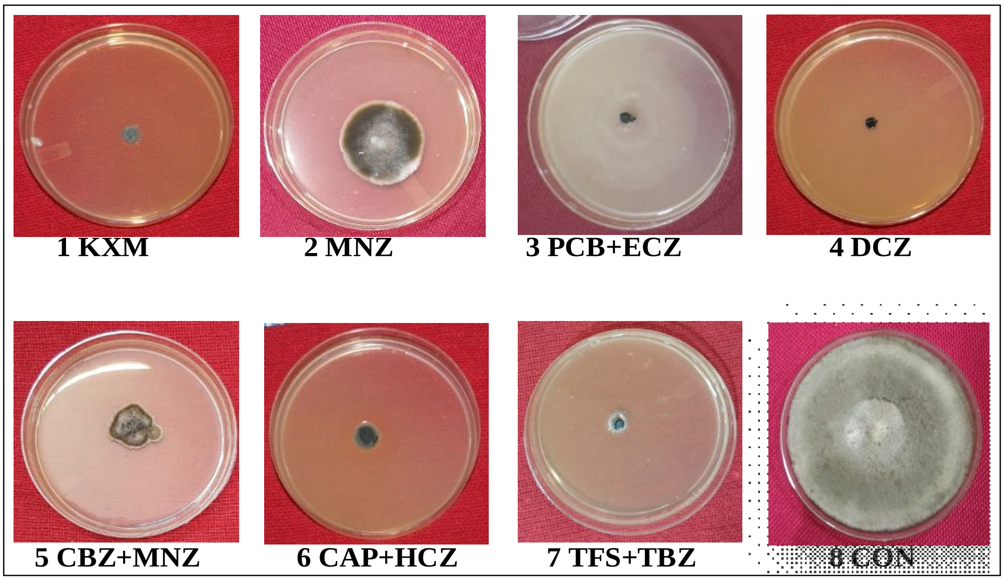

Plate 1b: Efficacy of fungicides against *A. alternata in vitro* (500 ppm).

$$PDI = \frac{\text{Sum of all individual ratings}}{\text{Number of plants observed} \times \text{Maximum disease rating scale}} \times 100$$

RESULTS AND DISCUSSION

Management of alternaria leaf blight of carrot through fungicides under *in vitro* condition

A total of seven fungicides using four different concentrations (250, 500, 750 and 1000 ppm) along with control were tested *in vitro* against *A. alternata,* applying poisoned food technique (Nene and Thapliyal, 1971) and using Potato Dextrose Agar (PDA) as basal medium. The observations on per cent growth inhibition (PGI) were recorded and the results are presented in Table 2 and Plate 1a, 1b, 1c and 1d.

All the fungicides tested were found significantly superior in inhibiting the mycelial growth of *A. alternata* over control. Among the fungicides difenoconazole 25% was inhibited the 100% mycelial growth at all the concentrations and was found significantly superior over rest of the treatments. The next best treatment was tebuconazole 50% +trifloxystrobin 25% (96.11, 100, 100 and100%) at 250, 500, 750 and 1000 ppm concentrations, respectively. Minimum mycelial growth inhibition was observed in mancozeb 75% WP (41.61, 57.64, 69.66 and 77.43%) followed by carbendazim 12%+mancozeb 63% (73.93, 76.11, 78.69 and 82.34 %) at 250, 500, 750 and

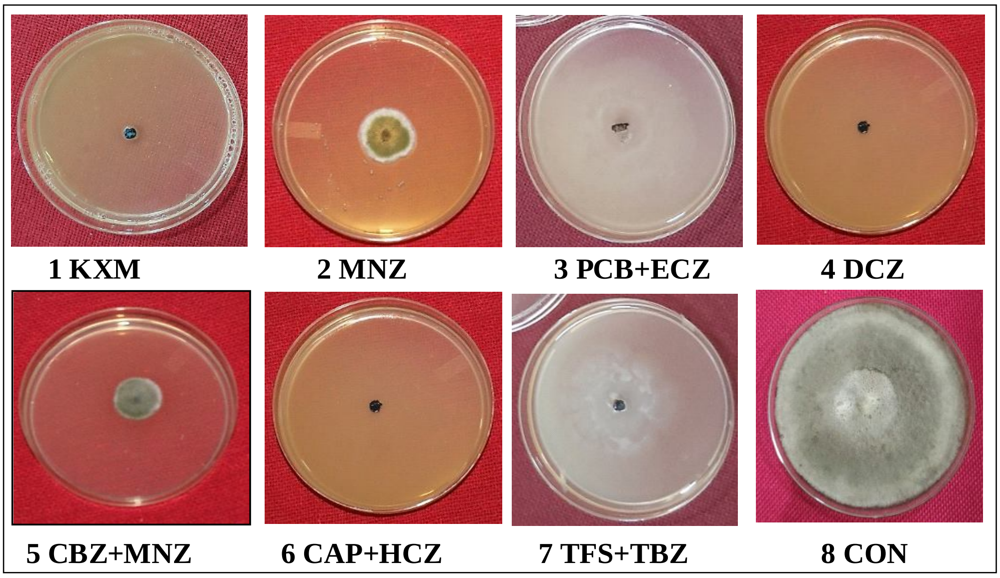

Plate 1c: Efficacy of fungicides against *A. alternata in vitro* (750 ppm).

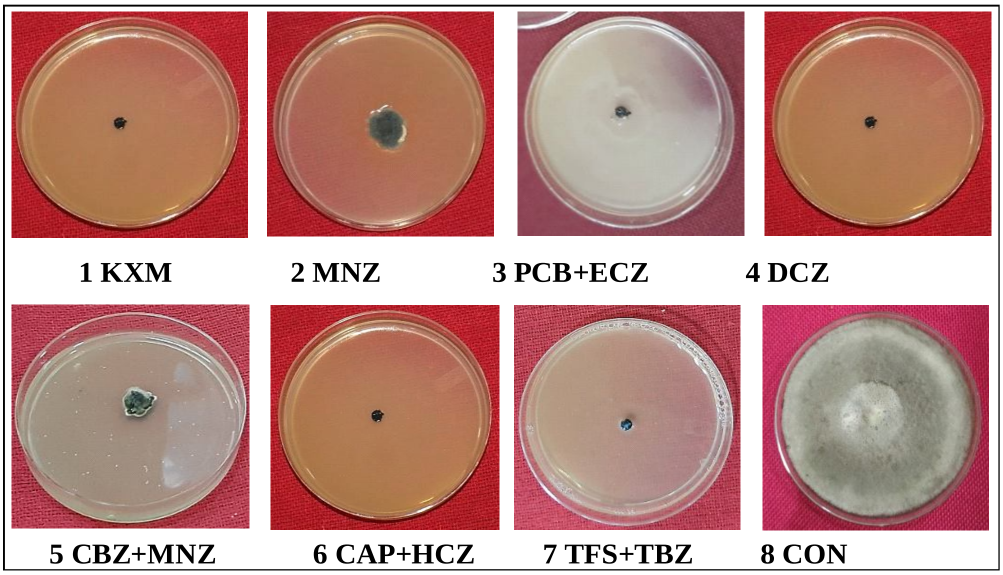

Plate 1d: Efficacy of fungicides against *A. alternata in vitro* (1000 ppm).

Table 3: Effect of different fungicides against *A. alternata* under *in vivo* conditions.

Treatments	Dosage(g/kg or ml/lit.)	PDI*	Disease Control (%)
Kresoxim methyl 44.3 SC @ 0.044%	1 ml	32.18 (34.54)	41.70
Pyraclostrobin 133 G/L + Epoxiconazole 50 G/L SE	1 ml	20.85 (27.15)	62.22
Difenoconazole 25 EC	0.5 ml	11.22 (19.55)	79.69
Captan 70% + Hexaconazole 5%	0.5 g	20.49 (26.90)	62.88
Trifloxystrobin 25% + Tebuconazole 50%	0.5 g	16.18 (23.71)	70.68
Control	-	55.20 (47.96)	0.00
S.Em±	-	0.29	
CD(P=0.05)	-	0.91	

Average of three replications.

Figures in parentheses are angular transformed values.

*PDI = Per cent disease intensity.

1000 ppm concentrations, respectively; along with control plate was showed 100% mycelium growth. The superior treatments under *in vitro* carry forward *in vivo* condition. Fungicides such as hexaconazole 4%+zineb 68%, pyraclostrobin 133 G/L+ epoxiconazole 50 G/L SE, difenoconazole 25 EC, trifloxystrobin 25%+tebuconazole 50% have been shown to significantly inhibit *Alternaria solani* and *A. alternata* (Choudhary *et al*. 2021; Dhaka and Choudhary 2022; Dhaka *et al.* 2022; Nagaraj *et al*., 2023; Choudhary *et al*., 2024).

Management of Alternaria leaf blight of carrot through fungicides under *in vivo* condition

Five fungicides along with control were evaluated in field condition and the results presented in Table 3.

The data depicted in Table 3 showed that the disease incidence percentage of all fungicide treatments were significantly lower than untreated control. The disease incidence ranged between 11.17% to 55.20%. Lowest disease incidence was noted in difenoconazole 25EC (11.17%) followed by trifloxystrobin 25%+tebuconazole 50% (14.42%), respectively.

The effective fungicides under *in vitro* condition were farther tested under *in vivo* condition. Among the treatments the lowest disease incidence was noted in difenoconazole 25EC (11.17%) followed by trifloxystrobin 25%+ tebuconazole 50% (14.42%) respectively. The maximum per cent disease incidence was observed in kresoxim methyl 44.3 SC @ 0.044% (32.18%) whereas, 55.20% disease incidence was recorded in control pot. Pyraclostrobin 133 G/L+Epoxiconazole 50 G/L SE and Captan 70%+ Hexaconazole 5% are at par.

Almost similar result recorded by even in the results of the experiment of Alkseeva (2009) difenconazole was quite effective for controlling Alternaria blight of carrot. Badri *et al*. (2013) proved that the hexaconazole was most superior in inhibiting *Alternaria alternata* causing umbel blight of kala zeera. Ginoya and Gohel (2015) recorded the tebuconazole (50%)+trifloxystrobin (25%) (0.20%) the disease intensity was 11.23% in *in vivo* condition against *Alternaria alternata* causing fruit rot disease of chilli. The results of fungicides (*in vivo*) are comparable with that of the Reshma *et al*. (2018) where in the field evaluation the difenconazole (0.1%) effectively reduced the leaf blight of chrysanthemum. Gayithri (2020) the difenconazole (0.1%) the disease intensity was 16.05% in *in vivo* condition against *Alternaria alternata* causing Alternaria leaf blight of carrot. Similar results were observed by many workers *viz*., Mazumder *et al*. (2016); Jangid *et al.* (2022) and Tadelo *et al.* (2024).

CONCLUSION

Among the seven fungicides screened were found difenoconazole 25% inhibited the 100% mycelial growth at all the concentrations and was found significantly superior over rest of the treatments. The next best treatment was tebuconazole 50%+trifloxystrobin 25% (96.11, 100, 100 and100%) and pyraclostrobin 133 G/L+epoxiconazole 50 G/L SE (92.36, 100, 100 and 100%), followed by kresoxim methyl 44.3 SC @ 0.044% (91.72, 95.94, 100 and 100%) and captan 70%+hexaconazole 5% (88.37, 88.07, 100, 100) at 250, 500, 750 and 1000 ppm concentrations. In case of application fungicide under *in vivo* condition among the all treatments lowest disease incidence was noted in in foliar spray with difenoconazole 25 EC at 0.5 ml (11.17%) followed by trifloxystrobin 25% +tebuconazole 50% at 0.5 g. (14.42%) whereas, 55.20% disease incidence was recorded.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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