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Evaluation of fungicides and bioagents for the management of chickpea root rot

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Abstract

Chickpea (*Cicer arietinum* L.) is an important pulse crop that suffers severe yield losses due to dry root rot caused by *Rhizoctonia bataticola* (syn. *Macrophomina phaseolina*). The present investigation entitled “Evaluation of Fungicides and Bioagents for the Management of Chickpea Root Rot” was conducted during the Rabi season of 2012–2013 under pot culture conditions using a Completely Randomized Design (CRD) with seventeen treatments. The pathogen was isolated from infected chickpea roots and identified based on cultural and morphological characteristics. Pathogenicity was confirmed through soil inoculation, fulfilling Koch’s postulates. *In vitro* evaluation of fungicides revealed that Carbendazim, Benomyl, and Fosetyl Al completely inhibited the mycelial growth of *Rhizoctonia bataticola* at all tested concentrations. Among herbicides, Pendimethalin and Oxyfluorfen showed maximum inhibition, whereas Imidacloprid exhibited no antifungal effect. Among bioagents, *Trichoderma viride* showed the highest antagonistic activity against the pathogen, followed by *Pseudomonas fluorescens* and *Bacillus subtilis*. *In vivo* studies demonstrated that treatments significantly influenced germination, growth parameters, and disease incidence. The combined treatment of Carbendazim + *Trichoderma viride* + *Bacillus subtilis* recorded the highest germination percentage, plant dry weight, root length, shoot length, and root and shoot dry weight at both 30 and 60 DAS. The lowest root rot incidence and highest disease reduction over control were observed with Carbendazim alone, followed by *Trichoderma viride*. The inoculated control recorded maximum disease incidence and minimum growth. The results clearly indicate that integrated management involving fungicidal seed treatment combined with bioagents is more effective than individual treatments for controlling chickpea root rot. This integrated approach offers an efficient and eco-friendly strategy for sustainable management of dry root rot in chickpea.

Keywords: *Rhizoctonia bataticola*, dry root rot, fungicides, bioagents, *Trichoderma viride*, *Bacillus subtilis*, *Pseudomonas fluorescens*

Introduction

Chickpea (*Cicer arietinum* L.) is the most important pulse crops grown, particularly in semi-arid and tropical regions worldwide. It contains high levels of protein, carbohydrates, fats, vitamins and minerals. *Cicer arietinum* L. plays very important role in sustainable agriculture through biological nitrogen fixation. In India, chickpea occupies a significant share of pulse production; however, its productivity is severely constrained by several biotic stresses, among which root rot is one of the most destructive soil-borne diseases.

Root rot of chickpea, primarily caused by *Rhizoctonia bataticola* (Taub.) Butler (syn. *Macrophomina phaseolina*), leads to considerable yield losses, especially under high soil temperature and moisture stress conditions. The disease is characterized by yellowing, wilting, sudden drying of plants, and dark lesions on roots, ultimately resulting in plant death. The pathogen survives in soil and crop residues as sclerotia, making its management difficult and allowing it to persist across cropping seasons.

Management of chickpea root rot has traditionally relied on chemical fungicides however, sole dependence on chemicals poses several challenges, including environmental pollution, development of pathogen resistance, high input costs, and adverse effects on beneficial soil microflora. In recent years, there has been increasing emphasis on eco-friendly and sustainable disease management strategies. Biological control using antagonistic microorganisms such as *Trichoderma* spp., *Pseudomonas fluorescens* and *Bacillus subtilis* has shown promising results in

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suppressing soil-borne pathogens through mechanisms like mycoparasitism, antibiosis, and induced systemic resistance.

Integrated disease management approaches combining chemical fungicides and bioagents are gaining importance as they offer effective disease suppression while reducing chemical load and improving soil health. Evaluating the comparative and combined efficacy of chemical fungicides and bioagents against chickpea root rot is therefore essential for developing sustainable and practical disease management strategies.

In view of the economic importance of chickpea and the destructive nature of root rot disease, the present investigation was undertaken to study the effectiveness of selected chemical fungicides and biological control agents in managing chickpea root rot under controlled and/or field conditions.

Materials and Methods

1) Experimental Location

The present investigation was conducted during the *rabi* season of 2011–2013 at the Department of Plant Pathology, Post graduate institute, Dr. PDKV, Akola. The experiment was carried out under pot culture. The soil of the experimental site was sandy loam with good drainage.

2) Pathogen Isolation and Identification

Root rot-infected chickpea plants showing typical symptoms such as sudden wilting and root discoloration were collected from the field. The infected root portions were washed thoroughly with tap water and cut into small pieces (5–10 mm). These pieces were surface sterilized with 0.1% HgCl_2 (mercuric chloride) for thirty second, followed by washings (three time) with sterile distilled water. The sterilized pieces were placed on Potato Dextrose Agar (PDA) medium and incubated at $27 \pm 2^\circ\text{C}$. The pathogen was identified as *Rhizoctonia bataticola* based on cultural and morphological characteristics.

3) Maintenance of Pathogen Culture

The pure culture of *Rhizoctonia bataticola* was maintained on PDA slants and subcultured periodically for further studies.

4) Mass Multiplication culture

The grains of sorghum were partially immersed in warm water (40°C to 45°C) for one hour. For air drying, grains spread on the clean blotting paper. Add an average 300 g air dried grains in a conical flask (1 liter) with 10 ml of water for autoclaved (30 minutes at 15 lbs psi pressure). After autoclave, in this flask add mycelial bits of *Rhizoctonia bataticola* and keep this flask under aseptic condition for incubation at $28 \pm 2^\circ\text{C}$ for 10 days. During this period, the flasks were shaken daily to prevent clumping of grains and to promote early fungal growth. Due to mycelial growth of fungus the grains turn whitish in colour. Well grown mass multiplied inoculum mix with an experimental sick plot before 15 days of sowing.

5) Preparation of sick soil & Pathogenicity test

Take a gunny bag and put sick plot soil for sterilization in autoclave 15 lbs psi pressure for 1 hour, continue for 3 days. After 3 days in that sterilized soil thoroughly mix mass multiplied inoculum in 1:10 proportion. Thus soil become a sick. Take 15 cm diameter size plastic pots and surface sterilized with 0.1% HgCl_2 (mercuric chloride). In sterilized plastic pots filled sick soil $1/4^{\text{th}}$ of its capacity and watered lightly. Keep these plastic pots 4 days for incubation. Sown 10 chickpea seeds of variety JG-62 and keep these pots under observation for seedling mortality. After sowing, an interval of 10 days record symptoms of root rot. Four

pots served as control without inoculation. From roots of root rot seedling re-isolate fungus on PDA media.

6) Preparation of Bioagents

The bioagents used in the experiment included *Trichoderma viride*, *Bacillus subtilis* and *Pseudomonas fluorescens*. The cultures were obtained from the Department of Plant Pathology. Talc-based formulations of bioagents were prepared and used at recommended concentrations.

7) Fungicides Used

The chemical fungicides selected for the study were Carbendazim, Benomyl and Fosetyl AL. These were used as seed treatment at recommended doses.

8) Evaluation of fungicides, insecticides and weedicide against root rot under *in vitro* condition.

To estimate the effect of fungicides, insecticides, and weedicides against *Rhizoctonia bataticola*, the compatibility was employed. The required amount of each fungicide, calculated on the basis of its active ingredient, was added to autoclaved potato dextrose agar (PDA) to achieve the desired concentrations of 0.1, 0.2, 0.3, 0.4, and 0.5 Percent. PDA medium without any chemical served as the control. The amended medium was poured into 90 mm Petri plates with three replications for each treatment. After solidification, each plate was inoculated aseptically at the center with a 6 mm mycelial disc cut from the actively growing margin of the test fungus. For seven days inoculated petri plates were incubated at $27 \pm 2^\circ\text{C}$.

After the incubation period, radial growth of the fungal colony was measured. After control plates were fully covered by the mycelial growth of pathogen, the percent inhibition of mycelial growth was calculated based on the mean colony diameter, using the following formula:

$$\text{Percent inhibition} = C - T/C \times 100$$

Where

C = radial growth of the test fungus in the control (mm)

T = radial growth of the test fungus in the treatment (mm)

9) Antagonistic test against chickpea root rot under *in vitro* condition

The fungal and bacterial biocontrol agent viz, *Trichoderma viride*, *Bacillus subtilis* and *Pseudomonas fluorescens* were tested for their biocontrol activity against *Rhizoctonia bataticola* by dual culture method. From the margin of 5 days old cultures cut mycelial disc of 6 mm diameter of both test pathogen and antagonists were placed opposite to each other on PDA in petriplates (90mm). The distance between two inoculum was 6 cm. The petriplates along with disc of *Rhizoctonia bataticola* served as the control. The inoculated petriplates were incubated at $27 \pm 2^\circ\text{C}$ for 7 days. The growth of *Rhizoctonia bataticola* was measured and the Percent growth inhibition of intersecting colonies was calculated by following formula.

$$\text{Per cent growth inhibition} = \frac{\text{Colony growth} - \text{Colony growth}}{\text{inter secting plate} \quad \text{in control plate}} \times 100$$

10) Management of root rot of chickpea under *in vivo* condition

The experiment of pot culture was conducted in green house condition with above 17 treatments of 3 replication by using

chickpea variety JG-62 additional with control pots without treatment. The mass multiplied inoculum of test fungus *Rhizoctonia bataticola* was added to the soil @ 100 g per kg soil. The earthen pots were sterilized using 0.1% HgCl₂ solution. The chickpea seeds were treated and sown 5 seeds per sterilized earthen pots and water lightly. The seedling mortality was recorded at 30 and 60 days after sowing. The details of the treatments used in the pot experiment are given below. The details of layout and plan for pot experiment

1. Year, season: 2012, Rabi
2. Design: CRD
3. Number of replications:3
4. Number of treatments:17
5. Total number of pots: 51
6. Number of plants/pot: 5
7. Variety: JG-62
8. Date of sowing: Oct 25 (25.10.2012)
9. Date of observations: Nov 25, Dec 25

Treatments

- 1) *Trichoderma viride*
- 2) *Bacillus subtilis*
- 3) *Trichoderma viride* + *Bacillus subtilis*
- 4) Fosetyl AL
- 5) Fosetyl AL + *Trichoderma viride*
- 6) Fosetyl AL + *Bacillus subtilis*
- 7) Fosetyl AL + *Trichoderma viride* + *Bacillus subtilis*
- 8) Carbendazim
- 9) Carbendazim + *Trichoderma viride*
- 10) Carbendazim + *Bacillus subtilis*
- 11) Carbendazim + *Trichoderma viride* + *Bacillus subtilis*
- 12) Pendimethalin
- 13) Pendimethalin + *Trichoderma viride*
- 14) Pendimethalin + *Bacillus subtilis*
- 15) Pendimethalin + *Trichoderma viride* + *Bacillus subtilis*
- 16) Control with pathogen
- 17) Control without pathogen

11) Observations recorded

Germination of seeds, shoot and root length, plant dry weight, shoot and root dry weight, measurement of disease incidence, statistical analysis was recorded.

Results and Discussion

1. Isolation of *Rhizoctonia bataticola*

Rhizoctonia bataticola was isolated from infected roots of chickpea Plate 1, showing typical root rot symptoms. On the basis of morphological features as described by cultural and vegetative structure, *Rhizoctonia bataticola* was identified.

Patel and Anahosur (2000)^[13] found association frequency of soil borne fungi with wilted chickpea plants and correlation coefficient between their frequency and other factors. Isolations made at 10 days interval from 10th day of sowing upto 90th day revealed preferential association of *Fusarium* spp. *Macrophomina phaseolina* (Tassi) Goid and *Sclerotium rolfsii* Sacc. In relation to plant age, soil temperature and moisture and found that the *Fusarium* spp. was associated consistently throughout the crop period. However, it showed increasing association upto 50 days. Low temperature was more congenial for *Fusarium* spp. Andrabi (2011)^[1] isolated *Fusarium oxysporum* f.sp. *ciceri*, *F. solani* and *Rhizoctonia solani* from the wilted chickpea (*Cicer arietinum*) plants.

2. Morphology of *Rhizoctonia bataticola*

In Plate 1, mycelium of *Rhizoctonia* were superficial or immersed, hyaline to brown, branched, septate, often tree like in form. The basic characters of the genus is formation of sclerotia. Sclerotia was seen dark brown to black, smooth, hard, and was formed of thick walled cells of irregular size but of uniform texture. The hyphae cells was barrel shaped, branching more or less at right angles and faint brown to brown colour.

3. Pathogenicity test of *Rhizoctonia bataticola*

The data presented in Table 1 revealed that in sick pots *Rhizoctonia bataticola* caused (100%) root rot on JG-62 in 30 DAS. In control no symptoms of root rot was observed as compared to the typical root rot symptoms was observed within 30 Days after sowing in remaining pots. The pathogen was reisolated from the infected plants, compared with the original culture, and found to be identical. Singh and Nene (1990)^[15] reported that pure cultures of *Rhizoctonia bataticola* (*Macrophomina phaseolina*) were isolated from infected chickpea, pigeon pea, groundnut and sorghum plants from ICRI SAT fields.

Table 1: Pathogenicity test of *Rhizoctonia bataticola* on variety JG- 62

Pathogen	<i>Rhizoctonia Bataticola</i>	Control
Variety	JG-62	JG-62
Number of seeds sown	5	5
Number of seed germinated	2	4
Percent seed germinated	40	80
Root rot	2	0
Percent root rot	100	0

4. Bio-efficacy of fungicides, insecticides, herbicides, and bioagents against *Rhizoctonia bataticola* in vitro.

4.1 In vitro effect of fungicides on growth of *Rhizoctonia bataticola*.

The above-mentioned fungicides, viz., Fosetyl AL 80% WP, Benomyl 50% WP, and Carbendazim 50% WP, were tested at five concentrations: 0.1%, 0.2%, 0.3%, 0.4%, and 0.5%. The "Poison Food Technique" was followed. The radial growth was measured in mm after 7 days of incubation at 27 ± 20 C and the data presented in Table 2 and Plate 2.

The data presented in Table 2 and Plate 2 showed that Carbendazim, Fosetyl AL, and Benomyl caused 100 Percent growth inhibition of *Rhizoctonia bataticola* at all the concentrations tested, i.e., 0.1%, 0.2%, 0.3%, 0.4% and 0.5%. Similar results were observed by, Sindhan *et al.* (2002)^[16] who reported that Carbendazim was most effective causing 94.2 and 100% inhibition in mycelial growth and sclerotial production respectively. Nasreen Sultana and A. Ghaffar (2010) A study was conducted on the *in vitro* and *in vivo* effects of fungicides, microbial antagonists, and oil cakes for the management of *Fusarium solani* causing seed rot, seedling infection, and root infection in bottle gourd, bitter gourd, and cucumber. Fungicides viz., Aliette, Benlate, and Carbendazim at 100 ppm completely inhibited the colony growth of *Fusarium solani*. In bitter gourd, Carbendazim completely eradicated the seed-borne infection of *Fusarium solani* and also provided maximum reduction of the disease in cucumber and bottle gourd. Root infection in bitter gourd was completely checked by Benlate and Carbendazim, while the disease was best controlled by Aliette, Topsin-M, and Carbendazim in bottle gourd and cucumber.

Table 2: Efficacy of fungicides on growth of *Rhizoctonia bataticola*

Treatments	Fungicides	Conc.	<i>Rhizoctonia bataticola</i>	
			Mean colony Diameter in mm	Percent Growth inhibition
T ₁	Carbendazim 50% WP	0.1	0	100
T ₂		0.2	0	100
T ₃		0.3	0	100
T ₄		0.4	0	100
T ₅		0.5	0	100
T ₆	Fosetyl Al 80%WP	0.1	0	100
T ₇		0.2	0	100
T ₈		0.3	0	100
T ₉		0.4	0	100
T ₁₀		0.5	0	100
T ₁₁	Benomyl 50% WP	0.1	0	100
T ₁₂		0.2	0	100
T ₁₃		0.3	0	100
T ₁₄		0.4	0	100
T ₁₅		0.5	0	100
T ₁₆	Control		90	0

4.2 In vitro effect of insecticides on growth of *Rhizoctonia bataticola*.

The insecticide viz., Imidacloprid 17.8% SL was evaluated at three different concentrations. The data presented in Table 3 and Plate 3 showed that Imidacloprid at 0.1 g, 0.2 g, and 0.3 g caused low Percent growth inhibition of *Rhizoctonia bataticola*, with no

inhibition (0%) observed. These findings are in agreement with the results of Houshyar and Darvish, who studied the interaction of the systemic insecticides Thiodicarb and Imidacloprid against *Rhizoctonia solani* and *Fusarium moniliforme* in cotton and reported that Imidacloprid 70.8% inhibited the mycelial growth of *Fusarium moniliforme*.

Table 3: Efficacy of insecticides on growth of *Rhizoctonia bataticola*

Insecticides	Treatments	<i>Rhizoctonia bataticola</i>	
		Mean colony diameter (mm)	Percent growth inhibition
Imidacloprid 17.8% SL	T ₁ -0.1 g	90	0
	T ₂ -0.2 g	90	0
	T ₃ -0.3 g	90	0
	T ₄ -Control	90	0

4.3 In vitro effect of herbicides on growth of *Rhizoctonia bataticola*

The herbicides viz., Pendimethalin 30% EC, Imazathapyr 10% SL, Targa Super, Whip Super, Oxadiargyl, and Oxyfluorfen were tested at three different concentrations.

In Table 4, Plate 4, showed that highest Percent inhibition growth of *Rhizoctonia bataticola* was observed in Pendimethalin 0.1, 0.2, 0.3g (100%), followed by Oxyfluorfen 0.1ml, 0.2ml, 0.3ml (100%) and Targa super 0.3 ml(100%). The lowest growth inhibition was

observed in Imazathapyr 0.1ml,0.2ml,0.3ml (0.00%). The results recorded in present studies are found in consences with (Khan (2010) ^[7], (Kathresan (2004), Chen HouDe *et al.* (2005) ^[3] reported that Fenoxaprop-P-ethyl [Fenoxaprop-P], Butachlor, Fluroxypyr, Chlorsulfuron + Isoproturon, Tribenuron-methyl [Tribenuron], Dicamba and Metsulfuron-methyl [Metsulfuron] inhibited mycelial growth in *R. cerealis* at varying degrees, and the EC50 values for these herbicides were 7.03, 26.38, 67.20, 88.05, 199.35, 1249.55 and 203.31 mg litre⁻¹, respectively.

Table 4: Efficacy of herbicides on growth of *Rhizoctonia bataticola*

Herbicides	Treatments	Conc.	<i>Rhizoctonia bataticola</i>	
			Mean Colony Diameter (mm)	Percent growth inhibition
Targa super	T ₁	0.1 g	67.44	25.06
	T ₂	0.2 g	13.77	84.7
	T ₃	0.3 g	0	100
Oxadiargyl	T ₄	0.1 g	80.55	10.5
	T ₅	0.2 g	80.33	10.74
	T ₆	0.3 g	51.55	42.72
Whip super	T ₇	0.1 g	54.11	39.87
	T ₈	0.2 g	27.55	69.38
	T ₉	0.3 g	5.78	93.57
Pendimethylene	T ₁₀	0.1 g	0	100
	T ₁₁	0.2 g	0	100
	T ₁₂	0.3 g	0	100
Oxyfluorfen	T ₁₃	0.1 g	0	100
	T ₁₄	0.2 g	0	100
	T ₁₅	0.3 g	0	100
Imazathapyr	T ₁₆	0.1 g	90	0
	T ₁₇	0.2 g	90	0
	T ₁₈	0.3 g	90	0
Control	T ₁₉	-	90	0
F test	Significant			
SE(m)±	0.83			
CD(P=0.01)	3.18			

4.4 In vitro effect of bioagents on growth of *Rhizoctonia bataticola*.

The biocontrol agents namely *Bacillus subtilis*, *Pseudomonas fluorescens*, *Trichoderma viride* were used. The effect of different treatments on the radial growth of mycelium of *Rhizoctonia bataticola* was studied using the dual culture technique.

The data presented in Table 5, Plate 5, showed that highest% inhibition growth was observed with *Trichoderma viride* (78.52%) next by *Pseudomonas fluorescens* (58.07%). The lowest growth inhibition was observed in *Bacillus subtilis* (40.71%). Similar finding by, Sindhan *et al.* (2002) [16] reported

that *Trichoderma viride*, the next best antagonist caused 62.3 and 87.0% inhibition in mycelial growth and sclerotia production followed by *Trichoderma harzianum*, *Aaergillus ochraceous*, *Bacillus subtilis* and *Pseudomonas citrinum*. *Aaergillus flavus* and *Aaergillus niger* proved to be least effective in comparison to other antagonists but were superior to control. Kumar *et al.* (2011) [8] reported the efficacy of *Trichoderma harzianum* and In *in vitro* conditions *Trichoderma viride* inhibiting mycelial growth of *Rhizoctonia bataticola* compared with *Pseudomonas maltophilia*, *Pseudomonas fluorescens* and *Bacillus subtilis*.

Table 5: Antagonistic effect of bio-agents on growth of *Rhizoctonia bataticola*.

Treatments	Bio agents	<i>Rhizoctonia bataticola</i> .	
		Mean colony Diameter (mm)	Percent growth inhibition
T ₁	<i>Bacillus subtilise</i>	53.36	40.71
T ₂	<i>Pseudomonas fluorescens</i>	37.73	58.07
T ₃	<i>Trichoderma viride</i>	19.33	78.52
T ₄	Control	90	0
'F test		Significant	
SE(m)±		1.46	
CD (P=0.01)		7.65	

5. Effect of fungicides, insecticides, herbicides, bioagents on chickpea root rot incited by *Rhizoctonia bataticola* in *in vitro* condition

5.1 Effect of combinations on Germination Percent

The effect of treatments were found statistically significant where soil sickness was developed with *Rhizoctonia bataticola*. The data presented in Table 6, showed that highest germination Percent i.e. 80% was observed in treatment T₈ i.e. Carbendazim 80% followed by treatment T₁₁ i.e. Carbendazim + *Trichoderma viride* + *Bacillus subtilis* i.e. 73.2%. The lowest Percent germination was observed in treatment T₄ Fosetyl Al 26.6% and in T₁₄ i.e. Pendimethylene + *Bacillus subtilis* 26.6%, similar in inoculated control T₁₆ 26.6%. These results are in support of findings of, Bunker and Mathur (2001) [2] who found that seed treatment with *Trichoderma viride*, *Trichoderma harzianum* and *Trichoderma aureoviride* were as effective as Bavistin seed treatment. It resulted germination highest and mortality reduced. Murugesan *et al.* (2009) [10] reported that Imidacloprid, Monocrotophos and *Pseudomonas fluorescens* improved germination and increased shoot length. Whereas adverse effect of neem oil on shoot length. Thomas Moly and Vyas (1984) [18] reported that seed treatment with Carbendazim resulted in significantly higher emergence in comparison with other fungicide treatments.

5.2 Effect of combinations on plant dry weight

Table 6 showed that the lowest plant dry weight was recorded in T₁₄, i.e., Pendimethalin + *Bacillus subtilis*, with values of 3.06 g and 4.5 g at 30 and 60 DAS, respectively, whereas the control recorded 2.33 g and 4.06 g at 30 and 60 DAS, respectively. The highest plant dry weight of 6.9 g and 8.13 g at 30 and 60 DAS, respectively, was observed in T₁₁, i.e., Carbendazim + *Trichoderma viride* + *Bacillus subtilis*, followed by 6.2 g and 8.13 g at 30 and 60 DAS, respectively, in T₉, i.e., Carbendazim + *Trichoderma viride*. The above findings are in conformity with, Sindhan *et al.* (2002) [16] Carbendazim 0.2% was most effective with 79.2% disease control and also significantly increased root and shoot length and dry weight in comparison to control.

5.3 Effect of combinations on root length (cm)

Table 6 showed that the highest root length at 30 DAS and 60 DAS was observed in T₁₁, i.e., Carbendazim + *Trichoderma*

viride + *Bacillus subtilis*, recording 15.31 cm and 22.01 cm, respectively. The lowest root length was observed in T₁₄, i.e., Pendimethalin + *Bacillus subtilis*, with values of 8.52 cm and 14.85 cm at 30 and 60 DAS, respectively, whereas the control recorded 8.88 cm and 14.44 cm at 30 and 60 DAS, respectively. The above findings are in conformity with, (Pahwa and Prakash (1996) [14]. Sindhan *et al.* (2002) [16] Carbendazim 0.2% was most effective with 79.2% disease control and also significantly increased root and shoot length and dry weight in comparison to control. Nagamani *et al.* (2011) [12], Field experiments were conducted during 2009-2010 and 2010-11 *rabi* seasons at Andhra Pradesh, India to devise an effective management strategy for dry root rot of chickpea. The treatments were T₁ - seed treatment with vitatax at 2 g/kg of seed; T₂ - seed treatment with Carbendazim at 2g/kg seed; T₃ - seed treatment with *T. viride* at 4g/kg of seed; T₄ - soil application of *Trichoderma viride*; T₅ - T₂ + T₅; T₆ - T₃ + T₄; T₇ - T₂ + T₃ + T₄; T₈ - control. The best treatment to decrease the mortality of root rot caused by *Rhizoctonia bataticola* [*Macrophomina phaseolina*] was he seed treatment with Carbendazim at 2 g/kg of seed + seed treatment with *Trichoderma viride* at 4 g/kg of seed + soil application of FYM fortified with *Trichoderma viride* (T₇). It also recorded highest shoot length and root length and also the highest yield.

5.4 Effect of combination on root dry weight (g)

Table 6, showed that highest root dry weight at 30 DAS and 60 DAS was observed in T₁₁ i.e. Carbendazim + *Trichoderma viride* + *Bacillus subtilis* i.e. 1.37g and 2.04g respectively. The lowest plant dry weight was 0.34 g and 0.54 g at 30 and 60 DAS respectively observed in T₁₄ i.e. Pendimethylene + *Bacillus subtilis* followed by T₁₃ i.e. Pendimethylene + *Trichoderma viride* whereas in control it was 0.32 g and 0.52 g at 30 and 60 DAS respectively. The results were in confirmation with, (Yadav *et al.* (2006) [19], Sindhan *et al.* (2002) [16] Carbendazim 0.2% was most effective with 79.2% disease control and also significantly increased root and shoot length and dry weight in comparison to control.

5.5 Effect of combinations on shoot length (cm)

The effect of the treatments was found to be significant at 30 and 60 DAS. Table 6 showed that the highest shoot length at both 30

DAS and 60 DAS was observed in T₁₁, i.e., Carbendazim + *Trichoderma viride* + *Bacillus subtilis* 22.88 cm and 27.03cm respectively followed by T₉ i.e. Carbendazim + *Trichoderma viride* i.e. 21.30 cm and 25.82 cm. The lowest Shoot length was observed in T₁₄ Pendimethalene + *Bacillus subtilis* 14.03cm, 20.7 cm at 30 and 60 DAS whereas in control it was 14.93cm and 17.36 cm at 30 and 60 DAS respectively. The findings of the present study are in agreement with, (Pahwa and Prakash (1996) ^[14], (Sindhan *et al.* (2002) ^[16].

5.6 Effect of combination on shoot dry weight (g)

The effect of treatments found significant at 30 and 60 DAS. The data presented in Table 6, showed that the lowest shoot length was observed in T₁₄ Pendimethalene + *Bacillus subtilis* 2.39 cm, 3.03 cm at 30 and 60 DAS whereas in control it was 2.87cm and

3.87cm at 30 and 60 DAS respectively. The highest shoot dry weight at 30 DAS and 60 DAS was 6.88 cm and 9.88 cm respectively observed in T₁₁ i.e. Carbendazim + *Trichoderma viride* + *Bacillus subtilis* next to 6.63cm and 9.63 cm in T₉ i.e. Carbendazim + *Trichoderma viride*. The findings of the present study are in agreement with, Sindhan *et al.* (2002) ^[16], Sharma *et al.* (2004) ^[17] seed treatment with Carbendazim gave the highest grain yields during both the years. Increase of phenolic compounds has also been observed earlier in mustard and chickpea plants with application of Bavistin (Carbendazim) and Carboxin In the present study, the effectiveness of Carbendazim against *Rhizoctonia bataticola* may probably be attributed to the increasing levels of phenols, which provided resistance to chickpea plants against the pathogen.

Table 6: Effect of germination Percent, plant dry weight, root length, root dry weight, shoot length, and shoot dry weight.

Treatments	No of seeds sown	<i>Rhizoctonia bataticola</i>											
		Germination Percent		Plant Dry weight (g)		Root Length (cm)		Root Dry weight (g)		Shoot Length (cm)		Shoot Dry Weight (g)	
		Total No. of germinated seeds	Percent seed germination	Plant dry wt. at 30 DAS (g)	Plant dry wt. at 60 DAS (g)	Root length at 30 DAS (cm)	Root length at 60 DAS (cm)	Root dry wt at 30 DAS (g)	Root dry wt at 60 DAS (g)	Shoot Length at 30 DAS (cm)	Shoot length at 60 DAS (cm)	shoot dry wt at 30 DAS (g)	Shoot dry wt at 60 DAS (g)
T ₁ <i>Trichoderma viride</i>	15	8	53.2 (46.83)*	6.1	8	14.1	22.77	0.92	1.61	20.86	26.33	5.42	8.42
T ₂ <i>Bacillus subtilise</i>	15	7	46.6 (43.05)*	5	7.23	13.38	21.38	0.86	1.53	20.43	25.9	5.11	7.44
T ₃ <i>Trichoderma viride</i> + <i>Bacillus subtilise</i>	15	8	53.2 (46.83)*	5.3	7.76	13.81	22.07	0.83	1.5	20.62	25.55	5.15	8.25
T ₄ Fosetyl Al	15	4	26.6 (31.05)*	3.09	4.8	10.04	15.04	0.37	0.61	18.29	22.63	2.77	3.93
T ₅ Fosetyl Al+ <i>Trichoderma viride</i>	15	6	40 (39.23)*	3.5	4.76	9.94	14.93	0.34	0.6	15.12	20.78	2.61	3.49
T ₆ Fosetyl Al+ <i>Bacillus subtilise</i>	15	8	53.2 (46.83)*	3.23	4.6	9.3	14.3	0.34	0.58	14.73	20.4	2.39	3.06
T ₇ Fosetyl Al+ <i>Trichoderma viride</i> + <i>Bacillus subtilise</i>	15	8	53.2 (46.83)*	3.72	4.53	9.77	14.77	0.37	0.6	17.49	21.4	2.55	3.55
T ₈ Carbendazim	15	12	80 (63.43)*	6.1	8.53	14.89	21.62	0.9	1.9	19.74	25.03	6.28	9.54
T ₉ Carbendazim+ <i>Trichoderma viride</i>	15	10	66.6 (54.70)*	6.2	7.86	15.26	21.98	1.0	1.99	21.3	25.82	6.63	9.63
T ₁₀ Carbendazim+ <i>Bacillus subtilise</i>	15	8	53.2 (46.83)*	6.03	7.7	15.01	21.43	0.75	1.76	20.84	25.63	5.97	9.1
T ₁₁ Carbendazim+ <i>Trichoderma viride</i> + <i>Bacillus subtilise</i>	15	4	73.2 (58.82)*	6.9	8.13	15.31	22.01	1.37	2.04	22.88	27.03	6.88	9.88
T ₁₂ Pendimethylene	15	7	46.6 (43.05)*	3.69	4.63	9.39	15.39	0.38	0.61	14.66	22.32	2.77	3.93
T ₁₃ Pendimethylene+ <i>Trichoderma viride</i>	15	7	46.6 (43.05)*	3.36	4.56	8.76	14.76	0.34	0.54	14.45	19.63	2.55	3.56
T ₁₄ Pendimethylene+ <i>Bacillus subtilise</i>	15	4	26.6 (31.05)*	3.06	4.56	8.52	14.85	0.34	0.54	14.02	20.7	2.39	3.03
T ₁₅ Pendimethylene+ <i>Trichoderma viride</i> + <i>Bacillus subtilise</i>	15	6	40 (39.23)*	3.26	4.5	8.88	14.88	0.36	0.56	14.62	18.29	2.44	3.44
T ₁₆ Control inoculated	15	4	26.6 (31.05)*	2.33	4.06	8.88	14.44	0.32	0.52	14.93	17.36	2.87	3.87
T ₁₇ Control without inoculated	15	8	53.2 (46.83)*	2.53	4.4	14.16	22.49	0.44	0.74	17.64	19.36	2.84	4.47
F test			Significant	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE(m)±			0.38	0.17	0.23	0.27	0.82	0.072	0.19	0.58	0.77	0.29	0.33
CD(P=0.01)			1.49	0.69	0.92	1.05	3.18	0.28	0.74	2.25	2.98	1.11	1.27

5.7 Effect of combination on Percent root rot

The effect of treatments was found to be significant. The data presented in Table 7, showed that highest% wilt over control was 75.6% observed in T₈ i.e. Carbendazim next to 75.6% in T₁ i.e. *Trichoderma viride*. The lowest% wilt over control was observed in T₁₄ i.e. Pendimethylene + *Bacillus subtilis* 35.8% whereas in control it was 29.00%. The above results are in conformity with findings Mukhopadhyay and Mukherjee (1991) [11] and Lokesh and Benagi (2007) [9] studied that causes of dry root rot of pigeonpea the efficacy of biocontrol agents on *Macrophomina phaseolina*. In dual culture technique both *Trichoderma virens* (PDBC TVS-2) and *Pseudomonas fluorescens* (PDBC Pf1) significantly inhibited the mycelial growth of *Macrophomina phaseolina* by 78.22 Percent and 76.66 Percent respectively. However, it was found to be on par with soil drenching using Carbendazim (0.1%). Seed treatment combined with soil

application of *Trichoderma virens* recorded the lowest root rot incidence (2.89%) among the four bioagents tested. Among the three methods of applying talc formulations of bioagents, seed treatment (4 g/kg seed) along with soil application (2 g talc powder mixed with FYM/pot) supported maximum plant growth and reduced root rot incidence compared to the other treatments, and was found significantly superior to seed treatment alone (2 g/kg seed). Jayalaxmi *et al.* (2008) found that chickpea dry root rot caused by *Rhizoctonia bataticola* is the most destructive disease and causes severe losses in yield. During rabi season of 2004-2005 and 2005-2006 a pot culture experiment was conducted for screening of gram breeders promising entries (12 + 1 susceptible check JG-62). From 12 genotypes tested against root rot disease, 4 were found resistant, 2 were moderately susceptible, 3 were susceptible and 3 were highly susceptible to dry root rot disease.

Table 7: Combine effect of bioagents and fungicides on Percent root rot caused by *Rhizoctonia bataticola*

Sr. No.	Treatments	<i>Rhizoctonia bataticola</i>	
		Mean percent root rot incidence	Percent root rot over control
1	T ₁ - <i>Trichoderma viride</i>	24.4(29.60)*	75.6
2	T ₂ - <i>Bacillus subtilis</i>	35.4(36.51)*	64.6
3	T ₃ - <i>Trichoderma viride</i> + <i>Bacillus subtilis</i>	26.6(31.05)*	73.4
4	T ₄ -Fosetyl Al	46.6(43.05)*	53.4
5	T ₅ -Fosetyl Al+ <i>Trichoderma viride</i>	48.8(44.31)*	51.2
6	T ₆ -Fosetyl Al+ <i>Bacillus subtilis</i>	53.2(46.83)*	46.8
7	T ₇ -Fosetyl Al+ <i>Trichoderma viride</i> + <i>Bacillus subtilis</i>	40(39.23)*	60
8	T ₈ -Carbendazim	24.4(29.60)*	75.6
9	T ₉ - Carbendazim+ <i>Trichoderma viride</i>	26.6 (31.05)*	73.4
10	T ₁₀ - Carbendazim+ <i>Bacillus subtilis</i>	26.6 (31.05)*	73.4
11	T ₁₁ - Carbendazim+ <i>Trichoderma viride</i> + <i>Bacillus subtilis</i>	26.6 (31.05)*	73.4
12	T ₁₂ -Pendimethylene	48.8 (44.31)*	51.2
13	T ₁₃ - Pendimethylene+ <i>Trichoderma viride</i>	59.8 (50.65)*	40.2
14	T ₁₄ - Pendimethylene+ <i>Bacillus subtilis</i>	64.2 (53.25)*	35.8
15	T ₁₅ - Pendimethylene+ <i>Trichoderma viride</i> + <i>Bacillus subtilis</i>	57.6 (49.37)*	42.4
16	T ₁₆ -Control inoculated	71 (57.42)*	29
17	T ₁₇ -Control without inoculated	0(0.00)*	100
'F test		Significant	
SE(m)±		2.75	
CD at 0.01%		10.64	



Plate 1: Pure culture and microscopic images of *Rhizoctonia bataticola*

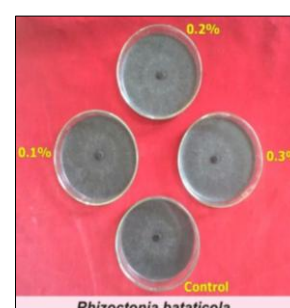


Plate 3: Efficacy of insecticide against *Rhizoctonia bataticola*

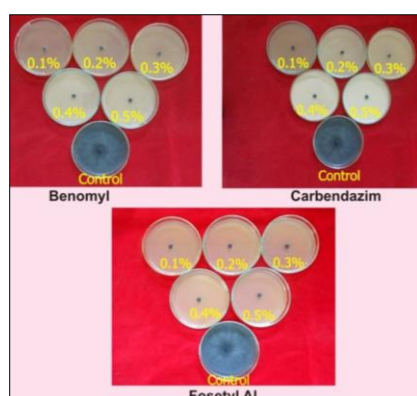


Plate 2: Efficacy of fungicide against *Rhizoctonia bataticola*

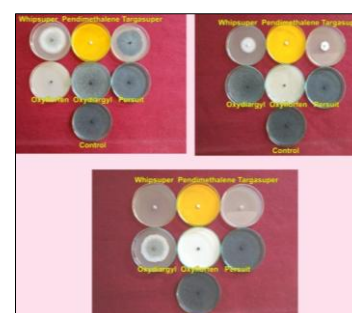


Plate 4: Efficacy of herbicide against *Rhizoctonia bataticola*



Plate 5: Efficacy of bioagents against *Rhizoctonia bataticola*

Summary and Conclusion

A pot experiment entitled “Evaluation of Fungicides and Bioagents for the Management of Chickpea Root Rot” was carried out in Completely Randomized Design (CRD) with Control having 17 treatments during Rabi season 2012-2013. The study was undertaken to ascertain the effect of seed dressing fungicides, insecticides, herbicides and bioagents on the *Rhizoctonia bataticola* and growth parameters of chickpea. During the course of investigation observations were recorded on Percent germination, plant dry weight, shoot dry weight root dry weight, shoot and root length (average of 5 plant) Percent wilt incidence.

The pathogenicity was proved by soil inoculation method. Based on the culture, morphological and pathogenic characteristics, the isolated cultures were identified as, *Rhizoctonia bataticola*. The findings observed during the experimentation are summarized below.

Evaluation of Fungicides, insecticides, herbicides, and bioagents against *Rhizoctonia bataticola*

The effect of three fungicides was evaluated *in vitro* against *Rhizoctonia bataticola* by employing poison food technique. Inhibiting mycelial growth of *Rhizoctonia bataticola* among the fungicides tested, Carbendazim, Benomyl and Fosetyl Al were found effective. Antagonist effect of *Trichoderma viride* among herbicides Pendimethalin and Oxyfluorfen was more effective. Among the fungicide tested, Carbendazim and Benomyl were found effective in inhibiting mycelial growth of *Trichoderma viride*.

Percent germination

An interaction effect of treatments found significant. In treatment T₈ i.e., Carbendazim (80%) followed by treatment T₁₁ Carbendazim + *Trichoderma viride* + *Bacillus subtilis* i.e. (73.2%) the highest Percent germination was observed whereas in inoculated control T₁₆ (26.6%).

Plant dry weight

The maximum effect was observed in treatment T₁₁, i.e., Carbendazim + *Trichoderma viride* + *Bacillus subtilis*, at every growth stage, showing significant differences over other treatments. The plant dry weight recorded in this treatment was 6.9 g and 8.53 g at 30 and 60 DAS, respectively. The minimum plant dry weight was observed in treatment T₁₄, i.e., Pendimethalin + *Bacillus subtilis*, with values of 3.06 g and 4.5 g at 30 and 60 DAS, respectively, whereas the control recorded 2.33 g and 4.06 g at 30 and 60 DAS, respectively

Root length

The effect of treatments was found significant at 30 and 60 DAS. In T₁₁ i.e. Carbendazim + *Trichoderma viride* + *Bacillus subtilis* observed the highest root length recorded at 30 DAS and 60 DAS was 15.31 cm and 22.01 cm, respectively, whereas the control showed root lengths of 8.88 cm and 14.44 cm at 30 and 60 DAS, respectively.

Root dry weight

In *Rhizoctonia bataticola*, the more root dry weight at 30 DAS and 60 DAS was 1.37g & 2.04g respectively observed in T₁₁ i.e. Carbendazim + *Trichoderma viride* + *Bacillus subtilis* whereas in control at 30 and 60 DAS it was 0.32 g and 0.52 g respectively.

Shoot length.

Rhizoctonia bataticola was highest shoot length is 22.88 cm and 27.03cm observed in T₁₁ i.e. Carbendazim + *Trichoderma viride* + *Bacillus subtilis* respectively at 30 DAS and 60 DAS. Whereas in control it was 14.93cm and 17.36cm at 30 and 60 DAS respectively.

Shoot dry weight

The more shoot dry weight was 6.88 cm and 9.88 cm observed in T₁₁ i.e. Carbendazim + *Trichoderma viride* + *Bacillus subtilis* respectively at 30 DAS and 60 DAS next by 6.63cm and 9.63 cm in T₉ i.e. Carbendazim + *Trichoderma viride*. whereas in control it was 2.87cm and 3.87cm at 30 and 60 DAS respectively.

Percent dry root rot incidence

It was less in treatment T₈ Carbendazim i.e 24.4% and the Percent dry root rot over control is i.e. 75.6% followed by in treatment T₁ *Trichoderma viride* 4g/kg seed i.e.24.4% and the Percent root rot over control is i.e. 75.6% whereas in inoculated control% root rot was 71.00% and% root rot over control was 29.00%.

References

1. Andrabi MAV, Razdan VK. Evaluation of different measures to control wilt causing pathogens in chickpea. Journal of Plant Protection Research. 2011;51(1):1-8.
2. Bunker RN, Mathur K. Integration of biocontrol agents and fungicide for suppression of dry root rot of Capsicum frutescens. Journal of Mycology and Plant Pathology. 2001;31(3):330-334.
3. Chen HD, Ni GH, Wang ZM, Yuan SZ. Effects of seven herbicides on growth and pathogenicity of *Rhizoctonia cerealis* Vander Hoeven. Chinese Journal of Yangzhou University, Agricultural and Life Sciences Edition. 2005;26(3):66-69.
4. Houshyar MF, Darvish Mojeni T. Effects of two systemic insecticides on damping-off pathogens of cotton. Journal of Agricultural Science and Technology. 2011;13:27-33.
5. Jayalakshmi SK, Usharani S, Benagi VI, Mannur DM. Sources of resistance to dry root rot of chickpea caused by *Rhizoctonia bataticola*. Agricultural Science Digest. 2008;28(2):147-148.
6. Kathiresan RM, Gnanavel I, Jayakanth UV, Arulchezhian MP, Anbhazhagan R, Padmapriya SP. Bio-efficacy and phytotoxicity of oxadiargyl in onion (*Allium cepa* var. *aggregatum*). Indian Journal of Weed Science. 2004;36(3-4):236-238.
7. Khan MI, Gul H, Khan I. Herbicides and their doses effects on wild onion (*Asphodelus tenuifolius* Cav.) in chickpea. Pakistan Journal of Weed Science Research. 2010;16(3):299-308.

8. Kumar S, Sharma S, Pathak DV, Beniwal J. Integrated management of jatropha root rot caused by *Rhizoctonia bataticola*. Journal of Tropical Forest Science. 2011;23(1):35-41.
9. Lokesha NM, Benagi VI. Biological management of pigeonpea dry root rot caused by *Macrophomina phaseolina*. Karnataka Journal of Agricultural Sciences. 2007;20(1):54-56.
10. Murugesan N, Kavitha A. Seed treatment with *Pseudomonas fluorescens*, plant products and synthetic insecticides against the leaf hopper, *Amrasca devastans*, in cotton. Journal of Biopesticides. 2009;2(1):22-25.
11. Mukhopadhyay AN, Mukherjee PK. Innovative approaches in biological control of soil-borne diseases in chickpea. In: Proceedings of the IV International Trichoderma and Gliocladium Workshop; 1991 Jul 17-20; Belgirate, Italy. Petria. 1991;1:146.
12. Nagamani P, Viswanath K, Babu TK. Management of dry root rot caused by *Rhizoctonia bataticola* (Taub.) Butler in chickpea. Biotica. 2011;5(3):364-369.
13. Patel ST, Anahosur KH. Association of soil-borne fungi infecting chickpea and correlation coefficient between frequency of fungi and other factors. Journal of Mycology and Plant Pathology. 2000;30(1):50-52.
14. Pahwa SK, Prakash J. Studies on effect of herbicides on the growth, nodulation and symbiotic nitrogen fixation in mungbean (*Vigna radiata* L. Wilczek). Indian Journal of Weed Science. 1996;28(3-4):160-163.
15. Singh SK, Nene YL. Cross inoculation studies on *Rhizoctonia bataticola* isolates from different crops. Indian Phytopathology. 1990;43(3):446-448.
16. Sindhan GS, Hooda I, Karwasra SS. Biological control of dry root rot of chickpea caused by *Rhizoctonia bataticola*. Plant Disease Research. 2002;17(1):68-71.
17. Sharma OP, Gupta RBL. Fungicides in the control of chickpea dry root rot caused by *Rhizoctonia bataticola*. Journal of Mycology and Plant Pathology. 2004;34(2):321-322.
18. Thomas M, Vyas SC. Nodulation and yield of chickpea treated with fungicides at sowing. International Chickpea Newsletter. 1984;11:37-38.
19. Yadav PK, Khan AH, Rammurti RK, Upadhyay. Effect of herbicides on germination, growth and nodulation in chickpea (*Cicer arietinum*). Indian Journal of Agricultural Sciences. 2006;76(11):682-684.