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Integrated diseases management of chickpea dry root rot caused by *Rhizoctonia bataticola* (Taub.) Butler

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Abstract
The study entitled "Integrated disease management of chickpea dry root rot caused by *Rhizoctonia bataticola* (Taub.) Butler" was conducted during Rabi 2023-24 at the Agricultural Research Farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur, to develop an eco-friendly strategy for managing dry root rot in chickpea. The objectives included isolation of the pathogen, evaluation of fungicides, bioagents, and organic amendments, and formulation of integrated management practices. The pathogen *R. bataticola* was isolated from diseased chickpea roots and maintained on PDA. Various seed treatments—Carbendazim, Tebuconazole, Captan + Hexaconazole, Carboxin + Thiram—and bioagents (*Trichoderma harzianum* and *T. hamatum*) were tested individually and in combination with organic amendments (safflower and cotton seed cakes) under screen house conditions. Significant variation was observed among treatments for pre-emergence seed rot, post-emergence mortality, and overall plant mortality. The integrated treatment comprising Carbendazim (3 g/kg seed) + *T. harzianum* (10 g/kg seed) + safflower seed cake (50 g/pot) exhibited the lowest average mortality (3.22%), followed by *T. harzianum* alone and Captan + Hexaconazole treatments. Untreated control recorded the highest mortality (42.32%). The results clearly established that integrated use of fungicides, bioagents, and organic amendments offers superior and sustainable management of dry root rot compared to individual components. This integrated approach minimizes chemical dependency, enhances soil health, and can be incorporated into chickpea production systems for long-term disease suppression.

Keywords: Chickpea, *Rhizoctonia bataticola*, dry root rot, integrated disease management

Introduction
Chickpea (*Cicer arietinum* L.) is a widely cultivated leguminous crop that holds significant agronomic, nutritional, and economic value worldwide. It is the second most important grain legume after common beans in terms of global production and consumption. Chickpeas have been cultivated for over 7,000 years, with their origin traced back to the Fertile Crescent region. Over centuries, they have spread across the Middle East, South Asia, North Africa, and the Mediterranean, becoming a dietary staple in many cultures. Chickpea cultivation is frequently challenged by a range of biotic and abiotic stresses that significantly limit its productivity and yield stability. Biotic stresses include fungal diseases such as *Ascochyta blight*, *Fusarium wilt*, *Botrytis gray mold*, and insect pests like *Helicoverpa armigera* (pod borer), which alone can cause yield losses exceeding 30% under severe infestations. Abiotic stresses, particularly drought, heat, and salinity, are especially detrimental in arid and semi-arid regions where chickpeas are predominantly grown. Drought stress during flowering and pod filling stages can reduce yields by more than 50% (Istanbuli *et al.*, 2022) [6]. Heat stress, particularly when temperatures exceed 35 °C during flowering, can lead to pollen sterility and flower drop, further affecting pod development. These stresses not only impact yield but also influence seed quality and disease susceptibility.

Among the biotic constraints, dry root rot caused by *Rhizoctonia bataticola* has emerged as a major disease, especially under hot and dry soil conditions. Recent studies have highlighted dry root rot (DRR) as an increasingly serious challenge to chickpea production, particularly in regions experiencing high temperatures and water scarcity (Pande *et al.*, 2012; Sharma *et al.*, 2010; Ghosh *et al.*, 2013) [7, 3, 3]. The disease is caused by the soil-borne fungus *Rhizoctonia bataticola* (Taub.) Butler, also known by its synonym *Macrophomina phaseolina* (Maubl.) Ashby.

DRR often forms part of a broader root disease complex and is especially damaging when plants are already under abiotic stress, such as drought or poor soil conditions, which weaken their natural defenses and make them more susceptible to infection (Hwang *et al.*, 2003) [4]. *R. bataticola* is a soil-inhabiting organism capable of infecting chickpea at any crop stage, but most commonly infects chickpea at post-reproductive stage in dry and warm regions (Sharma & Pande 2013) [8]. The pathogen thrives in high temperatures (30-35 °C) and low soil moisture levels, which are becoming increasingly common due to climate variability. Infected plants typically exhibit sudden wilting, dark brown to black discoloration at the root base, and progressive rotting of roots, ultimately leading to plant death. The disease can cause 30-80% yield loss**,** particularly when infection occurs at early growth stages.

Managing dry root rot is challenging due to the pathogen's ability to survive as microsclerotia in soil for extended periods and its rapid spread under drought and high temperature conditions. Limited availability of resistant cultivars and ineffective chemical control further complicate disease management. Although various fungicides are used to combat soil-borne diseases such as dry root rot in greengram, their application comes with several drawbacks. Chemical control methods are often not cost-effective and may lead to environmental issues such as disruption of soil microbial communities, groundwater contamination, chemical residues on edible crops, and the development of resistance in pathogens. This resistance can further compromise the effectiveness of disease-resistant crop varieties. Given these limitations, Integrated Disease Management (IDM) offers a more sustainable and eco-friendly strategy by combining cultural practices, biological control agents, and limited use of chemicals. The present study aimed to evaluate the effectiveness of IDM and explore host plant resistance as part of a holistic approach to managing dry root rot. While resistant sources to vascular wilt have been identified in various regions, only a limited number of chickpea lines or germplasms show moderate resistance to dry root rot. Consequently, there are currently no commercial chickpea varieties with confirmed resistance to this disease. To address this gap, the current research was undertaken with the goal of identifying resistant genotypes among desi and kabuli chickpeas for future use in breeding programs.

Materials and Methods

During present investigation on "Studies on management of chickpea dry root caused by *Rhizoctonia bataticola* (Taub.) Butler" various experiments were conducted at the Agriculture research farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur during Rabi, 2023-24 to fulfill the objectives defined. The details of the materials used and methods adopted for various experiments are being described here in under following various sub-heads.

Isolationa and pure culture of pathogen

Chickpea plants exhibiting typical dry root rot symptoms were collected from a farmer's field. The roots were washed to remove soil and then cut into 2.5 mm pieces using a sterilized blade. These root pieces were disinfected in 0.1% sodium hypochlorite solution for 2 minutes, followed by three washes in sterilized water to eliminate any traces of the chemical. The disinfected root pieces were blotted dry, and four pieces were placed in Petri dishes with solidified potato dextrose agar (PDA). The plates were incubated at 28±2 °C for seven days. Once fungal growth appeared, free from contamination, it was transferred to an agar slant using the hyphal tip method. Regular sub-culturing ensured the culture was purified, and pure fungal strains were maintained for further studies.

Chickpea Seed

Seeds of chickpea variety IPC-2006-77 was obtained from Division of Crop Improvemtn, ICAR-Indian Institute of Pulses Research, Kanpur.

Fungicides, Bioagents and organic ammedments

All the fungicides used in this study were uchased from the market. Bio control agents and Organic ammedments were were obtained from Department of Plant Pathology, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur.

Integrated Management of Dry Root of Chickpea

Various chemical systemic and non-systemic fungicides, bioagents and organic ammendments were evaluated against the test pathogen. Best treatments were integrated and evaluated against the test pathogen. Prior to sowing, pots (30 cm diameter) were sterilized using copper sulfate solution and filled with sterilized soil and farmyard manure (FYM) in a 3:1 ratio. The soil mixture was sterilized at 1.045 kg/cm² for one hour over three consecutive days. Pots were inoculated with 20 g of fungal inoculum, grown on sorghum grains. Ten surface-sterilized chickpea seeds (L-550) were sown in each pot, with four replications. A control group was included, where seeds were sown in uninoculated sterilized soil. The pots were placed in a cage house, watered regularly, and maintained under uniform conditions. Three replications were kept for all the treatments.

Treatments Details

Tr. No.	Treatments
T_1	Seed treatment with Carbendazim @ 1.5 g/kg seed
T_2	Seed treatment with Tebuconazole 20% EC @ 1.5g/kg seed
T_3	Seed treatment with Captan 70% + Hexaconazole 5% WP @ 3g/kg seed
T_4	Seed treatment with Carboxin 37.5% + Thiram 37.5% WP @ 3g/kg seed
T_5	Seed treatment with *Trichoderma* (5x107cfu/g carrier)
T_6	Seed treatment with *T. hamatum* (5x107cfu/g carrier)
T_7	Soil application of safflower seed cake @ 50g
T_8	Soil application of cotton seed cake @ 50g
T_9	$T_1 + T_5 + T_7$
T_{10}	$T_3 + T_5 + T_8$
T_{11}	Control

Observations

Observations on % germination, plant mortality, PESM, PESR and% average mortality were recorded/calculated as described earlier.

Statistical analysis

The data obtained in all the experiments (*in vitro*) was subjected to statistical analysis. The standard error (S.E.) and critical difference (C.D.) @ 1% level of significance was worked out. Per cent data was transformed into arc sine values.

Results and Discussion

Integrated management of chickpea dry root rot, caused by *R. bataticola*

The most effective fungicides, bio-agents, and organic amendments identified through various *in vitro* studies during the present investigation were evaluated—both individually and in combination—for the management of dry root rot in chickpea caused by *Rhizoctonia bataticola*. The integrated treatments were tested using the sick soil method by sowing a susceptible chickpea cultivar, IPC-2006-77, in polybags under screen house conditions.

Per cent incident of mortality

Integration of various treatments resulted in a significant reduction in disease incidence, with pre-emergence seed rot, post-emergence seedling mortality, and average mortality ranging from 4.12% to 17.23%, 3.30% to 22.55%, and 4.21% to 21.75%, respectively. These values were considerably lower than those observed in the untreated control, which recorded 37.00%, 47.36%, and 42.32% for the respective parameters. Among the tested treatments, the combination of Carbendazim 5% WP (seed treatment) at 3.0 g/kg seed + *Trichoderma harzianum* (ST) at 10 g/kg seed + safflower seed cake (soil application) at 50 g per pot was found to be the most effective. This treatment recorded the lowest pre-emergence seed rot (4.12%), post-emergence mortality (4.63%), and average mortality (3.22%). This was followed in efficacy by *T. harzianum* (ST) at 10 g (6.00%, 7.86%, and 6.32%), Captan 70% + Hexaconazole 5% WP (ST) at 3 g/kg seed (5.63%, 8.23%, and 6.32%), and the combination of Captan 70% + Hexaconazole 5% WP (ST) at 3 g/kg seed + *T. harzianum* (ST) at 10 g + cotton seed cake (SA) at 50 g (11.23%, 12.32%, and 10.21%). Other effective treatments included *T. hamatum* (ST) at 10 g (12.36%, 14.53%, and 13.55%), Tebuconazole 25% EC (ST) at 1.5 g (12.32%, 12.58%, and 13.55%), and Carbendazim 50% WP (ST) at 1 g (11.32%, 16.85%, and 14.32%). Remaining treatments recorded pre-emergence seed rot between 14.21% and 21.33%, post-emergence mortality between 17.341% and 22.36%, and average mortality ranging from 15.33% to 21.55%, all notably lower than the untreated control.

The present findings on the integrated management of dry root rot in chickpea caused by *Rhizoctonia bataticola* are in alignment with earlier research conducted by Dhingani and Solanky (2016) [2], Ingle *et al.* (2017) [5], and Dhawan *et al.* (2019) [1]. Dhingani and Solanky (2016) [2] evaluated the efficacy of fungicide seed treatment using Carbendazim (0.3%), biological agents such as *Trichoderma viride* and *T. harzianum* (applied at 3% as seed treatment and 5 kg/ha as soil application), and organic amendments including farmyard manure (FYM), neem cake, and castor cake at 500 kg/ha. Their study revealed that soil application of *T. harzianum* (THNI) at 5 kg/ha mixed with 500 kg/ha FYM in furrows, five days prior to sowing, achieved 72.39% seed germination, the highest yield (1533 kg/ha), and 63.90% disease control. This was closely followed by the application of *T. harzianum* with neem cake at the same rate, which recorded 74.90% germination, 1489 kg/ha yield, and 63.63% disease suppression.

In a related study, Ingle *et al.* (2017) [5] assessed nine treatment combinations involving fungicides (Carbendazim + Mancozeb at 0.25%, and Carboxin + Thiram at 2.0 g/kg seed), bio-agents (*Pseudomonas fluorescens* at 1% seed treatment and 0.5% soil application, and *T. harzianum* at 0.4% seed treatment and 2.5% soil application), and organic inputs (neem cake and FYM at 500 kg/ha) for managing root rot in soybean caused by *Rhizoctonia bataticola*. The most effective treatment involved seed treatment with Carboxin + Thiram (2.0 g/kg seed) combined with soil drenching of the same fungicide (0.1%) at 50 days after sowing (DAS), which resulted in the lowest disease incidence (9.64%) and 68.14% reduction in root rot over the control. Another promising treatment included pre-sowing application of FYM enriched with *T. harzianum* and *P. fluorescens* (2.5 kg and 5 kg, respectively), along with neem cake at 500 kg/ha, and seed treatment with *T. harzianum* (4 g/kg) and *P. fluorescens* (10 g/kg), which resulted in a root rot incidence of 10.37% and 65.75% reduction compared to the untreated control.

Conclusion

The study clearly demonstrated the effectiveness of integrated disease management practices in reducing the incidence of dry root rot in chickpea. Among all treatments, the combination of Carbendazim (ST) + *Trichoderma harzianum* (ST) + safflower seed cake (SA) was the most effective, resulting in the highest reduction in plant mortality. This highlights the synergistic effect of combining chemical seed treatment with biological control agents and organic amendments. Other treatments, such as *Trichoderma* spp. alone, and Captan 70% + Hexaconazole 5% WP (ST), also showed significant control over the disease. Furthermore, the integrated approach involving Captan 70% + Hexaconazole 5% WP (ST) + *Trichoderma* (ST) + cotton seed cake (SA) also proved beneficial, indicating that such combinations can enhance disease suppression compared to individual components.

Overall, the findings suggest that integrated use of fungicides, biocontrol agents, and organic soil amendments is a promising strategy for managing dry root rot in chickpea under field conditions. Adoption of such holistic approaches can help in sustainable disease management, reduce chemical dependency, and support long-term soil health.

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