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Fruit rot diseases of chilli and their management in agro-climatic conditions of Manipur

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Colletotrichum capsici, Colletotrichum gloeosporioides, Gloeosporium sp. and *Fusarium* sp. were consistently found associated with fruit rot disease of chilli posing a serious threat to the production of chillis in Manipur. Of the 5 fungicides tested *in vitro* by food poison technique, Carbendazein and Thiopenate methyl @ 0.1% each could completely inhibit the linear mycelial growth of *C. capsici* whereas complete inhibition of *C. gloesporioides* was observed from Carbendazein (@ 0.1%), Mancozeb (@ 0.2%) and Thiopenate methyl (@ 0.1%) treated plates. In dual culture technique with six biocontrol agents *Trichoderma harzianum, T. hamatum* and *T. viride* could induce maximum per cent inhibition on the linear growth of *C. capsici*. Further, after locally available medicinal plants tested, *Solanum suranttens* was found most effective in inhibiting the growth of *C. capsici*.

Key words : Fruit rot fungi, fungicides, bio-control agents, mycelial growth, fruit rot of chilli

INTRODUCTION

Chilli (*Capsicum annum* Linn.) belongs to a family Solanaceae. India is one of the leading countries for the commercial production of chilli. Andhra Pradesh, Karnataka and Maharastra account for 75% of the country's net area under chilli cultivation and its production. 2.5 to 3 per cent of country's production is being exported (Singh *et al.*, 1983). In Manipur, chilli (commonly known as morok) is known since ancient time. It is widely grown as a summer crop, occupying an area of 5470 hectares of land and producing 5.47 M.T. (Anon., 1992). Various types of chillies are grown in Manipur. Chilli suffers from many diseases caused by fungi, bacteria, nematodes, viruses and physiological disorders. Among the fungal diseases, namely leaf spot, wilt, die-back and anthracnose and fruit rot assume at alarming proportion in the state. Fungi namely *Colletotrichum capsici, Colletotrichum gloeosporioides, Gloeosporium* sp., *Fusarium* sp., (Mc. Govern and Polston, 1995; Bongshiing, 2000) have been consistently found to be associated with fruit rot of chilli in India. Botanicals, biocontrol agents and several fungicides have effectively managed fruit rot disease of chilli (Kotle *et al.*, 1994; Gomathi and Kannabiran, 2000; Rajarajeshwari and Satya Narayan, 1994). A number of chilli germplasms have been screened against fruit rot disease and a few resistant cultivars has been identified (Muneem *et al.*, 1995).

MATERIALS AND METHODS

Fruiting bodies (acervuli) and tissue from the undersurface of the collected fruit rot specimens were cut into small bits of 1mm size and directly transferred to Potato Dextrose Agar (PDA) plates. The inoculated Petridishes were then incubated at 25 ± 1° C for 3 days. The growing hyphal tips were cut from the periphery of actively growing 3-day-old culture and transferred to PDA slants for purification of the fungi. The purified cultures were maintained on PDA slants by subculturing from time to time for further use.

The fungi associated with fruit rot were identified in the laboratory of Plant Pathology Department, C.A.U.,Imphal, with the relevant keys, monographs etc.

The efficacy of five fungicides on linear growth of

fungi was studied by using poisoned food technique described by Sharvelle (1960). The concentration of the fungicides was adjusted to 100% active ingredient (a.i.). The fungicides namely Carbendazim (Methyl-2-benzimidazole-carbamate, 50%, W.P) @ 0.1%, Blitox-50 (Copper oxychloride, 50% W.P) @ 0.2%, Mancozeb (Manganese ethylene bis dithiocarbamate plus zinc, 75% W.P) @ 0.2%, Thiophanate methyl (1, 2-bis (3-Methoxycar-bony 1-2-thioureido) benzene, 70% W.P) @ 0.1% and Hexaconazole ((RS)-2-(2, 4-dichlorophenyl) -1-(1H-1, 2, 4-triazol-1-1-y1) hexan -2-ol, 5% EC) @ 0.1% were incorporated in 50 ml Potato Dextrose Agar after autoclaving to give desired concentrations. Each treatment was replicated four times.

A five mm mycelial disc taken from 3-day-old actively growing cultures was aseptically transferred to each Petridish. The Petridishes were then incubated at 25 ± 1°C for 7 days. The medium without fungicides served as control. The radial growth of each fungus was recorded at every 24 h interval till the control plates were fully covered with fungal mycelium. The per cent inhibition on growth was calculated by the method described by Vincent (1927) as given below :

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

where, I = per cent inhibition, T = growth in treatment, C = growth in control

Six biocontrol agents namely, *Trichoderma harzianum*, *T. hamatum*, *T. viride*, *Verticillium licanii*, *Beauveria bassiana* and *Metarhizium anisopliae* were taken for the experiment under *in vitro* conditions. Dual culture plate technique described by Gurha (2001) using Potato Dextrose Agar medium was followed.

Five mm mycelial disc each taken from 3 day old actively growing culture of fungi and antagonist were asceptically transferred to Petridishes containing PDA by placing 3 cm apart from each other. The plates were then incubated at 25± 1°C. Each treatment was replicated four times. The growth of antagonists and test pathogens was recorded after every 24 h of incubation. The per cent inhibition on the test pathogens due to biocontrol agent was calculated by using the formula as described above.

The relative efficacy of five plant extracts namely Shingkhangga (*Solanum torvum*), Yellow-berried nightshade (*Solanum suranttense*), Darek (*Melia azadirachta*), Tulsi (*Ocimum sanctum*) and garlic (*Allium sativum*) were assayed *in vitro* against chilli fruit rot fungi using the method described by Sindhan *et al.* (1999). The extracts were prepared in the ratio 1 : 1 (w/v). The plant leaves were washed with sterile distilled water and then crushed with an equal quantity of sterile distilled water (w/v) with the help of a mortar and pestle, the extracted juice was then passed through a double layered cheese cloth. This formed the standard 100% plant extracts. Desired amount of each extract was separately incorporated aseptically into each conical flask containing 50 ml sterilized Potato Dextrose Agar medium to give 5% and 10% concentrations and dispensed in sterilized Petridishes.

A five mm mycelial disc cut from 3-day-old actively growing cultures was transferred asceptically to each Petridish. The inoculated plates were incubated at 25 ± 1°C for 7 days. The medium without plant extracts served as control. Each treatment was replicated four times. Efficacy of the botanicals at 5% and 10% concentrations was assayed by measuring linear mycelial growth of the fruit rot fungi. The inhibition per cent was alsocalculated by using the formula as described above.

Chilli cultivars collected from various localities under different Districts of Manipur

District	Locality	Common Name
Imphal West	Mayang Imphal	Tha Animachai Chabi,
Meitei	Malom	morok ashangba
	Langjing	Meitei morok mapop Chaobi
		Meitei morok atenbi
Thoubal	Thentha Khunjao	Marok Angouba
Bishnupur	Sagang	Morok masingkha (Uchithi)
	Moirang	Umorok (Chatrick)
Churachanpur	Taithu	Morok amuba
	Bijang	Umorok (Manao)
	Churachanpur	Umorok (Brown)
	Moaglenphai	Yenshang morok (Malcha)
Tamenglong	Kaikao	Umorok (red)
	Langmei	Umorok (orange)
Ukhrul	Singda	Hao morok ashangba
	Ukhrul	Morok achouba
	Ukhrul	Morok ashangba
Senapati	Mao	Yenshang morok

During the experiment 17 chilli cultivars were collected to screen against fruit rot. The different chilli cultivars collected from various localities under different districts of Manipur were given below :

Seedlings were raised during January 2005. Two months old seedlings were transplanted in the experimental field. The plants were exposed under natural infection and disease intensity on fruit rot were recorded during ripening stage to screen the reaction type of the cultivars.

A scale with disease index value of 0,1,2,3 and 4 was adopted. The index values of the scale were as–

Scale	Reaction type	Description
0	Immune	no infection on fruit.
1	Resistant	less than 1% of fruit surface area infected.
2	Moderately resistant	1-5% of fruit surface area infected.
3	Susceptible	6-50% of fruit surface area infected.
4	Highly susceptible	51-100% of fruit surface area infected.

RESULTS

After repeated isolation of fruit rot of chilli, *Colletotrichum capsici, Colletotrichum gloeosporioids, Gloeosporium* sp. and *Fusarium* sp. were consistently found to be associated with chilli fruits showing typical disease symptoms of fruit rot. The isolated fungi were identified with the relevant literature, monographs etc. in the laboratory.

Results depicted in Table 1 revealed that of the five fungicides tested *in vitro* by poisoned food technique, Carbendazim and Thiophanate methyl @ 0.1 % each could completely inhibit the linear mycelial growth of *Colletotrichum capsici* whereas complete inhibition of *Colletotrichum gloeosporioides* was observed from Carbendazim @ 0.1 %, Mancozeb @ 0.2 % and Thiophanate methyl @ 0.1 % treated plates. However, Carbendazim could completely inhibit the linear growth of *Gloeosporium* sp. and *Fusarium* sp. Further, it was observed that Copper oxychloride was least effective on growth of chilli fruit rot fungi . All the fungicides tested showed significantly different effect on radial mycelial growth of chilli fruit rot fungi.

Data presented in Table 2 showed the efficacy of six biocontrol agents on growth of chilli fruit rot fungi in dual culture technique. Among the six biocontrol agents, three species of *Trichoderma* could come in contact with the test fungi within two days. While *Verticillium licanii, Beauveria bassiana* and *Metarhizium anisopliae* took 4 days.

Table 1 : Effect of fungicides on linear growth of fruit rot pathogens of chilli *in vitro*

Name of Fungicide	Concentration (%)	Growth (cm) *				Inhibition %			
		Colletotrchum capsici	*Colletotrichum gloeosporioides*	*Gloeosporium* sp.	*Fusarium* sp.	*Colletorichum capsici*	*Colletotrichum gloeosporioides*	*Gloeosporium* sp.	*Fusarium* sp.
Mancozeb (75. W.P)	0.1	0.0 (0.707)	0.0 (0.707)	0.0 (0.707)	0.0 (0.707)	100.0	100.0	100.0	100.0
Copper oxychloride (50 W.P)	0.2	5.125 (2.371)	4.6 (2.258)	3.80 (2.074)	4.325 (2.197)	42.2	48.89	57.78	51.94
Thiophanate methyl (70. W.P)	0.1	1.25 (1.323)	0.0 (0.707)	1.375 (1.369)	3.30 (1.949)	86.6	100.0	84.72	63.33
Carbendazim (50 W.P)	0.2	4.125 (2.150)	0.0 (0.707)	1.675 (1.475)	3.875 (2.091)	55.5	100.0	81.39	56.94
Hexaconazole (5. E.C)	0.1	0.0 (0.707)	0.0 (0.707)	1.325 (1.350)	2.075 (1.604)	100.0	100.0	85.28	76.94
Control	—	9.00 (3.082)	9.00 (3.082)	9.00 (3.082)	9.00 (3.082)	0.0	0.0	0.0	0.0
S.E (d)		.01	.05	.01	.02				
C.D. at 5 %		.02	.10	.02	.38				

* Figures in Parentheses were square root transformed (x+.5)
* Mean of 4 replications

Table 2 : Effect of biocontrol agents on the linear growth of fruit rot fungi

Treatment	Duration required for point of contact (day)				Growth after 72 h (cm)*				% inhibition on colony diameter over control			
	Colletot -richum capsici	*Colletotr -ichum gloeospo -rioides*	*Gloeosp- orium* sp.	*Fusa- rium* sp.	*C. capsici*	*C. gloeospo -rioides*	*Gloeospo -rium* sp.	*Fusarium* sp.	*C. capsici*	*C. gloeos- porioides*	*Gloeos- porium* sp.	*Fusarium* sp.
Isolate + *Trichoderma harzianum*	2	2	2	2	4.22	4.17	4.32	4.32	12.08	16.10	10.37	14.79
Isolate + *Trichoderma hamatum*	2	2	2	2	4.12	4.07	4.10	4.17	14.17	18.11	14.94	17.75
Isolate + *Trichoderma viride*	2	2	2	2	4.20	4.22	4.25	4.42	12.50	15.09	11.82	12.82
Isolate + *Verticillium licanii*	4	4	4	4	4.55	4.60	4.55	4.80	5.21	7.44	5.60	5.32
Isolate + *Beauveria bassiana*	4	4	4	4	4.65	4.85	4.62	4.90	3.12	2.41	4.15	3.35
Isolate + *Metarhizium anisopliae*	4	4	4	4	4.44	4.67	4.50	4.74	7.29	6.04	6.64	6.31
Isolate					4.80	4.97	4.82	5.07	0.00	0.00	0.00	0.00
S. E. (d)					0.03	0.01	0.02	0.02				
C.D. at 5%					0.07	0.02	0.04	0.04				

* Mean of 4 replications.

Trichoderma hamatum showed maximum inhibition on radial mycelial growth of *Colletotrichum capsici* (14.17%) *C. gloeosporioides* (18.11%) *Gloeosporium* sp. (14.49%) and *Fusarium* sp. (17.75%) respectively. Considerable inhibition of radial growth of *C. gloeosporioides* (16.10%) and *Fusarium* sp. (14.79%) was shown by *Trichoderma harzianum* whereas by *T. viride* on *C. capsici* (12.50%) and *Gloeosporium* sp. (11.82%). It was further observed that *Verticillium licanii*, *Beauveria bassiana* and *Metarhizium anisopliae* showed negligible amount of inhibition on radial growth of all the fruit rot fungi.

Results presented in Table 3 showed the significant different effects of five locally available botanicals at 5 % and 10 % concentration against the growth of four fungi causing fruit rot of chilli. Among them, *Solanum surattense* @10% showed maximum inhibition on radial growth of *Colletotrichum capsici* (65.00%), *C. gloeosporioides* (70.33%), *Gloeosporium* sp. (66.11%) and *Fusarium* sp. (59.78%) respectively. However *Solanum torvum* @10% and *Solanum surattense* @ 5% showed slightly similar effect of inhibition on radial growth of fruit rot fungi. It was observed from the table that *Melia azadiracta*, *Ocimum sanctum* and *Allium sativum* were found to be least effective as compared with other plant extracts studied. Data presented in Table 4 showed screening of 17 available local chilli cultivars against fruit rot under natural field conditions. None of chilli cultivars was found resistant to fruit rot. However, four cultivars namely Morok angouba, Morok amuba, Morok masingkha and Yenchang morok were found to be immune to fruit rot disease. The cultivars, Tha animakhai chabi, Umorok (Orange colour), Umorok (red), Umorok (brown), Umorok (chatrick) and Umorok (manao) were found to be moderately resistant. The cultivars Malcha (Yenchang morok) and Hao morok ashangba were susceptible to fruit rot showing nearly 50% of the part of fruit being infected. While Morok asangba (Ukhrul), Morok achouba (Ukhrul), Meitei morok ashangba, Meitei morok mapop chaobi and Meitei morok atenbi were found highly susceptible to fruit rot disease. It was further observed that cultivars with large fruits with thick

Table 3 : Effect of botanicals on the linear growth of fungi

Botanicals	Part of botanical used	Common name/local name	Concentration (%)	Mycelial Growth (cm)*				Per cent inhibition over the control			
				Colletotichum capsici	*C. gloeosporioides*	*Gloeosporium* sp.	*Fusarium* sp.	*Colletotichum capsici*	*C. gloeosporioides*	*Gloeosporium* sp.	*Fusarium* sp.
Solanum torvum Sw.	Leaf	Shingkhanga	5	4.72	4.17	4.10	5.05	47.55	53.67	54.44	43.89
			10	4.05	3.72	3.70	4.15	55.00	58.67	58.89	53.89
Solanum surattense Burm. F	Leaf	Yellow berried nightshade	5	4.05	3.70	3.70	4.27	55.00	58.89	58.89	52.55
			10	3.15	2.67	3.05	3.62	65.00	70.33	66.11	59.78
Melia azadiracta L	Leaf	Darek	5	5.62	5.02	5.10	6.02	37.55	44.22	43.33	33.11
			10	5.27	4.85	4.40	4.77	41.00	46.11	51.11	47.00
Ocimum sanctum L	Leaf	Tulsi	5	6.17	5.72	5.75	6.22	31.44	36.44	36.11	30.89
			10	5.82	5.12	4.85	5.20	35.33	43.11	46.11	42.22
Allium sativum L	Clove	Garlic	5	5.07	4.77	4.70	5.67	43.67	47.00	47.78	37.00
			10	4.47	4.05	4.00	4.47	50.33	55.00	55.55	50.33
Control.	-	-		9.00	9.00	9.00	9.00	00.00	00.00	00.00	00.00
S.E.(d)			5	0.03	0.03	0.03	0.03				
			10	0.02	0.01	0.02	0.03				
C.D. at 5%			5	0.06	0.06	0.06	0.06				
			10	0.05	0.02	0.04	0.06				

* Mean of 4 replications

Table 4 : Screening of available local chilli cultivars against fruit rot

Score	Number of varieties	Name of cultivars
Immune	4	Morok angouba, Morok amuba, Morok masingkha and Yenchang morok.
Resistance	0	Nil
Moderately resistant	6	Tha animakhai chabi, Umorok (orange colour), Umorok (chatrick), Umorok (red colour), Umorok (brown), Umorok (manao)
Susceptible	2	Malcha (Yenchang morok), and Hao morok ashangba.
Highly susceptible	5	Morok ashangba (Ukhrul), Morok achouba (Ukhrul), Meitei morok ashangba, Meitei morok mapop chaobi and Meitei morok atenbi.
Total	17	

pericarp were affected less as compared with smaller fruit with a thin pericarp.

DISCUSSION

Four fungi namely, *Colletotrichum capsici, Colletotrichum gloeosporioides*, *Gloeosporium* sp. and *Fusarium* sp. were isolated from fruit rot disease of chilli. All these fungi were found to be associated with riped chilli fruits showing typical disease symptoms of fruit rot. *Colletotrichum capsici*, *Alternaria solani, Curvularia ovoidea* and *Fusarium moniliforme* were associated with fruit rot of chilli in India as reported by Raja and Pillayarswamy, (1972). Among the five fungicides tested *in vitro*, Carbendazim and Thiophanate methyl @ 0.1% each could completely inhibit the linear mycelial growth of *Colletotrichum capsici.* Carbendazim @ 0.1%, Mancozeb @0.2% and Thiophanate methyl @ 0.1% could completely inhibit the linear growth of *Colletotrichum gloeosporioides*, and *Fusarium* sp. The present findings corroborate thõse of Mishra and Rath (1988) who also reported that Bavistin (Carbendazim) was very effective in inhibiting the mycelial growth of *Fusarium* sp. whereas Captan and Blitox – 50 were not as effective as Bavistin. Similarly Suryawanshi and Deokar (2001) observed that Carbendazim could inhibit growth of *Fusarium oxysporum* followed by Thiophanate methyl.

Among six biocontrol agents, *Trichoderma harzianum, Trichoderma hamatum* and *Trichoderma viride* showed maximum inhibition on radial mycelial growth of each fungus in dual culture technique. *T. hamatum* showed maximum inhibition

on radial mycelial growth of *Colletotrichum capsici* (14.17%), *C. gloeosporioides* (18.11%), *Gloeosporium* sp (14.49%) and *Fusarium* sp. (17.78%) respectively. Considerable inhibition on radial mycelial growth was shown by *T. harzianum* on *C. gloeosporioides* (16.10%) and *Fusarium* sp. (14.79%) whereas by *T. viride* on *C. capsici* (12.50%) and *Gloeosporium* sp. (11.82%). It was further observed that other remaining three biocontrol agents showed negligible amount of inhibition on radial growth of all the four fruit rot fungi. Sharma and Chandel (2003) reported that maximum inhibition on mycelial growth of *Fusarium oxysporum* f. sp. *gladioli* was obtained with *Trichoderma harzianum* (75.36%) followed by *Trichoderma viride* (70.95%), *Trichoderma virens* (61.43%) and least with *Rhizopus* (29.21%) in dual culture technique.

Five locally available botanicals were tested on growth of four fungi causing fruit rot of chilli. Among them *Solanum surattense* showed maximum inhibitory effect on the mycelial growth of the fungi followed by *Solanum torvum* and *Allium sativum* at 5% and 10% concentrations. *Ocimum sanctum* (Tulsi) showed least effective as compared with other plant extracts studied. More effectiveness of *Solanum surattense* against fruit rot fungi might be due to its more antimicrobial properties than other botanicals tested. The present findings are in agreement with those of Gomathi and Kannabiran (2000) who reported that aquous leaf extract of *Solanum tovum, Datura metel* and *Prosopis juliflora* were found to effectively inhibit the mycelial growth of *Colletotrichum capsici* and *Gloeosporium piperatum* infecting *Capsicum annum.* Futher, they reported that leaf extract of *Solanum surattense* showed considerable inhibition on radial mycelial growth of *Gloeosporium piperatum* (44.4%) and *Colletotrichum capsici* (26.7%). Seventeen locally available chilli cultivars showed different degree of reactions to fruit rot disease of chilli under field conditions. The present finding are in agreement with those of Patil *et al.* (1993) who found that less infection by *Colletotrichum capsici* on chilli varieties with thick pericarp than varieties with smaller fruits and thin pericarp. Similarly, Basak (1997) who reported that out of 10 chilli cultivars screened against 3 major fruit rotting fungi namely *Colletotrichum capsici, C. gloeosporioides, (Glomerella cingulated)* and *Fusarium semitectum (F. pallidoroseum)*. Cultivars C-011 and C-045 were susceptible to *G. cingulata and C. capsici*. C-123 to *C. capsici* and Chittagong local and Bogra local were highly susceptible to *G. cingulata* and *C. capsici*. The remaining cultivars were moderately resistant

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