

“Correlation between soil moisture and soil temperature on infection and symptom expression of chickpea by *Rhizoctonia bataticola* causing dry root rot disease”

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Abstract

Dry root rot (DRR) of chickpea, caused by *Rhizoctonia bataticola* (Taub.) Butler [syn. *Macrophomina phaseolina* (Tassi) Goid.], is an important disease associated with warm and moisture-deficit conditions. The present study was conducted at the Zonal Agricultural Research Station, Kalaburagi, Karnataka, to determine the timing of pathogen establishment and symptom expression in chickpea in relation to soil moisture and soil temperature. Three chickpea varieties, JG 11, KCD 11 and SA 1, were evaluated, with 200 seeds of each variety sown separately. Soil moisture and soil temperature were recorded at three-day intervals from 15 to 57 days after sowing (DAS). A seedling was collected at each observation date, the pathogen was first recovered from the roots of SA 1 at 24 DAS, whereas it was detected in JG 11 and KCD 11 at 27 DAS. Recovery from shoot tissues began at 33 DAS in SA 1 and at 39 DAS in JG 11 and KCD 11. The pathogen was subsequently recovered from both roots and shoots of all varieties up to 57 DAS. Visible DRR symptoms appeared at 57 DAS, when soil moisture had declined from 87.2% to 56.5%, while soil temperature ranged from 28.6 to 31.9°C. The results showed that as soil moisture decreased and soil temperature remained relatively high during the reproductive stage, latent infections progressed into visible dry root rot symptoms. The pathogen was detected in root tissues well before symptoms appeared in the field, indicating that infection occurs much earlier than symptom expression. Therefore, early detection of the pathogen in roots can help in better understanding the development and progression of the disease before visible symptoms become evident.

Keywords: Chickpea, dry root rot, *Rhizoctonia bataticola*, *Macrophomina phaseolina*, soil moisture, soil temperature, pathogen colonization, symptom expression

Introduction

Chickpea (*Cicer arietinum* L.) is one of the most widely grown grain legumes in the world and is an important pulse crop in India. It is cultivated in 57 countries and serves as a valuable source of protein for millions of people (Merga and Haji, 2019) [6]. India is the leading producer of chickpea, followed by Australia, Türkiye, Ethiopia and Myanmar (FAO, 2024). As a legume crop, chickpea also improves soil fertility by fixing atmospheric nitrogen through symbiotic association with *Rhizobium* bacteria, thereby benefiting crops grown in rotation (Zehara *et al.*, 2020) [15].

Chickpea production is affected by several diseases and environmental stresses, particularly drought and high temperature. Among these constraints, dry root rot (DRR) has become an important disease of chickpea, especially in rainfed and semi-arid regions (Ghosh *et al.*, 2013) [4]. The disease is caused by the soil- and seed-borne fungus *Rhizoctonia bataticola* (Taub.) Butler, also known as *Macrophomina phaseolina* (Tassi) Goid. The pathogen survives in soil and infected plant residues for long periods and can infect a wide range of hosts, making crop rotation alone insufficient for effective disease management (Yesil and Bastas, 2016; Gupta and Sharma, 2015) [5, 14].

The development of DRR is closely related to soil moisture and temperature. The disease usually becomes more severe under warm and dry conditions, particularly during flowering and pod formation, when chickpea plants require more water. Declining soil moisture weakens the plants and

makes them more vulnerable to infection, while higher temperatures may further increase disease development. Sinha *et al.* (2019) [12] reported considerably greater disease severity under severe drought than under well-irrigated conditions. Likewise, Chilakala *et al.* (2022) [1] observed that the combination of pathogen infection with heat and drought stress increased DRR severity under field conditions. Soil moisture and temperature strongly influence the development and expression of dry root rot. Drought stress favours pathogen survival and microsclerotial production, whereas elevated temperatures may stimulate root exudation and increase the susceptibility of chickpea roots to infection by *Rhizoctonia bataticola* (Schroth and Hildebrand, 1964) [8].

Soil moisture also affects the survival and development of *R. bataticola*. Dry conditions may encourage the formation and persistence of microsclerotia, whereas adequate soil moisture can restrict their development (Dhingra and Sinclair, 1975; Olaya and Abawi, 1996) [2, 7]. Under controlled conditions, Sharma and Pande (2013) [4] recorded higher disease incidence and severity at 40% and 60% soil moisture than at 80% and 100% moisture. These findings indicate that moisture stress not only favours pathogen development but also increases the susceptibility of chickpea plants to dry root rot.

Therefore, the present study was undertaken to determine the timing of *Rhizoctonia bataticola* colonization in chickpea roots and shoots and to examine its relationship

with soil moisture, soil temperature and symptom expression under natural field conditions in a dry root rot sick plot.

Materials and methods

An experiment was conducted during Rabi 2025–26 in a dry root rot sick plot at ZARS, Kalaburagi to determine the time required for infection initiation by the pathogen and symptom expression of dry root rot of chickpea caused by *Rhizoctonia bataticola* under natural field conditions. Three chickpea varieties JG-11, KCD-11 and SA-1 were sown in the dry root rot sick plot of chickpea along with the screening entries. A total of 200 seeds of each variety were sown separately. Soil moisture and soil temperature observations were recorded from 15 days after sowing (DAS) and recorded at an interval of three days until symptom expression. Soil moisture (%) was measured using a soil moisture meter, whereas soil temperature (°C) was recorded using a soil thermometer. To monitor pathogen infection within the plant root system, two seedlings from each variety were randomly uprooted at every three-day interval. The seedlings were washed thoroughly under running tap water to remove adhering soil particles. Root and shoot portions were separated and surface sterilized with one per cent sodium hypochlorite solution for one minute followed by three washings in sterile distilled water. The sterilized tissues were split longitudinally and piece of root and shoot portions were aseptically transferred onto Potato Dextrose Agar (PDA) medium. The inoculated plates were incubated at $28 \pm 1^\circ\text{C}$ and observed periodically for the growth of *R. bataticola*. Presence or absence of the pathogen from root and shoot tissues was recorded at each observation interval. Simultaneously, the crop was examined regularly for the appearance of visible dry root rot symptoms in the field.

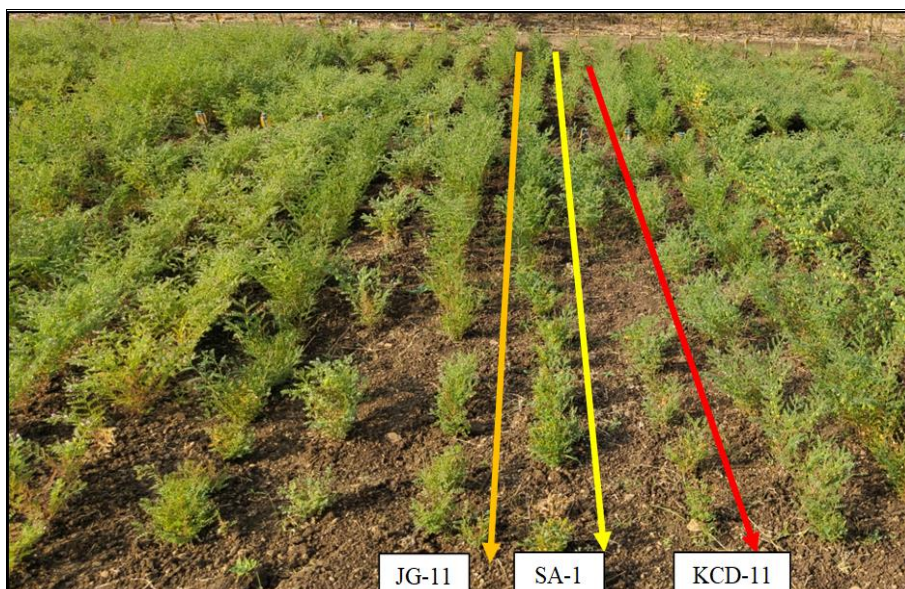
Results and discussion

Experiment was conducted to study the influence of soil moisture and soil temperature on the infection of chickpea by the pathogen causing dry root rot. The observations recorded on pathogen infection in relation to soil moisture and temperature at three-day intervals are presented in (Table 1 and Plate 1). In this experiment, 200 seeds each of three different chickpea varieties were sown in a dry root rot sick plot under natural field conditions. Continuous observations were noted at an interval of three days starting from 15 days after sowing (DAS). During each observation, soil moisture and soil temperature were recorded. At every three-day interval, two seedlings from each entry were carefully uprooted and washed cleanly under tap water to remove adhering soil particles. The seedlings were surface sterilized, vertically split opened and smashed in a sterile mortar and pestle. Pieces from the root and shoot portions were placed on PDA medium to confirm the presence of the dry root rot pathogen infection in different parts of the plant system. The results revealed up that at 21 DAS no pathogen was observed either in shoots or root tissues. The earliest pathogen growth was detected at 24 DAS from the roots of SA-1, while the shoots remained free from infection. This indicated that root infection occurred before the appearance of visible symptoms in the field. At 27 DAS, pathogen growth was observed from the roots of JG-11 and KCD-11

in addition to SA-1, whereas no growth was detected from the shoots of these entries. Root infection continued to be observed in all the entries from 27 to 57 DAS. At 33 DAS, pathogen growth was detected from the shoots of SA-1, while the roots of all entries continued to show infection. Further progression of the disease was evident at 39 DAS, when pathogen growth was seen from both roots and shoots of JG-11, KCD-11 and SA-1. Thereafter, continuous pathogen growth was observed from both roots and shoots of all the entries during subsequent observations up to 57 DAS, indicating persistent colonization of the pathogen within the plant system. In JG-11 and KCD-11, the first pathogen growth on PDA plates was observed at 27 DAS from the roots, whereas in the SA-1, infection was detected earlier at 24 DAS. The pathogen continued to be isolated from the infected plant parts in all the entries during successive observations, even in the absence of visible disease symptoms in the field. This clearly proved that infection and internal colonization by the pathogen occurred much earlier than symptom expression (Plate 2).

Once characteristic dry root rot disease symptoms started appearing in the field at 57 DAS, corresponding to the flowering stage of the crop to pod setting stage, further root isolation was discontinued. The observations suggest that the pathogen remains established within the plant for a considerable period before visible symptoms appear. As the crop approached flowering and soil moisture gradually declined, the latent infection progressed to visible disease expression. Thus, the study indicated that dry root rot infection is initiated well before symptom appearance and the development of visible above-ground symptoms is associated with crop growth stage and the gradual reduction of soil moisture under field conditions.

The present findings are consistent with previous reports concerning early pathogen colonization and the influence of soil moisture on dry root rot development. Chandran *et al.* (2021) ^[9] reported that *Rhizoctonia bataticola* colonized chickpea roots before the appearance of visible disease symptoms, supporting the early detection of the pathogen in root tissues in the present study. The progressive decline in soil moisture and subsequent development of symptoms were also consistent with the findings of Sharma and Pande (2013) ^[4], who recorded higher disease incidence and severity at 40 and 60% soil moisture. Similarly, Soni *et al.* (2022) ^[13] reported the highest disease incidence at 25% soil moisture and the lowest incidence at 100% soil moisture, confirming that moisture stress favours the development and progression of dry root rot. The appearance of symptoms during the flowering stage in the present study agrees with Sharma *et al.* (2015) ^[5], who reported that moisture stress during the reproductive stages predisposes chickpea plants to severe dry root rot. The relatively high soil temperatures recorded during the study may have contributed to disease development by increasing host susceptibility, possibly through enhanced root exudation, as suggested by Schroth and Hildebrand (1964). Chilakala *et al.* (2022) ^[1, 8] also observed that dry root rot symptoms become more pronounced during the later stages of crop growth. Their assessment of pathogen-induced changes in root architecture at the podding stage further supports the importance of reproductive-stage stress in the expression and progression of dry root rot.



Sowing of genotypes JG-11, SA-1 and KCD-11 for conformation of infection by *Rhizoctonia bataticola* in chickpea DRR sickplot



Plate 1: Expression of DRR symptom at 57 DAS in JG-11, SA-1 and KCD-11



Plate 2: Confirmation of infection by *R. bataticola* in chickpea causing dry root rot disease in different genotypes

Table 1: Relation of soil moisture and soil temperature on infection of chickpea by *Rhizoctonia bataticola* causing dry root rot disease in dry root rot sick plot

DAS	Date of observation	Soil moisture (%)	Soil temperature (°C)	JG-11		KCD-11		SA-1	
				Roots	Shoot	Roots	Shoot	Roots	Shoot
15	24-11-2025	87.2	31.1	X	X	X	X	X	X
18	27-11-2025	85.3	29.8	X	X	X	X	X	X
21	30-11-2025	82.1	29.6	X	X	X	X	X	X
24	03-12-2025	79.5	30.8	X	X	X	X	✓	X
27	06-12-2025	77.6	31.9	✓	X	✓	X	✓	X
30	09-12-2025	74.9	28.6	✓	X	✓	X	✓	X
33	12-12-2025	73.1	30.4	✓	X	✓	X	✓	✓
36	15-12-2025	71.1	28.8	✓	X	✓	X	✓	✓
39	18-12-2025	69.6	30.7	✓	✓	✓	✓	✓	✓
42	21-12-2025	66.5	29.3	✓	✓	✓	✓	✓	✓
45	24-12-2025	63.3	29.6	✓	✓	✓	✓	✓	✓
48	27-12-2025	61.4	30.3	✓	✓	✓	✓	✓	✓
51	30-12-2025	60.1	30.8	✓	✓	✓	✓	✓	✓
54	02-01-2026	58.4	31.7	✓	✓	✓	✓	✓	✓
57	05-01-2026	56.5	31.1	✓	✓	✓	✓	✓	✓

DAS – Days after sowing, ✓- Infection conformed, X – Infection not conformed.

Conclusion

Further studies on the combined effect of soil moisture and soil temperature on infection by pathogen in the host revealed that, the pathogen establishes infection at early stages of crop growth. The pathogen was first detected in root tissues at 24 days after sowing (DAS) in SA-1 genotype and at 27 DAS in JG-11 and KCD-11 genotypes, even in the absence of visible symptoms. This indicates that infection occurs much earlier than symptom expression. The pathogen gradually colonized the plant system and later spread to shoot tissues. Visible symptoms of dry root rot appeared at later stages of crop growth, particularly around 57 DAS during the flowering stage. The delayed symptom expression was closely associated with declining soil moisture levels and increasing temperature, suggesting that environmental stress triggers the transition from latent infection to active disease symptom expression. The major change anticipated under moisture stress condition is that, as the moisture level starts declining in the rhizosphere, the pathogen switches from vegetative growth stage in to stationary stage by forming sclerotial bodies, as the no of sclerotial bodies and their size increases the translocation of water and nutrients from roots to shoots is obstructed very much that too at reproductive stage, hence the symptoms become more visible at this stage onwards.

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