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Jaskaran Singh
Department of Plant Pathology, SVPUA&T, Meerut, Uttar Pradesh India

Kamal Khilari
Department of Plant Pathology, SVPUA&T, Meerut, Uttar Pradesh India

Ramji Singh
Department of Plant Pathology, SVPUA&T, Meerut, Uttar Pradesh India

Prashant Mishra
Department of Plant Pathology, SVPUA&T, Meerut, Uttar Pradesh India

Pankaj Kumar
Department of Biotechnology, SVPUA&T, Meerut, Uttar Pradesh India

Rajendra Singh
Department of Entomology, SVPUA&T, Meerut, Uttar Pradesh India

Correspondence
Jaskaran Singh
Department of Plant Pathology, SVPUA&T, Meerut, Uttar Pradesh India

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Studies on the compatibility of *Trichoderma spp.* with nematicides under *in vitro* conditions

Jaskaran Singh, Kamal Khilari, Ramji Singh, Prashant Mishra, Pankaj Kumar and Rajendra Singh

Abstract
Biological control is environmentally acceptable approach for disease management, it involves the use of beneficial microorganisms to control plant pathogens and the diseases they cause. Biological control of soil borne plant pathogens is a vital area of plant pathological research all over the world in these days. Among the fungal biocontrol agents, *Trichoderma* spp. have acquired much importance. Although use of biocontrol agents could reduce the use of chemicals to a limited extent, it is less reliable and less efficient. One of the most promising possibilities of biocontrol with *Trichoderma* strains within the frames of a complex integrated plant protection, which is based on the combined application of physical, chemical and biological means of disease control. In the case of the integrated management strategy when *Trichoderma* strains are combined with chemical pesticides, on the basis of an experiment was conducted to evaluate the different pesticides for compatibility against *Tricoderma* spp. Four nematicide namely; Carbofuron, Aldicarb, Phorate and Thionazin were tested at 0.1% and 0.2% concentrations *in vitro* by poisoned food technique. The observations were recorded on radial mycelial growth of *Trichoderma* after 24, 48 and 72 hours intervals. Minimum inhibition of mycelial growth of *Trichoderma* was observed in Phorate (4.37& 8.75%) at the concentration (0.1& 0.2%) followed by carbofuran (11.63 & 13.13%). Whereas Aldicarb was found most inhibitory (36.50 & 58.39%) at both the concentration respectively. Results indicate that Carbofuran and Phorate compatible with *Trichoderma* for the management of RKN in rice.

Keywords: Root knot nematode, Biocontrol

Introduction

Biological control of soil borne plant pathogens by species of *Trichoderma* is a vital area of plant pathological research all over the world in these days (Mukhopadyay, 1987) [1]. Most of the soilborne diseases are not amenable for management through chemicals. Use of several antagonistic species of *Trichoderma* (*Trichoderma viride, Trichoderma harzianum and Trichoderma virens*) against a range of economically important soil borne plant pathogens has been well documented (Cook and Baker, 1983; Chet, 1987; Raghuchander *et al*., 1997; Anitha and Tripathi, 2000; Mukerjee *et al*., 2001) [3, 16, 2, 18].

Biological control involves the use of beneficial microorganisms to attack and control plant pathogens, and the diseases they cause. It is an environmentally acceptable approach to disease management. Among the fungal biocontrol agents *Trichoderma* spp. have acquired much importance (Papavizas, 1985; Sreenivasaprasad S. and Manibhushanrao, 1990) [14, 20]. *Trichoderma* spp. are fungi that occur worldwide. Recent studies shows that they are not only parasites of fungal plant pathogens but also can produce antibiotics. In addition, certain strains can induce systemic and localized resistance to several plant pathogens. Moreover, some strains may enhance plant growth and development (Ha, T. N., 2010) [8]. *Trichoderma* spp. has received the most attention for control soil borne pathogens.

The beneficial effects of the *Trichoderma spp* is that it establishes symbiotic rather than parasitic relationships with the plant, by increasing plant growth and productivity, helping to overcome stress stimulations, and improving nutrient absorption (Harman *et al*., 2004) [7].

Species of the *Trichoderma* are able to inhibit the growth of variety of potentially pathogenic fungi. A recent list of mechanisms are viz., mycoparasitism, antibiosis, competition for nutrients or space, tolerance to stress through enhanced root and plant development, solubulization and sequestration of inorganic nutrients, induced resistance and inactivation of the pathogens enzymes (Lewis and Lumsden, 2001) [9]. Growth promotion due to *Trichoderma* spp. is also reported in several crop species (Manoranjitham *et al*., 1999) [11].

Although use of biocontrol agents could reduce chemical application to a limited extent, it is less reliable and less efficient (Monte, 2001) [12]. One of the most promising possibilities for the application of biocontrol *Trichoderma* strains is within the frames of a complex integrated plant protection, which is based on the combined application of physical, chemical and biological means of control. In the case of the application of a complex integrated strategy when *Trichoderma* strains are combined with chemical pesticides, therefore it is important to collect information about the effects of pesticides on the biocontrol agent (Kredics *et al*., 2003).

The combined use of biocontrol agents and chemical pesticides has attracted much attention as a way to obtain synergistic or additive effects in the control of soil-borne pathogens (Locke *et al*., 1985) [10]. The effect of certain fungicides, insecticides and herbicides on *Trichoderma* spp. was reported earlier with an emphasis on practical applications (Kredics *et al*., 2003).

The objective of the present study was to check the compatibility of some strains of *Trichoderma* spp. With different nematicides actually used against soil and seed borne diseases such as rice, wheat, corn, cucurbits and pulses.

Materials and methods

The biocontrol agent *Trichoderma harzianaum* was collected from Namatology Laboratory, Department of Plant Pathology Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut U.P. All the nematicide (Table 1) were tested at 0.1% and 0.2% concentration(0.1gm and 0.2 gm nematicide add into 100 ml PDA media respectively) under *in vitro* condition by using of poison food technique as described by Nene and Thapliyal (1993) [13], Dhingra and Sinclair (1995) [6].

Table 1: Nematicides used in the experiment

Sl. No.	Trade Name	Chemical Name	Concentration Used (%)
1.	Thimet	Phorate	0.1&0.2
2.	Temik	Aldicarb	0.1&0.2
3.	Furadan	Carbofuran	0.1&0.2
4.	Thionazin	Phosphorothioate	0.1&0.2

Petri plates containing only PDA without any nematicide were maintained as control. After solidification of media in to Petri plates, the 3 mm bit from 7 days old culture of *Trichoderma* spp. cut by cork borer and placed in the center of each Petri plates containing nematicide treated PDA and without treated PDA. The observations were recorded on radial growth after 24, 48 and 72 hours intervals. The colony diameter of *Trichoderma harzianaum* in the treatments was measured and compared with check (control) and reduction in growth was taken as a measure of toxicity. Percent inhibition of the growth of biocontrol agent over the control was calculated by using the following formula.

Percent Inhibition = (C-T)/C× 100

Where,
C= colony diameter at biocontrol agent in control
T=colony diameter at biocontrol agent in treatment

The experiment was conducted in a complete randomized design (CRD) with eight treatments presented in table 2.

Results and discussion

The compatibility of four nematicides was tested *in vitro* on mycelial radial growth, conidia production and germination of *Trichoderma harzianum.* It is evident from the data presented in table 2, that after 72 hours the maximum radial mycelial growth of *Trichoderma harzianum* was observed i.e, 4.37cm and 4.16cm in Phorate at 0.1 & 0.2% concentration. In case of Carbofuran the radial mycelial growth of *Trichoderma harzianum* was observed i.e., 4.03cm and 3.9cm and in Thionazin i.e., 3.46cm and 3.13cm at 0.1 & 0.2% concentration respectively. The minimum radial mycelial growth of *Trichoderma harzianum* was observed i.e., 2.90cm and 1.90cm in Aldicarb at 0.1 & 0.2% concentration.

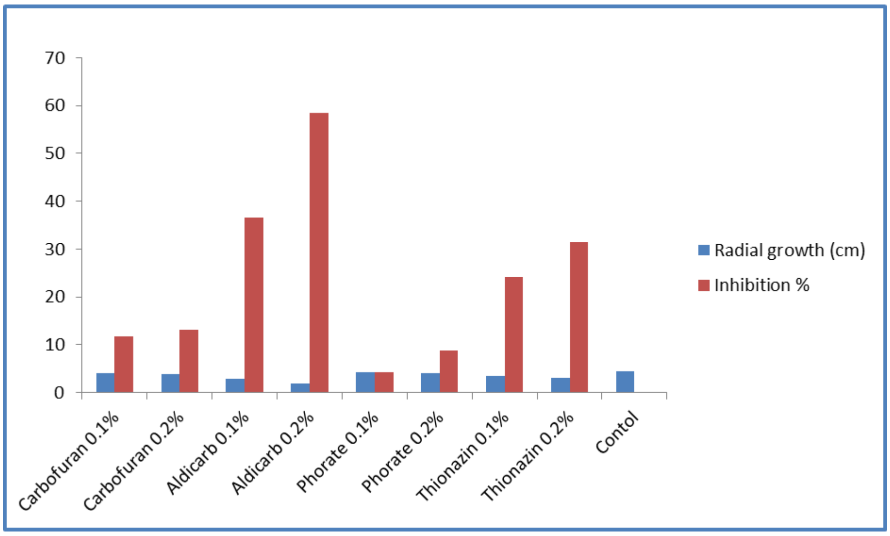
After 72 hours the minimum inhibition of mycelial growth of *Trichoderma harzianum* was observed in Phorate i.e. 4.37% and 8.75% at both the tested concentration (0.1 & 0.2%) followed by Carbofuran (11.63% &13.13%). Whereas, in Aldicarb maximum inhibitory (36.50% growth inhibition & 58.39% growth inhibition) at 0.1 & 0.2% concentrations respectively. Results indicate that Carbofuran and Phorate were compatible with *Trichoderma harzianum* and may combine apply for the management of root knot nematode in rice.

These results of the present study are in consonance with the earlier reports of several workers (Desai and Kulkarni, 2004; Ranganathswamy *et al*., 2011; Singh *et al.,* 2012; Thiruchchelvan *et al*., 2013; Vasundara *et al*., 2015; Dhanya *et al*., 2016 and Pranab Datta *et al*., 2017) [4, 17, 19, 21, 22, 5, 15].

In the present study, *T. harzianum* were found highly to moderately compatible with insecticides *viz.*, acephate 75% SP, fenvalerate 0.4% DP, imidacloprid 17.8% SL, acetamiprid 20% SP and thiamethoxam 25% WG, at their recommended dosages. However, quinalphos 25% EC and profenofos 50% EC were incompatible with the test *Trichoderma* spp. These results of the present study are in consonance with the earlier reports of several workers (Desai and Kulkarni, 2004; Ranganathswamy *et al*., 2011; Singh *et al.,* 2012; Thiruchchelvan *et al*., 2013; Vasundara *et al*., 2015; Dhanya *et al*., 2016 and Pranab Datta *et al*., 2017) [4, 17, 19, 21, 22, 5, 15].

Table 2: Radial growth of *Trichoderma* at different periods of time.

Treatments	After 24 hours		After 48 hours		After 72 hours	
	Radial growth (cm)	Inhibition %	Radial growth (cm)	Inhibition %	Radial growth (cm)	Inhibition %
Carbofuran 0.1%	0.500	28.57	2.200	12.00	4.033	11.69
Carbofuran 0.2%	0.400	42.85	2.100	16.00	3.967	13.13
Aldicarb 0.1%	0.400	42.85	1.400	44.00	2.900	36.50
Aldicarb 0.2%	0.393	43.85	1.033	58.68	1.900	58.39
Phorate 0.1%	0.533	23.85	2.233	10.68	4.367	4.37
Phorate 0.2%	0.667	4.71	2.033	18.68	4.167	8.75
Thionazin 0.1%	0.233	66.71	1.633	34.68	3.467	24.08
Thionazin 0.2%	0.267	61.85	1.367	45.32	3.133	31.39
Control	0.700	-	2.500	-	4.567	00.00
CD at 5% level	0.219	-	0.247	-	0.209	-



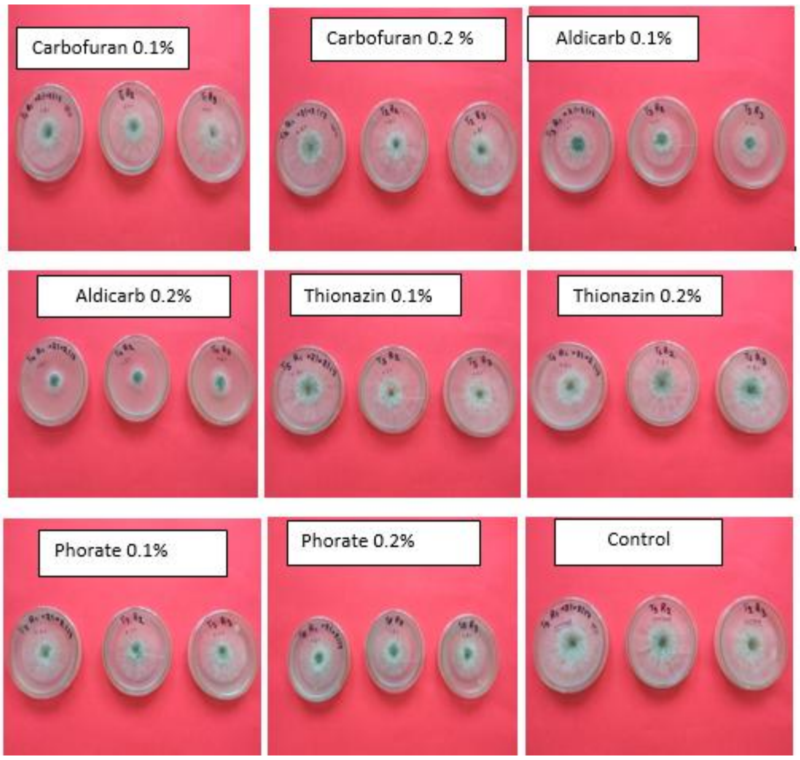


Fig 1: Radial growth of *Trichoderma harzianaum* after 72 hrs

Conclusion

From the present study it is clear that phorate @ 0.1% and 0.2% can applied with *Trichoderma harzianaum* for management of nematode diseases.

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