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ORIGINAL ARTICLE

Efficacy of Fungicides Against *Sclerotinia sclerotiorum* Causing Sclerotinia Rot of Fennel

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ABSTRACT
Fennel (Foeniculum vulgare Mill.) is major seed spice crop, belongs to family Apiaceae (Umbelliferae). Fennel crop suffers from various diseases caused by fungi and other microorganisms. Amongst the major fungal diseases of fennel, the stem rot disease caused by Sclerotinia sclerotiorum (Lib.) de Bary, is becoming a measure threat to the fennel cultivation. The present investigations aimed to test some fungicides against S. sclerotiorm under in vitro and in vivo conditions. Among these fungicides, Carbendazim and Carbendazim 12% + Mancozeb 63 % WP inhibited completely the mycelial growth of S. sclerotiorum at all concentrations (50,100 and 150 ppm) followed byCaptan 70 % + Hexaconazole 5 % WP95.20, 100 and 100 % at 50,100 and 150 ppm respectively. The fungicides were tested in vivo by applying as seed application, foliar application and seed - cum - foliar application. Carbendazim was found most effective inreducing the disease intensity followed by Carbendazim 12% + Mancozeb 63 % WP.
Keywords: *Fennel, Sclerotinia sclerotiorum, Sclerotinia rot, fungicides*

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INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.) is major seed spice crop, belongs to family *Apiaceae* (*Umbelliferae*). Fennel oil and fennel oleoresins are used in pizza sauces, toppings, non-alcoholic beverages, liquors, ice creams and in seasoning of processed meats. In India, fennel has 38.66 thousand hectares area with annual production of 59.75 thousand tonnes and average productivity of 647 kg/ha [1]. Gujarat stands first in fennel production. The crop was grown on 27.58 thousand hectares with annual production of 30.71 thousand tonnes and average productivity of 1114 kg/ha in Rajasthan [2]. Fennel crop suffers from various diseases viz., Ramularia blight (*Ramularia foeniculi*) [9], Root rot (*Rhizoctonia solani*) [6] Wilt., (*Fusarium oxysporum* f. sp. *funiculi*) [6], Powdery mildew (*Leveillula taurica*var. *languinosa*) [6], Alternaria blight (*Alternaria alternata*) [4] and Stem rot (*S. sclerotiorum*) [6]. Amongst the major diseases of fennel the stem rot disease caused by *S. sclerotiorum* (Lib.) de Bary, is becoming a measure threat to the fennel cultivation. The disease appears in field during umbel formation, i.e. on 65-70 days old crop. Sudden drooping of leaves followed by drying of plants are characteristic features of the disease. In the pith of the infected stem, large cavities lined by fluffy mycelium and numerous black sclerotia of the fungus are seen. During survey in fennel growing areas of Rajasthan state like Baran, Kota, Bundi and Jhalawar districts during *Rabi* 2014- 2015 the incidence of stem rot was observed up to a significant level. Therefore, the present investigations aimed to test some five fungicides against *S. sclerotiorm* under *in vitro* and *in vivo* conditions.

MATERIAL AND METHODS

Collection and isolation of the pathogen

Sclerotinia rot infected plants of fennel were collected from KVK, Ajmer and isolations were made on potato dextrose agar (PDA) medium from black sclerotia present inside the diseased stem as well as from individual stem rot lesion as per procedure and purified by hyphal tip method.

In vitro efficacy of fungicides against *Sclerotinia sclerotiorum*

Laboratory experiment was carried out to find out the efficacy of five fungicides [Propineb 70WP(Antracol); Carbendazim 50WP(Bavistin); Carbendazim 12% + Mancozeb 63%WP (Companion); Mancozeb 75%WP(Indofil M-45); Captan 70% + Hexaconazole 5 % WP(Steam)] with three (50,100 and

150 ppm) concentrations against *S. sclerotiorum* to find out per cent inhibition on growth of the pathogen by poisoned food technique [11]. Requisite quantity of each fungicide was incorporated in sterilized PDA medium, thoroughly mixed by shaking prior to pouring in sterilized Petri plates and were allowed to solidify. These Petri plates were inoculated with 5 mm dia. disc of seven day old culture of the pathogen in the centre of the plate and incubated at 25 ± 1˚C. Each treatment was replicated thrice with suitable control. The efficacy of fungicides in each treatment and average of three replications were calculated. Per cent mycelial growth inhibition was calculated by using Bliss [2] formula-

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

Where,
I = Per cent mycelia inhibition
C = Growth of fungal plant pathogen in control (mm)
T = Growth of fungal plant pathogen in dual culture plate (mm)

***In vivo* efficacy of fungicides against stem rot of fennel**

The experiment was carried out in earthen pots (30 cm dia.) with cultivar RF-178. The pathogen multiplied on sorghum grains at 25 ± 1 ˚C for one week was used as the soil inoculum. Prior to sowing, pots were surface sterilized with copper sulphate solution and filled with sterilized soil. The soil was sterilized at 1.045 kg/cm^2 for one hour for three consecutive days.These pots were inoculated with fungal inoculum multiplied on sorghum grains before sowing. For inoculation the upper 5 cm layer of soil of each pot was thoroughly mixed with sorghum inoculum @ 20 g/pot. 10 seeds were maintained per pot and kept in cage house. Five fungicides [Propineb 70WP(Antracol); Carbendazim 50WP(Bavistin); Carbendazim 12% + Mancozeb 63%WP(Companion); Mancozeb 75%WP(Indofil M-45); Captan 70% + Hexaconazole 5 % WP(Steam)] were tested by applying as seed application, foliar application (30 DAS) and seed – cum – foliar application in four replications.

At 30 DAS, 0.1% of Carbendazim and 0.2% of rest of the fungicides were used as single foliar spray. The disease incidence and per cent disease control were calculated 50 DAS by following formula-

$$\text{Per cent Disease Incidence} = \frac{\text{No. of infected plants}}{\text{Total No. of plants}} \times 100$$

$$\text{Per cent disease control} = \frac{\text{Disease in control} - \text{Disease in treatment}}{\text{Disease in control}} \times 100$$

RESULTS AND DISCUSSIONS

In vitro* efficacy of fungicides against *Sclerotinia sclerotiorum

The efficacy of fungicides was evaluated against *S. sclerotiorum* on PDA by poisoned food technique. The data suggested (Table-1) that increase in concentration of the fungicides caused increased inhibition of mycelial growth of the fungus. Among these, Carbendazim and Carbendazim 12% + Mancozeb 63 % WP inhibited completely the mycelial growth of *S. sclerotiorum* at all concentrations (50,100 and 150 ppm). This was followed by Captan 70% + Hexaconazole 5% WP with inhibition of 95.20, 100 and 100 % at 50,100 and 150 ppm respectively. Propineb was found least effective at all concentrations against *S. sclerotiorum.*

Five fungicides were tested at 50, 100 and 150 ppm concentrations to inhibit mycelial growth of *S. sclerotiorum*. Carbendazim and Carbendazim 12% + Mancozeb 63 % WP gave maximum inhibition of mycelial growth of *S. sclerotiorum* at all concentrations. Palat *et al.* [7], Pandey *et al*. [8] and Singh *et al.* [12] reported Carbendazim as significantly superior in inhibiting mycelial growth of *S. sclerotiorum*. While Javeria *et al.* [5] reported Carbendazim and Carbendazim 12% + Mancozeb 63 % WP were significantly superior in inhibiting mycelial growth of *S. sclerotiorum*.

***In vivo* efficacy of fungicides against stem rot of fennel**

Seed application

A perusal of data (Table-2) revealed minimum disease incidence with Carbendazim (31.61 %) followed by Carbendazim 12% + Mancozeb 63 % WP(36.58 %) as compared to control (77.90 %). Maximum reduction in per cent disease incidence over control was observed with Carbendazim (59.42 %) followed by Carbendazim 12% + Mancozeb 63 % WP(53.04 %) over control. Per cent disease incidence of

Captan70% + Hexaconazole 5% WP (36.94 %) was found at par with Carbendazim 12% + Mancozeb 63 % WP(36.58 %). Minimum reduction in disease incidence was observed in Propineb(15.53 %).

Foliar application

A perusal of data (Table-2) revealed a similar trend of results as above. The highest reduction in disease incidence over control was observed in Carbendazim (51.66) followed by Carbendazim 12% + Mancozeb 63 % WP(51.05 %). Minimum reduction in disease incidence was observed in Propineb(13.91 %).

Seed-cum-foliar application

A perusal of data (Table-2) revealed minimum per cent disease incidence in Carbendazim (20.58 %) followed by Carbendazim 12% + Mancozeb 63 % WP(23.95 %) over control (78.95 %).

Among these applications, seed-cum-foliar application of fungicides was found most effective tocontrol the disease for reducing disease intensity, followed by seed application and foliar application alone. Carbendazim was found most effective in reducing the disease intensity followed by Carbendazim 12% + Mancozeb 63 % WP.These results are in agreement with the results of Palat *et al.* [6], Pandey *et al.* [7] and Singh *et al.* [12] reported Carbendazim as significantly superior in inhibiting mycelial growth of *S. sclerotiorum.* While Prajapati and Narain [10] and Javeria *et al.* [5] reported Carbendazim and Carbendazim 12% + Mancozeb 63 % WP were significantly superior in inhibiting mycelial growth of *S. sclerotiorum*.

Table: 1: *In vitro* efficacy of fungicides against *S. sclerotiorum* by poisoned food technique after 7 days of incubation at 25 ±1^{0}C

Fungicide	Per cent mycelial growth inhibition at various concentrations (ppm) *			
	50	100	150	Mean
Propineb	5.95 (14.23)	16.80 (23.86)	48.60 (44.56)	23.78
Carbendazim	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00
Carbendazim + Mancozeb	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00
Mancozeb	38.60 (38.43)	53.17 (47.86)	76.80 (63.57)	56.19
Captan + Hexaconazole	95.20 (76.93)	100.00 (90.00)	100.00 (90.00)	98.40
Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
Mean	56.63	61.66	70.90	
SEm±				**CD (p=0.05)**
F			0.69	1.98
C			0.45	1.30
FxC			1.20	3.43

*Average of three replications ; Figures given in parentheses are angular transformed values

Table:2: *In vivo* efficacy of fungicides against stem rot of fennel

Fungicide	Dose (%)	Seed application*		Foliar application*		Seed-cum-foliar application*	
		Disease incidence (%)*	Per cent disease control	Disease incidence (%)*	Per cent disease control	Disease incidence (%)*	Per cent disease control
Propineb	0.2	65.80 (54.20)	15.53	70.85 (57.28)	13.91	61.85 (51.95)	21.65
Carbendazim	0.1	31.61 (34.21)	59.42	39.78 (39.25)	51.66	20.58 (27.16)	73.93
Carbendazim + Mancozb	0.2	36.58 (37.18)	53.04	40.28 (40.28)	51.05	23.95 (29.24)	69.66
Mancozeb	0.2	53.85 (47.51)	30.87	58.86 (50.16)	28.48	48.95 (44.82)	37.99
Captan + Hexaconazole	0.2	36.94 (37.58)	52.58	45.87 (42.56)	44.26	28.56 (32.26)	63.82
control	-	77.90 61.95)	0.00	82.30 (65.16)	0.00	78.95 (62.85)	0.00
SEm±		0.58	-	0.71	-	0.72	-
CD (p=0.05)		1.78	-	2.28	-	2.30	-

*Average of four replications; Figures given in parentheses are angular transformed values

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