# Efficacy of bio-agents in managing root rot of okra caused by *Rhizoctonia solani*


## Abstract

Okra or lady's finger [*Abelmoschus esculentus* (L.) Moench] is one of the most important summer vegetables of Rajasthan as well as India and belongs to the family *Malvaceae* and it is known as "*Bhindi*" in Hindi. Okra is attacked by several diseases caused by fungi and important one is root rot caused by *Rhizoctonia solani* Kuhn, which is an important constraint to the crop and causes significant economic losses. During present study, two bio-agents were evaluated alone and in combination through seed (4 g/kg) and soil (4 kg/ha) applications for two consecutive years under artificial inoculation conditions in the field. Among these, seed + soil application of *Trichoderma harzianum* was found most effective in reducing disease incidence (48.76%) and in increasing pod yield (13.46%) followed by seed treatment with *T. harzianum* + soil application of *Pseudomonas fluorescens* (46.41% and 12.84%, respectively). Looking to the increasing demand of organically produces in the market, root rot disease can be managed effectively with these eco-friendly approaches for supplying organically produced vegetables to fulfil the ever-increasing demand among health-conscious people.



**Keywords:** Okra, Root rot, *Rhizoctonia solani*, Bio-control agents, Disease control


## Introduction

Okra or lady's finger [*Abelmoschus esculentus* (L.) Moench] which is known as "*Bhindi*" in Hindi, is one of the most important summer vegetables of Rajasthan as well as India and belongs to the family *Malvaceae* (Tindall, 1983). Earlier, its botanical name was *Hibiscus esculentus* (L.) under the section *Abelmoschus* of *Hibischus*. The section *Abelmoschus* was subsequently proposed to be raised to the rank of distinct genus. The wider use of *Abelmoschus* was subsequently accepted in the taxonomic and contemporary literature (Hochreutimer, 1924). Although, about 50 species have been described, eight are most widely accepted (Saifullah and Rabbani, 2009).

Okra seeds are also good source of quality edible oil (20% to 40%) with tryptophan acid up to 47.4 per cent, in the form of unsaturated fatty acid, proteins along with fruits which contain vitamins, minerals such as calcium and potassium, calories and amino acids (Berry *et al*., 1988). In paper industries, the stem of okra plants is used for fiber purposes

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(Mithal, 2006). Martin (1982) has suggested that its roasted and grinded seeds can used as a substitute for coffee.

Okra crop is attacked severely from the vagary of diseases caused by fungi, bacteria, viruses and nematodes in the field, which not only reduces the potency of seed, but also degrades the health beneficial and nutritional quality components of the fruits. The important diseases of okra are root rot (*Rhizoctonia solani* Kuhn*)*, powdery mildew (*Oidium* spp.), Fusarium wilt (*Fusarium oxysporum*), charcoal rot (*Macrophomina phaseolina*), Cercospora leaf spot *(Cercospora abelemoschi*), damping off (*Pythium* spp.), root knot (*Meloidogyne* sp.) and yellow vein mosaic (*Bhindi Yellow Vein Mosaic Virus*) (Anon., 2003). Among the fungal diseases, root rot is one of the important diseases caused by *Rhizoctonia solani*.

Amongst these diseases, root rot caused by *Rhizoctonia solani*, is an important constraint to the crop and causes significant losses. The pathogen mainly attacks the root and underground parts, but it is also capable of infecting the other plant parts like the green foliage parts, the seeds and the hypocotyls (Acharya *et al*., 2014). Among the initial symptoms of the disease, yellowing of leaves is a first symptom which in next two or three days, leaves droop and wither off. Infected plants may wilt within a week after the appearance of first symptom. When stem is examined closely, dark lesions can be observed on the bark near ground level. The roots of infected plants are poorly developed; finer roots are either not formed or rotted. Plants show stunted growth and can easily be pulled out. If the plants are pulled from soil, the basal stem along with main root, may show symptoms of rotting. The tissues are weakened and break off easily in advanced cases and sclerotial bodies can be seen scattered on the affected roots. The fungus is mainly a soil dweller and spreads from plant to plant through irrigation water and implements and cultural operations. The sclerotia and pycniospores may also become air borne and cause further spread of the pathogen (Rangaswami and Mahadevan, 2008). Crop losses by root rot of okra (*Rhizoctonia solani)* is ranged from negligible to 50-60 per cent depending on the extent of severity and different stages of crop (Safiuddin *et al.,* 2014).

Exclusive dependency on fungicides and their indiscriminate use for managing diseases of various crops has resulted in residue, environmental hazards and development of resistance in pathogens. Due to increasing consciousness in consumers about organic produce, particularly medicinal products, efforts are being diverted to manage the diseases through eco-friendly approaches as a tool for integrated disease management because they do not cause bio-accumulation in eatables and environmental pollutions. Involvement of bio-agents in disease management system is also an important segment of disease control, looking to the hazards caused by toxic chemicals or in a situation where pathogens develop resistance to fungicides. In lieu of this, the present investigation was undertaken to evaluated different bio-agents alone and in combination in field for two consecutive years for managing the disease and increasing yield recovery for the profit of growers and consumers.

**Material and Methods**

The field experiment was conducted at Instructional Farm, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) for two consecutive years. Jobner is situated at latitude 26°5' N, longitude of 75°20' E and altitude of 427 meters above MSL (mean sea level). The region falls under semi-arid eastern plain (Agro Climatic Zone- lll A) of Rajasthan.

The two most promising fungal and bacterial bio-agents were evaluated through seed and soil applications for two consecutive years during *Zaid* 2022 and 2023 either alone or in combinations in randomized block design (RBD) in 1.8 m x 2.25 m plots with three replications. Commercial formulation of bio-agents (*Trichoderma harzianum* and *Pseudomonas fluorescens*) was applied through seed and soil methods. Before applying bio-agents on the surface of the seeds, seeds were moistened with five per cent gum solution applied at 10 ml/kg of seeds. The bio-agents were used as seed treatment @ 4 g/kg seeds where as in soil @ 4 kg /ha. The crop was sown in first week of Feb. Inoculum multiplied on sorghum grains was added @ 20 g/m row length at the time of sowing. Observations on disease incidence (75 DAS) and pod yield (up to harvest) were recorded.

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**Results and Discussion**

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Two most promising bio-agents were evaluated through seed and soil applications for two consecutive years during *Zaid* 2022 and 2023 either alone or in combinations. These bio-agents were caused significant reduction in root rot incidence and increased pod yield of okra in comparison to untreated check (Table-1 and Fig.-1). Among these, seed + soil application of *Trichoderma harzianum* was found most effective in reducing disease incidence (48.76%) and in increasing pod yield (13.46%) followed by seed treatment with *T. harzianum* + soil application of *Pseudomonas fluorescens* (46.41% and 12.84%), seed treatment with *P. fluorescens* + soil application of *T. harzianum* (45.32% and 10.45%, respectively). The soil application of *P. fluorescens* was found least effective in reducing the disease incidence (18.83%) and in increasing minimum pod yield (3.12%) over control.

Incremental cost benefit ratio (ICBR) was calculated to interpretate the economics of these bio-agents. The data indicated that the highest ICBR was obtained by the seed application of *Trichoderma harzianum* (1:53.52) followed by seed treatment with *P. fluorescens* (1:48.23), seed + soil treatment with *T. harzianum* (1:22.73), *T. harzianum (*seed treatment) + *P. fluorescens (*soil application) (1:21.67), *P. fluorescens* (seed treatment) + *T. harzianum* (soil application) (1:17.64), *P. fluorescens (*seed treatment) + *P. fluorescens (*soil application) (1:16.34) and *T. harzianum* (soil application) (1:7.06) whereas, lowest ICBR was observed with soil application of *P. fluorescens* (1:5.31).

The significance of chemicals and bio-control agents cannot be denied in plant disease management and especially bio-agents that have been proved to be highly effective in managing soil borne fungal plant pathogens. Our findings are in accordance with the results of Melo and Faull (2000) and Rangeshwaran *et al*. (2001). Melo and Faull (2000) screened 14 *Trichoderma* strains for the control of *Rhizoctonia solani* and among them three *T. koningii* strains produced toxic metabolites with strong activity against *Rhizoctonia solani*, inhibiting mycelial growth by 79 per cent. *T. harzianum* and *T. koningii also* reduced the viability of sclerotia of *Rhizoctonia solani* by 81.8 per cent and 53 per cent, respectively. Rangeshwaran *et al*. (2001) studied the impact of seed treatment with two bacterial antagonists *viz., Pseudomonas putida* and *Pseudomonas fluorescens* to control the root rot of chickpea caused by *Rhizoctonia* sp. and found that seed treatment with both the antagonists significantly reduced root rot of chickpea. Among these antagonists, *P. fluorescens* was found to be highly effective in reducing (6.4%) incidence as compared to *P. putida*. Madhi *et al*. (2020) who conducted study on root rot and damping-off diseases of okra and control them biologically using *Pseudomonas fluorescens* bacteria. The results showed the isolation of several pathogenic fungal, as well as fungi is also accompanying them, where the *Rhizoctonia solani* recorded the highest percentage of appearance and frequency which was (14.6, 16%) respectively. Singh *et al.* (2020) concluded that microbial volatile organic compounds (mVOCs) have great potential in plant ecophysiology, yet the role of below ground VOCs in plant stress management remains largely obscure. Analysis of biocontrol producing VOCs into the soil allow detailed insight into their interaction with soil borne pathogens for plant disease management. A root interaction trial was set up to evaluate the effects of VOCs released from *Trichoderma viride* BHU-V2 on soil-inhabiting fungal pathogen and okra plant growth. Ahmed (2023) stated that management of plant root diseases by the application of seaweed, particularly *fluorescent Pseudomonas*, is capturing the interest of plant scientists. In this study, the effect of seaweed soil amendment alone or mixed with endophytic *fluorescent Pseudomonas* (EFP-47) in reducing the root infecting fungi of okra was evaluated in pots and field plot experiments. It is suggested that endophytic *fluorescent Pseudomonas* and seaweed could be used for the management of root diseases of okra.

**Table 1: Effectiveness of bio-control agents in managing root rot of okra under field conditions**

| T. No. | Bio agents | PDI 2022 | PDI 2023 | Pooled | Disease reduction (%) over control | Yield (q/ha) 2022 | Yield (q/ha) 2023 | Pooled | Per cent increase in yield over check | Cost of treatment + Labour Charges (ha) | Gross return (ha) | ICBR ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T1 | *T. harzianum* (seed treatment) | 43.12 (41.05) | 40.45 (39.49) | 41.79 (40.27) | 26.89 | 54.26 | 52.02 | 53.14 | 7.36 | 272 | 212560 | 1:53.52 |
| T2 | *P. fluorescens* (seed treatmenet) | 44.34 (41.75) | 41.33 (40.01) | 42.84 (40.88) | 25.05 | 53.68 | 51.87 | 52.78 | 6.63 | 272 | 211120 | 1:48.23 |
| T3 | *T. harzianum* (soil application) | 45.09 (42.18) | 42.33 (40.59) | 43.71 (41.39) | 23.52 | 52.84 | 50.25 | 51.55 | 4.14 | 1160 | 206200 | 1:7.06 |
| T4 | *P. fluorescens* (soil application) | 47.23 (43.41) | 45.55 (42.45) | 46.39 (42.93) | 18.83 | 52.05 | 50.03 | 51.04 | 3.12 | 1160 | 204160 | 1:5.31 |
| T5 | *T. harzianum* (seed treatment) + *T. harzianum* (soil application) | 30.44 (33.49) | 28.13 (32.03) | 29.29 (32.77) | 48.76 | 57.18 | 55.13 | 56.16 | 13.46 | 1172 | 224640 | 1:22.73 |
| T6 | *P. fluorescens* (seed treatment) + *Pseudomonas fluorescens* (soil application) | 35.23 (36.41) | 30.33 (33.42) | 32.78 (34.93) | 42.65 | 55.46 | 53.12 | 54.29 | 9.69 | 1172 | 217160 | 1:16.34 |
| T7 | *T. harzianum* (seed treatment) + *P. fluorescens* (soil application) | 32.43 (34.71) | 28.83 (32.48) | 30.63 (33.60) | 46.41 | 57.29 | 54.41 | 55.85 | 12.84 | 1172 | 223400 | 1:21.67 |
| T8 | *P. fluorescens* (seed treatment) + *T. harzianum*(soil application) | 33.35 (35.27) | 29.16 (32.68) | 31.26 (33.99) | 45.32 | 56.09 | 53.24 | 54.67 | 10.45 | 1172 | 218680 | 1:17.64 |
| T9 | Control | 59.16 (50.28) | 55.15 (47.96) | 57.16 (49.12) | 0.00 | 50.61 | 48.38 | 49.50 | 0.00 | - | 198000 | - |
| | SEm± | 1.50 | 1.41 | 0.89 | | 2.88 | 2.69 | 1.70 | | | | |
| | CD (P=0.05) | 4.51 | 4.24 | 2.68 | | 8.67 | 8.10 | 5.14 | | | | |
| | CV (%) | 6.51 | 6.43 | 4.75 | | 9.16 | 8.94 | 6.64 | | | | |

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

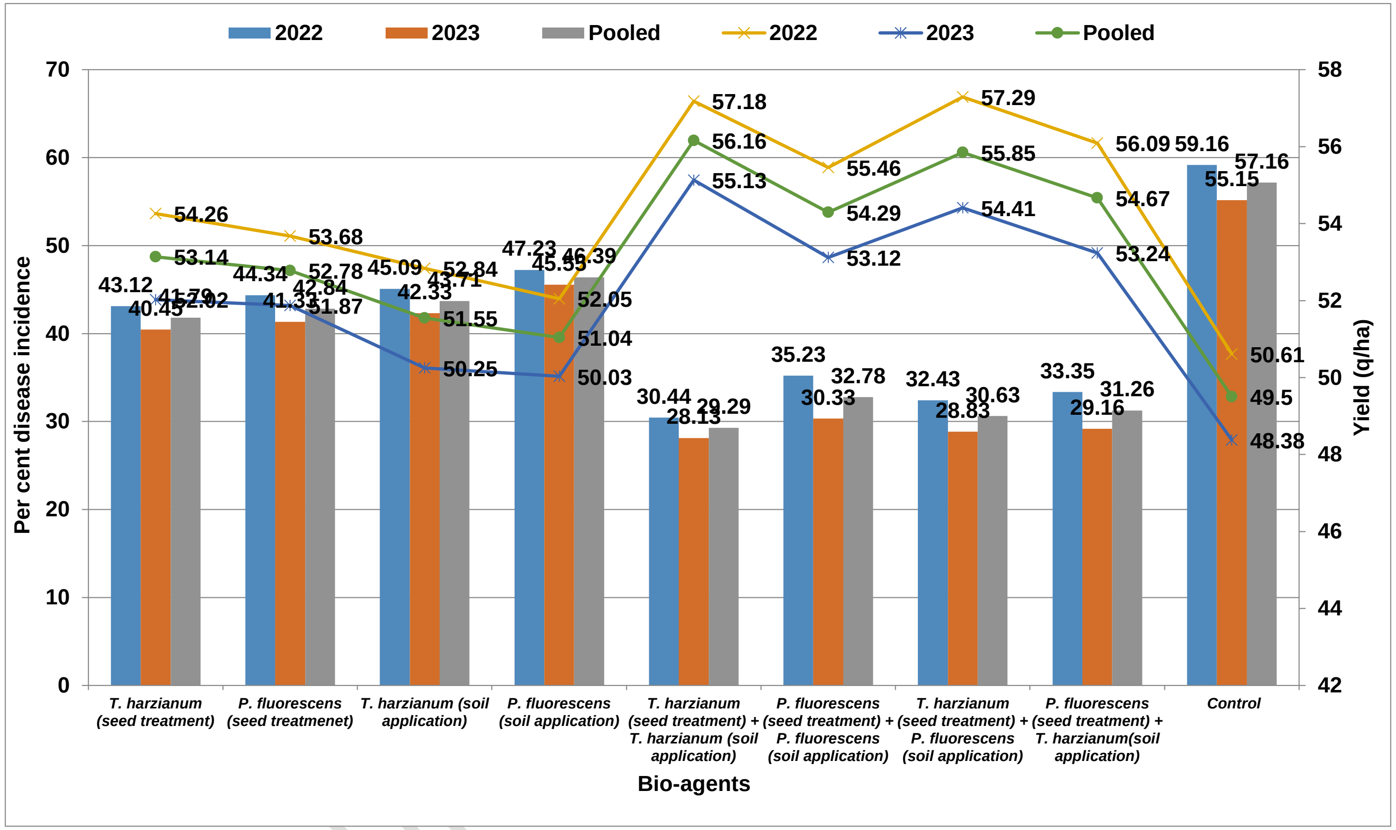


**Fig. 1: Efficacy of bio-agents on root rot of okra under field conditions**

## Conclusion

Conclusively, seed + soil application of *Trichoderma harzianum* was found most effective in reducing disease incidence (48.76%) and in increasing pod yield (13.46%). Looking to the increasing demand of organically produces in the market, root rot disease can be managed effectively with these eco-friendly approaches for supplying organically produced vegetables to fulfil the ever-increasing demand among health-conscious people.

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