JOURNAL OF PURE AND APPLIED MICROBIOLOGY, June 2016. Vol. **10**(2), p. 1641-1644

Evaluation of Chemicals and Bioagents for Managing *Phytophthora* Root Rot and Root-knot Nematode Disease Complex in Capsicum under Naturally Ventilated Polyhouse

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https://doi.org/10.22207/JPAM.10.2.101

(Received: 03 January 2015; accepted: 09 February 2015)

Capsicum is an important vegetable crop of Karnataka. Among the various diseases affecting capsicum, *Phytophthora* root rot (*Phytophthora capsici)* and root-knot nematode (*Meloidogyne incognita*) infestation are considered as the most destructive under protected cultivation. Totally six fungicides and seven bioagents were screened against *P.capsici* under *in vitro.* Among the fungicides, Bordeaux mixture and Metalaxyl MZ were highly inhibitory to *P. capsici.* Among the antagonists, *Trichoderma* were most effective in inhibiting the growth of *P. capsici.* Least inhibition was noticed with *Bacillus* sp followed by *Pseudomonas*. Effect of various disease management tools on seedling emergence, *Phytophthora* root rot incidence and root knot index were studied. As part of integrated management strategies an investigation was carried out to manage the disease through soil application of fungicide, nematicide and bioagents. Metalaxyl MZ significantly reduced the *Phytophthora* root rot incidence of 69.23% disease reduction over control under polyhouse condition. Integration of Carbofuran + *P. lilacinus* (0.33) also proved superior in managing root knot disease over control.

Keywords: *Phytopthora capsici, Meloidogyne incognita, Capsicum annuum,* Management.

Capsicum (*Capsicum annuum* L.) is infected by a number of diseases, among them wilt complex has gained major importance in India and the losses caused by disease are up to the extent of 30 to 40 per cent. The wilt disease, incited by a number of pathogens, is the devastating soil-borne disease and hence it is difficult to manage. The disease has been observed to be caused by *Phytophthora capsici* and Root-knot nematode, *Meloidogyne incognita.* Keeping in view the etiology, exorbitant losses and lack of information regarding integrated management of wilt complex disease using bio-control agents and chemicals, the present studies were conducted to evolve the effective management strategies under naturally ventilated polyhouse condition. The study was carried out in Zonal Agricultural and Horticultural Research Station, UAHS, Shivamogga, Karnataka.

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MATERIALS AND METHODS

The fungus, *Phytophthora capsici* was isolated from capsicum plants affected with wilt complex disease. The pure cultures of pathogen were maintained on potato dextrose agar media at 4°C. Root-knot nematode was extracted from the wilt affected soil and also from affected root galls.

In-vitro Evaluation of Fungicides against Phytophthora capsici

The efficacy of fungicides *viz*. Metalaxyl MZ, Alliete, Carbendazim, Mancozeb, Bordeaux mixture and Avatar were tested at three different concentrations 0.05%, 0.075%, 0.1% against each pathogen under *in-vitro* condition by poisoned food technique to find out the effective fungicides. The petri-plates containing Potato dextrose agar media amended with desired concentration of fungicides were inoculated with 5 mm discs of pathogen and incubated with 25±1°C temperature. The plates without any fungicides served as check. The radial mycelial growth was recorded in each treatment and percent inhibition over check was calculated.

In-vitro Evaluation of bioagents against Phytophthora capsici

Seven Bioagents viz., *Bacillus subtillis, Psuedomonas fluorescens, Paecilomyces lilacinus, Trichoderma harzianum, T. viride, T. koningii* and *T. virens* were evaluated for their efficacy through dual culture technique. The bioagents and the test fungus were inoculated side by side on a single petridish containing solidified Potato Dextrose Agar. Five replications were maintained for each treatment with one control by maintaining only pathogen separately. The diameter of the colony of both bioagents and the pathogen was measured in two directions and average was recorded. The per cent inhibition of growth of the test fungus was calculated

Evaluation of chemicals and bioagents against capsicum wilt complex under polyhouse condition

The fungicides found effective *in vitro* were tested *in vivo* as soil application to the plant. The studies were carried out in polyhouse. Treatments were imposed to the beds before sowing *viz*., Metalaxyl MZ (0.1%), Copper oxychloride (0.1%), Carbofuran (10g/plant), *P. lilacinus* (20g/plant), *T. harzianum* (20g/plant), *P. fluorescens* (20g/plant), Metalaxyl MZ (0.1%) + Carbofuran (10g/plant), Metalaxyl MZ (0.1%) + *P. lilacinus* (20g/plant), Metalaxyl MZ (0.1%) + *T. harzianum* (20g/plant), Metalaxyl MZ (0.1%) + *P. fluorescens* (20g/plant) and Carbofuran (20g/plant) + *P. lilacinus* (20g/plant). The antagonists (20 g each) were properly mixed with 1 kg FYM and then mixed with the top soil layer of plot. The observations on wilt incidence and RKI were recorded in each treatment.

RESULTS AND DISCUSSION

In vitro* evaluation of fungicides against *P. capsici

The present investigation in Table 1 revealed that cent per cent inhibition of mycelial growth of *P. capsici* was recorded with Bordeaux mixture and Metalaxyl MZ at all tested concentrations which are followed by Avatar (75.89%) and Alliete (72.30%) at 0.1%. Least inhibition of 55.93 and 55.03 per cent was recorded in Bavistin and Mancozeb respectively. Similar observations have been recorded by Babadoost and Islam[2] with respect to metalaxyl MZ as highly inhibitory to the mycelial growth of *P. capsici* under *in-vitro* conditions[3]. Bordeaux mixture (1%), Blitox and Metalaxyl MZ which were found effective in inhibiting the growth and sporangial formation of *P. capsici* and *P. meadii*[13,14,16].

In vitro* evaluation of bioagents against *P. capsici

Efficacy of bioagents was studied under *in vitro* conditions by following dual culture

Table 1. *In vitro* evaluation of fungicides against *Phytophthora capsici*

Fungicides		Percent inhibition Concentration (%)			
Common name	Trade name	0.05	0.075	0.1	Mean
Carbendizim	Bavistin 50 WP	55.75 (48.30) *	55.93 (48.41)	55.93(48.41)	55.87 (48.37)
Aliette	Fosetyl 80 WP	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)
Metalaxyl MZ	Ridomil 72WP	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)	100.00 (90.05)
Hexaconazole 4%+ Zineb 68%	Avatar72 WP	58.99 (50.18)	71.94 (58.01)	75.89 (60.59)	68.94 (56.13)
Dithane M45	Mancozeb 75WP	58.99 (50.18)	44.42 (41.80)	55.03 (47.89)	52.81 (46.61)
Bordeaux mixture	-	55.03 (47.89)	61.69 (51.76)	72.30 (58.24)	63.00 (52.54)
Mean	71.46 (57.71)	72.33 (58.26)	76.52 (61.02)	73.43 (58.97)	
	Fungicides (F)	Concentration (C)	F × C		
S.Em. ±	0.31	0.22	0.55		
C.D @ 1 %	0.84	0.67	1.46		

*Figures in the parenthesis are arcsine transformed values

Table 2. *In vitro* evaluation of bioagents against *Phytophthora capsici*

Bioagents	Per cent inhibition
Paecilomyces lilacinus	44.63 (41.94)*
Trichoderma harzianum	100.00 (90.05)
T. viride	53.70 (47.15)
T. virens	58.15 (49.71)
T. koningii	48.15 (43.96)
Pseudomonas fluorescens	57.86 (51.87)
Bacillus subtillis	45.19 (42.26)
SEm±	0.28
CD@1%	1.17

*Figures in the parenthesis are arcsine transformed values

method against *P. capsici* and the results are presented in Table 2. There was significant difference among all the tested bioagents. *Trichoderma harzianum* (100%) was significantly superior in inhibiting the mycelial growth of *P. capsici* followed by *T. virens* (58.15%), *P. fluorescens* (57.86%) and *T. viride* (53.70%). Further, *T. koningii* (48.15%), *Bacillus subtilis* (45.19%) and *P. lilacinus* (44.63%) remained on par with each other in inhibition. Inhibition of mycelial growth was recorded in *P. fluorescens* (43.81%). This has been reported by many workers[8,10].The antagonism of *Trichoderma* spp. against many fungi is mainly due to production of acetaldehyde[13]. This may also be the reason for antagonistic effect of native isolates of *Trichoderma* against *P. capsici*. The antagonistic nature of *Bacillus subtilis* and *Pseudomonas* sp[6]. Similar results were observed in the efficacy of *Trichoderma* spp. and *Pseudomonas* spp. against the pathogen *P. capsici*[1, 2, 11].

Table 3. Evaluation of Chemicals and Bioagents against *Phytophthora capsici* and *Meloidogyne incognita*

S. No.	Treatments	% seedling emergence	% Increase over Control	% disease incidence	% disease reduction over control	Nematode Population Initial	Nematode Population Final	RKI (0-5)
T1	Metalaxyl MZ	74.93	39.62	18.02 (25.13)*	69.23	905.33	815.67	4.00
T2	COC	72.67	35.40	25.50 (30.35)	56.45	881.40	791.40	4.00
T3	Carbofuran	76.93	43.35	37.40 (37.72)	36.13	757.00	466.67	2.67
T4	*P. lilacinus*	76.00	41.61	27.07 (31.37)	53.78	610.00	220.00	1.00
T5	*T. harzianum*	77.67	44.71	21.29 (27.49)	63.65	655.60	345.60	1.67
T6	*P. fluorescens*	78.89	46.98	27.43 (31.60)	53.15	745.17	435.17	2.00
T7	T1+T3	76.83	43.16	18.22 (25.28)	68.89	720.00	258.33	2.67
T8	T1+T4	76.67	42.85	20.31 (26.80)	65.31	606.00	294.67	1.33
T9	T1+T5	75.55	40.77	16.20 (23.75)	72.34	660.77	350.33	1.67
T10	T1+T6	73.80	37.51	20.07 (26.63)	65.73	737.00	427.00	2.00
T11	T3+T4	73.33	36.64	35.77 (36.75)	38.92	650.00	205.00	0.33
T12	Control	53.67	-	58.40 (49.86)	-	920.67	975.33	5.00
SEm.±0.19		-	1.42	-			0.22	
CD@5%		0.56	-	4.20	-			0.65

*Figures in the parenthesis are arcsine transformed values

Evaluation of chemicals and bioagents against capsicum wilt complex under polyhouse condition

The data presented in Table 3 also revealed that, highest percent seedling emergence over control were recorded in *P. fluorescens* (46.98%), *T. harzianum* (44.71%), Carbofuran (43.35%) and Metalaxyl MZ + Carbofuran (43.16%) treatments respectively. Further, Metalaxyl MZ (69.23), Metalaxyl MZ + Carbofuran (68.89%), Metalaxyl MZ + *P. fluorescens* (65.73%) and Metalaxyl MZ + *P. lilacinus* (65.31%) showed higher disease reduction over control respectively. The integration of biocontrol agents with Metalaxyl MZ resulted lesser disease incidence. Integration of Carbofuran + *P. lilacinus* (0.33) recorded less gall index of 0.33 followed by *P. lilacinus* (1.00). Further, *T. harzianum* and Metalaxyl MZ + *T. harzianum* showed 1.67 gall index compared to control (5.00 RKI). The present findings are supported by earlier works wherein integration of bio-control agents with fungicides and nematicides gave significantly higher disease control in several crops than that obtained either by bio-control agent or by fungicide or by nematicide alone[9,14,15]. Treatment with Metalaxyl MZ may eradicate the wilt causing pathogens or other microflora thereby less competition for biocontrol agents to colonize the seed, root surface and proliferation[5, 11]. The subsequent application of compatible fungicide/ nematicide may support the growth of antagonists and may also prevent the plant from the attack of pathogens. The other workers also observed the additive effects of compatible fungicide/nematicide and antagonists[4]. Integrated *T. viride* or *T. harzianum* with Metalaxyl MZ and Cymoxanil (8%) + Mancozeb (64%) to control root rot in cotton[7]. Results from the present investigation concluded that, soil application of Metalaxyl MZ or Carbofuran+ bioagents applied simultaneously to manage the root galling and *Phytopthora* rot in Capsicum.

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