Biological Forum
an International Journal 17(7): 93-96(2025)
ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

In vitro Evaluation of Fungicides Against *Rhizoctonia solani*, the Causal Organism of Root Rot of Pea

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(Received: 12 April 2025; Revised: 26 May 2025; Accepted: 23 June 2025; Published online: 09 July 2025)
(Published by Research Trend)

ABSTRACT: Pea (*Pisum sativum* L.), commonly known as table pea, is a major leguminous vegetable crop belonging to the Fabaceae family. Among the fungal pathogens causing disease in peas, *Rhizoctonia solani* is particularly destructive, leading to root rot. This study assessed the *in vitro* effectiveness of seven fungicides carbendazim 50% WP, copper oxychloride 50% WP, tebuconazole 25.9% EC, hexaconazole 5% SC, propiconazole 25% EC, tebuconazole 50% + trifloxystrobin 25% WG, and thiophanate methyl 70% WP against *R. solani* at multiple concentrations. Complete inhibition of mycelial growth was observed with carbendazim, tebuconazole, hexaconazole, propiconazole, and the combination of tebuconazole + trifloxystrobin at 100, 150, and 200 ppm. Conversely, copper oxychloride at 500 and 1000 ppm was the least effective, followed by thiophanate methyl 70% WP.

Keywords: Pea, Pathogen, Fungicide, Concentration, Inhibition.

INTRODUCTION

Pea (*Pisum sativum* L.), an important legume of the Fabaceae family, is widely cultivated as a cool-season vegetable crop. It originated in the Mediterranean region and is consumed fresh, canned, or processed. Various types include garden, dry, edible-podded, and dwarf peas (Duke, 1981). Through symbiosis with *Rhizobium*, peas enrich soil nitrogen and support crop rotation. Optimal growth occurs in well-drained, light soils at 10–23°C and pH 5.5–7.0 (McKay *et al.*, 2003). Nutritionally, peas are rich in protein (15.5–39.7%), vitamins (A, B-complex, C), minerals (Ca, P, K), and antioxidants (Clark, 2007). Dried peas offer even higher protein (22.9%) and carbohydrate (60.7%) content (Duke, 1981; Hulse, 1994).

Pea is a key crop in India, ranking fourth in area and fifth in global output (FAO, 2022). It spans 5.82 lakh hectares with 6.7 million tonnes yield annually (Anonymous, 2022a). Major growing states include Uttar Pradesh, Madhya Pradesh, and Rajasthan. In Rajasthan, 12,687 hectares produce 25,385 tonnes, with Jaipur alone contributing 7,801 hectares and 7,335 tonnes (Anonymous, 2022b). Low yields are mainly due to poor germination, nutrient deficiency, and especially diseases.

Pea crops are vulnerable to over 20 pathogens, including those causing Ascochyta blight, powdery and downy mildew, seedling blight, grey mold, root rot, white mold, anthracnose, rust, bacterial blight, soft rot, and viral diseases like pea mosaic virus and seed-borne mosaic virus (Gupta and Paul 2001).

Among fungal infections, root rot caused by *Rhizoctonia solani* is especially damaging. It can infect a wide array of host plants and persist in soil through sclerotia or saprophytic growth (Dube, 2013). The teleomorph is *Thanatephorus cucumeris*, and isolates are often categorized into anastomosis groups (AGs) based on hyphal fusion (Sneh *et al.*, 1991). This pathogen attacks pea seeds, hypocotyls, and epicotyls (Acharya *et al*., 2014). Due to its capacity to survive in soil for up to six years, control becomes challenging.

Favorable conditions for disease development include warm and moist environments, especially affecting young seedlings (Cubeta and Vilgalys 1997). Incidence in India has been reported between 14.8% and 64.7% (Masoodi *et al*., 2016), and in Rajasthan, losses can go up to 72.98% (Sharma *et al*., 2016). Nationwide yield losses have ranged from 30% to 57% (Sharma *et al*., 2022).

Chemical intervention becomes necessary where root rot is prevalent. Therefore, this study focuses on evaluating the *in vitro* antifungal efficacy of certain fungicides against *Rhizoctonia solani*.

MATERIAL AND METHODS

The effectiveness of seven fungicides (carbendazim 50% WP, copper oxychloride 50% WP, tebuconazole 25.9% EC, hexaconazole 5% SC, propiconazole 25% EC, tebuconazole 50% + trifloxystrobin 25% WG, and thiophanate methyl 70% WP) was assessed against the mycelial growth of *Rhizoctonia solani* at concentrations of 100, 150, 200, 500, 1000, and 1500 ppm (Table 1).

The poisoned food technique was utilized to evaluate the fungicidal activity. For each fungicide, a stock solution with an active ingredient concentration of 30,000 mg ml^{-1} was prepared. Appropriate volumes were drawn from the stock and mixed with molten potato dextrose agar (PDA) to achieve the desired test concentrations. Twenty millilitres of the amended medium were poured into sterilized Petri dishes.

A 5 mm diameter mycelial disc was excised from a 15-day-old culture of *R. solani* using a sterile cork borer and carefully placed at the center of each plate under aseptic conditions. Control plates contained PDA without any fungicide. The experiment followed a completely randomized design (CRD) with three replications per treatment. All plates were incubated at 28 ± 1°C in a BOD incubator.

After 4 days of incubation, the radial growth of fungal colonies was measured. The percentage inhibition of mycelial growth compared to the control was calculated using the standard formula. Data obtained were subjected to statistical analysis under CRD.

$I = C – T / C * 100$

Where, I = Per cent mycelial inhibition of test pathogen, C = Radial growth (mm) in control, T = Radial growth (mm) in treated plates.

Table 1: Details of chemical fungicide and concentrations used in experiment.

Sr. No.	Fungicides	Concentration tested (ppm)		
1.	Copper oxychloride 50% WP	500	100	1500
2.	Carbendazim 50% WP	100	150	200
3.	Tebuconazole 25.9% EC	100	150	200
4.	Hexaconazole 5%SC	100	150	200
5.	Propiconazole 25% EC	100	150	200
6.	Tebuconazole 50% + Trifloxystrobin 25% WG	100	150	200
7.	Thiophanate methyl 70% WP	100	150	200
8.	Control	—	—	—

RESULTS AND DISCUSSION

Seven fungicides (copper oxychloride 50% WP, carbendazim 50% WP, tebuconazole 25.9% EC, hexaconazole 5% SC, propiconazole 25% EC, tebuconazole 50% + trifloxystrobin 25% WG, and thiophanate methyl 70% WP) were assessed *in vitro* against *Rhizoctonia solani* using the poisoned food method on PDA medium. Each treatment was tested at multiple concentrations and replicated thrice. The results (Table 2, Fig. 1) clearly demonstrated that increased fungicide concentrations were directly associated with greater inhibition of mycelial growth.

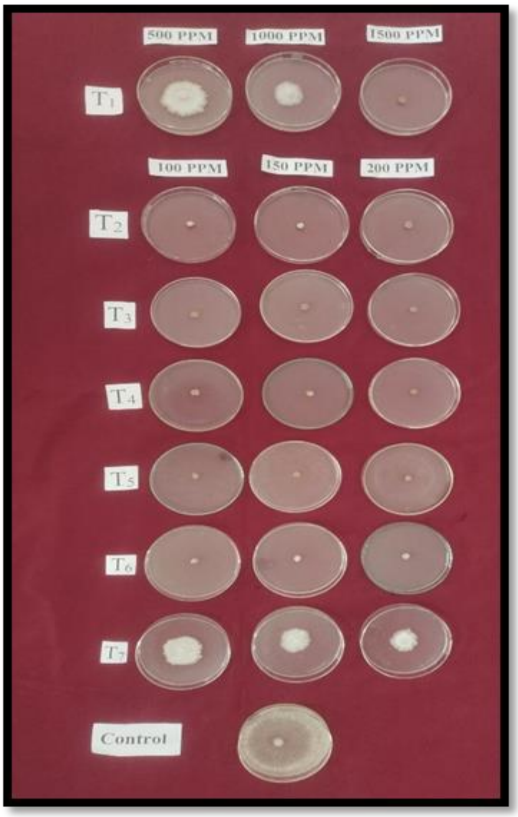
Complete suppression of the pathogen's mycelial growth was observed at 100, 150, and 200 ppm for carbendazim 50% WP, tebuconazole 25.9% EC, hexaconazole 5% SC, propiconazole 25% EC, and the combination product tebuconazole 50% + trifloxystrobin 25% WG. These fungicides showed significantly better performance compared to others. In contrast, copper oxychloride 50% WP recorded the least inhibition, with values of 46.11% and 64.07% at 500 and 1000 ppm, respectively. Thiophanate methyl 70% WP followed, showing 53.15%, 61.67%, and 64.26% inhibition at 100, 150, and 200 ppm, respectively.

The present findings align with those of Chanu *et al*. (2019), who reported complete suppression of *Fusarium oxysporum* f.sp. *pisi* by carbendazim. Similar results were obtained by Shivran *et al*. (2020), who demonstrated the efficacy of carbendazim against *R. solani* in clusterbean. Supporting this, Kumar *et al*. (2014) observed that both propiconazole and carbendazim were highly effective in managing web blight in black gram. In addition, Yadav *et al.* (2020) reported that the combination of tebuconazole and trifloxystrobin at 200 and 500 ppm significantly inhibited *R. solani* mycelial growth *in vitro*, and also performed best under field conditions by reducing disease incidence by 83.12% and enhancing seed yield by 84.71%.

Table 2: Effect of fungicides on mycelial growth inhibition of *Rhizoctonia solani*.

Treatment	Concentration (ppm)	Mycelial growth (mm)	Percent mycelial growth inhibition
T_1 = Copper oxychloride 50% WP	500	48.50	46.11 (42.77)
	1000	32.33	64.07 (53.18)
	1500	0.00	100.00 (90.00)
T_2 = Carbendazim 50% WP	100	0.00	100.00 (90.00)
	150	0.00	100.00 (90.00)
	200	0.00	100.00 (90.00)
T_3 = Tebuconazole 25.9% EC	100	0.00	100.00 (90.00)
	150	0.00	100.00 (90.00)
	200	0.00	100.00 (90.00)
T_4 = Hexaconazole 5% SC	100	0.00	100.00 (90.00)
	150	0.00	100.00 (90.00)
	200	0.00	100.00 (90.00)
T_5 = Propiconazole 25% EC	100	0.00	100.00 (90.00)
	150	0.00	100.00 (90.00)
	200	0.00	100.00 (90.00)
T_6 = Tebuconazole 50% + Trifloxystrobin 25% WG	100	0.00	100.00 (90.00)
	150	0.00	100.00 (90.00)
	200	0.00	100.00 (90.00)
T_7 = Thiophanate methyl 70% WP	100	42.17	53.15 (46.81)
	150	34.50	61.67 (51.75)
	200	32.17	64.26 (53.29)
T_8 = Control		90	0.00 (0.00)
	S Em. ±	**0.50**	**0.32**
	CD at 5%	**1.42**	**0.93**

*Average of three replications of each concentration; **Figures in parentheses are Arc sine percent angular transformed values.



Here, T_1= Copper oxychloride 50%WP, T_2 = Carbendazim50%WP, T_3=Tebuconazole 25.9% EC, T_4 = Hexaconazole 5%SC, T_5 = Propiconazole 25%EC, T_6 = Tebuconazole 50%+Trifloxystrobin 25% 75WG, T_7 = Thiophanate methyl 70%WG, T_8=Control

Fig. 1. Effect of fungicides on the mycelial growth of *Rhizoctonia solani.*

CONCLUSIONS

The research was made to evaluate the in vitro efficacy of seven fungicides against Rhizoctonia solani by poisoned food technique. The results revealed that carbendazim 50% WP, tebuconazole 25.9% EC, hexaconazole 5% SC, propiconazole 25% EC, and tebuconazole 50% + trifloxystobin 25% WG at 100, 150, and 200 ppm were found to be the most effective with 100% inhibition of mycelial growth of pathogen. While copper oxychloride 50% WP exhibited the lowest inhibition of mycelial growth, recording 46.11% and 64.07% at concentrations of 500 and 1000 ppm, respectively. It was followed by thiophanate methyl 70% WP, which showed inhibition rates of 53.15%, 61.67%, and 64.26% at 100, 150, and 200 ppm, respectively.

FUTURE SCOPE

Conducting detailed studies on *in vitro* evaluation of fungicides helps in identification of effective chemical with its right dosage against *Rhizoctonia solani*.

Acknowledgement. The authors are thankful to the Head, Department of Plant Pathology and the Dean, College of Agriculture Ummedganj, Agriculture University, Kota and to advisory committee members for their valuable guidance, support and facilities to conduct this research experiment successfully.

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How to cite this article: Charanjeet Bhadu and C.B. Meena (2025). *In vitro* Evaluation of Fungicides Against *Rhizoctonia solani*, the Causal Organism of Root Rot of Pea. *Biological Forum, 17*(7): 93-96.