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Mapping the Distribution and Host Range of *Rhizoctonia bataticola* causing Dry Root Rot in Chickpea in Arid and Semi-Arid Regions of Rajasthan

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ABSTRACT: Dry root rot (DRR), caused by *Rhizoctonia bataticola*, is an emerging constraint to chickpea (*Cicer arietinum* L.) production in arid and semi-arid regions of Rajasthan, India. This study aimed to map the distribution of the disease and evaluate the host range of the pathogen under field and controlled conditions. A systematic roving survey conducted during *Rabi*, 2019–20 across five major chickpea-growing districts *viz.*, Bikaner, Churu, Jhunjhunu, Hanumangarh, and Sri-Ganganagar revealed widespread disease incidence, with an overall mean Per cent Disease Incidence (PDI) of 23.87%. The highest incidence was recorded in Bikaner (27.64 %), while Hanumangarh had the lowest (18.89 %). Host range studies with a highly virulent isolate (RBbk$_1$) under pot experiment showed that multiple field crops, vegetables, and weed species supported pathogen infection. These findings highlight the influence of localized environmental conditions and agronomic practices on disease incidence and wide host range of *R. bataticola*, reinforcing its status as a persistence and economically significant pathogen. Underline the need for integrated disease management strategies targeting both crop and non-crop reservoirs of the pathogen.

Keywords: Dry root rot, *Rhizoctonia bataticola*, Disease incidence, Host range, Integrated disease management.

INTRODUCTION

Chickpea is a key legume crop in India, particularly in arid and semi-arid regions. Gram or chickpea (*Cicer arietinum* Linnaeus), a member of family *Fabaceae*, is a self-pollinated leguminous crop having diploid chromosome (2n=16 chromosomes) set (Tekeoglu *et al*., 2000). This crop is an integral part of many Asian and sub-Saharan countries food security programs, and this region accounts for more than 95% of the global chickpea production (Wood and Grusak 2007). The major chickpea growing states of India are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Uttar Pradesh, Andhra Pradesh, Gujarat, Chhattisgarh, Jharkhand and Telangana. Among these states, Maharashtra stands first in area and production. Rajasthan stands third in terms of area and production both. The cultivation of chickpea is well adapted to the conditions prevailing in Rajasthan Despite its agronomic and nutritional significance, chickpea productivity remains low due to abiotic and biotic stresses (Devasirvatham and Tan 2018; Flowers *et al*., 2010; Sinha *et al.*, 2019). It's susceptibility to various diseases and attacks of various fungal pathogens during the crop in the field (Riaz *et al*., 2012). Among biotic constraints, dry root rot caused by *Rhizoctonia bataticola* is a serious concern (Pande and Sharma 2010). Favourable conditions for the disease *i.e.* high temperatures and low soil moisture are increasingly prevalent due to climate variability. The pathogen causes extensive root damage, leading to wilting and drying of plants, particularly at the flowering and podding stages. The affected roots become black, brittle, and devoid of lateral rootlets (Rai *et al*., 2022). Despite its impact, data on the spatial distribution and host range of the pathogen in Rajasthan is limited. This study addresses this gap through field surveys and host susceptibility assays.

MATERIALS AND METHODS

A. Survey and Collection of Diseased Samples

A Roving method of survey was followed to assess the incidence of Dry Root Rot disease of chickpea. The survey of major chickpea growing districts of Rajasthan, *i.e.*, Bikaner, Churu, Jhunjhunu, Hanumangarh and Sri-Ganganagar was conducted during *Rabi*, 2019-20 to record incidence of disease and to collect diseased samples for isolation of pathogen. In each district, five villages of one Tehsil were visited. In each village, five farmer's fields were surveyed for disease incidence and other information. Samples from each field was collected and brought to the laboratory. For further studies, one sample from each village was retained on the basis of maximum per cent disease

incidence (PDI). The disease incidence was recorded in 3m × 3m marked area in each field from five locations and per cent disease incidence (PDI) was calculated by counting the diseased and the total number of plants per spot. The plant showing dry root rot symptoms was considered as a diseased plant. Based on observations the per cent disease incidence was calculated by using following formula;

$$\text{PDI (\%)} = \frac{\text{Number of diseased plants}}{\text{Total number of plants}} \times 100$$

Whereas, PDI = Per cent Disease Incidence

B. Host Range Studies

Thirteen domesticated crops and four weeds (Table 1) were screened against highly virulent isolate ($RBbk_1$) of *Rhizoctonia bataticola* under pot experiment during *Rabi*, 2020-21. The seeds of crops and weeds were collected during the *Rabi*, 2019-20. The seeds were rolled on seven days old sporulating culture grown on PDA contained in Petri plates. Inoculated seeds were sown in 30 cm diameter earthen pots (pre-sterilized and having autoclaved soil) with three replications. These pots were kept in cage house and watered regularly as per requirement and observation on host reaction was recorded up to 45 days of sowing. Susceptibility was marked as '+' and resistance as '–'.

Table 1: List of domesticated crops and weeds used for host range studies.

Sr. No.	Local Name	English Name	Scientific Name
Field Crops			
1.	Sarson	Mustard	*Brassica juncea*
2.	Gehun	Wheat	*Triticum aestivum*
3.	Jo	Barley	*Hordeum vulgare*
4.	Isabgol	Psyllium husk	*Plantago ovata*
Vegetable Crops			
5.	Matar	Pea	*Pisum sativum*
6.	Pyaj	Onion	*Allium cepa*
7.	Tamatar	Tomato	*Solanum lycopersicum*
8.	Baingan	Brinjal	*Solanum melongena*
Weeds			
9.	Jangali Jai	Wild oat	*Avena fatua*
10.	Bathua	Chenopodium	*Chenopodium album*
11.	Motha	Nutgrass	*Cyperus rotundus*
12.	Satyanashi	Mexican prickly poppy	*Argemone mexicana*
13.	Carrot grass	Parthenium	*Parthenium hysterophorus*

RESULTS

A. Distribution of Dry Root Rot in Rajasthan

During *Rabi*, 2019-20 a roving survey was carried out in five key chickpea growing districts of Rajasthan *viz.*, Bikaner, Churu, Jhunjhunu, Hanumangarh and Sri-Ganganagar to access the prevalence of dry root rot disease. The findings (Table 2, Fig. 1 and Plate 1) dry root rot posed a significant challenge across these regions. Among the districts, Bikaner recorded the highest average disease incidence at 27.64 per cent, with Bhaderan village exhibited the maximum mean per cent disease incidence of 31.12 per cent across all surveyed locations. In contrast, Hanumangarh showed the lowest average PDI (18.89%), with Dhani Charnan village showed the lowest mean disease incidence at 17.76 per cent. Among other districts, Churu (26.66%) and Jhunjhunu (25.63%) also showed high average per cent disease incidence, while Sri-Ganganagr exhibited a moderate incidence (20.55%). The overall range of disease incidence across all five districts of Rajasthan varied from 08.38 per cent (Dhani charnan village of Hanumangarh district) to 36.21 per cent (Bhaderan village of Bikaner district). In total, 125 fields were surveyed across the five districts and the overall mean disease incidence was found to be 23.87 %. The findings clearly indicate that disease pressure was unevenly distributed, with some villages like Bhaderan and Udsar Lodera facing severe outbreaks, whereas others such as Dhani Charnan and Kankadwala had comparatively lower disease incidence, highlighting the influence of localized environmental conditions and agronomic practices.

Table 2: Places of sample collection and disease incidence in surveyed fields in five districts of Rajasthan in year 2019-20.

Sr. No.	Districts	Name of Tehsil	Name of Village*	% disease incidence in surveyed field and Sample No.					Av. PDI of village (Av. of five fields)
1.	Bikaner	Lunkaransar	Kankadwala	35.33 (1)	10.38 (2)	29.09 (3)	23.23 (4)	12.54 (5)	22.11
			Nathwana	22.85 (6)	26.14 (7)	29.30 (8)	30.30 (9)	31.85 (10)	28.08
			Udana	15.70.(11)	33.74 (12)	35.72 (13)	25.04 (14)	21.80 (15)	26.40
			Rojhan	22.65 (16)	35.13 (17)	28.21 (18)	32.94 (19)	33.65 (20)	30.51
			Bhaderan	34.65 (21)	28.54 (22)	35.25 (23)	36.21 (24)	20.98 (25)	31.12
Average PDI of Bikaner									**27.64**
2.	Sri-Ganganagar	Anoopgarh	5 PGM	24.82 (26)	13.20 (27)	19.54 (28)	20.65 (29)	24.47 (30)	20.53
			79 GB	19.42 (31)	14.38 (32)	22.90 (33)	14.76 (34)	30.55 (35)	20.40
			7 PGM	23.00 (36)	11.78 (37)	21.74 (38)	20.70 (39)	21.63 (40)	19.77
			15 A (B)	23.42 (41)	22.75 (42)	25.99 (43)	16.45 (44)	24.95 (45)	22.71
			90 GB	21.23 (46)	18.39 (47)	24.86 (48)	10.65 (49)	21.66 (50)	19.35
Average PDI of Sri- Ganganagar									**20.55**
3.	Hanumangarh	Nohar	Chok Rajasar	19.00 (51)	15.00 (52)	21.95 (53)	18.00 (54)	20.80 (55)	18.95
			Dhani Charnan	21.62 (56)	18.39 (57)	19.37 (58)	08.38 (59)	21.07 (60)	17.76
			2 BKK	20.97 (61)	18.17 (62)	19.57 (63)	20.50 (64)	13.98 (65)	18.64
			4 BKK	9.75 (66)	24.28 (67)	18.95 (68)	12.55 (69)	30.80 (70)	19.26
			1 NHR-B	16.00 (71)	19.94 (72)	21.48 (73)	19.48 (74)	22.50 (75)	19.88
Average PDI of Hanumangarh									**18.89**
4.	Churu	Sardarsahar	Jeevan Desar	31.02 (76)	30.28 (77)	25.04 (78)	24.42 (79)	29.13 (80)	27.97
			Beekamsara	15.00 (81)	26.20 (82)	23.60 (83)	28.71 (84)	30.35 (85)	24.77
			Glrgichiya	19.43 (86)	26.08 (87)	30.09 (88)	24.06 (89)	34.09 (90)	26.75
			Bhojrasar	29.88 (91)	25.12 (92)	31.90 (93)	17.18 (94)	20.87 (95)	24.99
			Udsar Lodera	18.65 (96)	31.14 (97)	25.30 (98)	33.75 (99)	35.47 (100)	28.86
Average PDI of Churu									**26.66**
5.	Jhunjhunu	Chidawa	Vijaypura	30.98 (101)	25.14 (102)	26.85 (103)	12.03 (104)	27.55 (105)	24.51
			Khemu Ki Dhani	26.35 (106)	28.39 (107)	30.35 (108)	21.02 (109)	24.09 (110)	26.04
			Gothri	22.28 (111)	26.55 (112)	19.14 (113)	31.78 (114)	28.99 (115)	25.74
			Lamba Gothra	25.57 (116)	33.50 (117)	28.12 (118)	16.99 (119)	26.25 (120)	26.08
			Ojtu	29.12 (121)	26.54 (122)	26.12 (123)	18.04 (124)	29.08 (125)	25.78
Average PDI of Jhunjhunu									**25.63**
Overall Mean (Mean of 125 fields)									**23.87**
***PDI = Percent Disease incidence**									

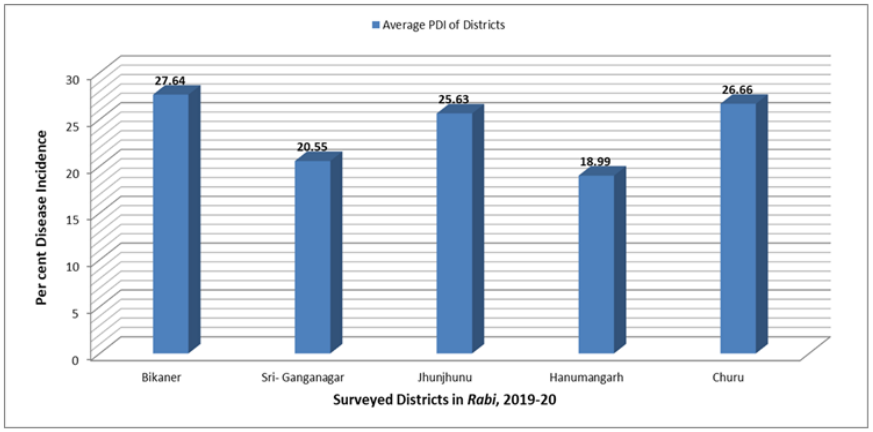

Fig. 1. Disease incidences of dry root rot of chickpea in major surveyed districts of Rajasthan (Avg. of 25 surveyed fields).

Plate 1. Different survey locations of Rajasthan to collect samples of dry root rot disease of chickpea.

B. Host Range of Rhizoctonia bataticola

During *Rabi* 2020-21, eight field or vegetable crops and five weed species were artificially inoculated to access the host range and pathogenic potential of the highly virulent isolate of *R. bataticola* ($RBbk_1$) under pot house conditions. The result presented in Table 3 revealed that among Field crops evaluated, *Brassica juncea* (Mustard), *Triticum aestivum* (Wheat), *Hordeum vulgare* (Barley) and *Plantago ovata* (Psyllium husk) exhibited positive host reaction (+), confirming their susceptibility to the pathogen. Similarly, all tested vegetable crops *i. e. Pisum sativum* (Pea), *Allium cepa* (Onion), *Solanum lycopersicum* (Tomato) and *Solanum melongena* (Brinjal) also showed susceptibility to the *R. bataticola*. These results indicating wide host range of the pathogen within the families *Brassicaceae*, *Poaceae*, *Plantaginaceae*, *Fabaceae*, *Liliaceae* and *Solanaceae*. While among the weed species only *Avena fatua* (Wild oat) and *Chenopodium album* (Bathua) belongs to family *Poaceae* and *Amaranthaceae* respectively, showed positive host reaction, suggesting their role as alternative host and potential reservoir of the pathogen in the absence of primary host in fields of semi-arid regions. However, *Cyperus rotundus* (Motha), *Argemone Mexicana* (Mexican prickly poppy) and *Parthenium hysterophorus* (Carrot grass) did not show any sign of infection and remained (-) uninfected, indicating resistance to the pathogen. These findings highlight the wide host range of *Rhizoctonia bataticola*, reinforcing its status as a persistence and economically significant pathogen.

Table 3: Reaction of *R. bataticola* with different crops and weeds under artificial inoculation conditions (in pots).

Sr. No.	English Name	Scientific Name	Family	Host Reaction
Field Crops				
1.	Mustard	*Brassica juncea*	*Brassicaceae*	+
2.	Wheat	*Triticum aestivum*	*Poaceae*	+
3.	Barley	*Hordeum vulgare*	*Poaceae*	+
4.	Psyllium husk	*Plantago ovata*	*Plantaginaceae*	+
Vegetable Crops				
5.	Pea	*Pisum sativum*	*Fabaceae*	+
6.	Onion	*Allium cepa*	*Liliaceae*	+
7.	Tomato	*Solanum lycopersicum*	*Solanaceae*	+
8.	Brinjal	*Solanum melongena*	*Solanaceae*	+
Weeds				
9.	Wild oat	*Avena fatua*	*Poaceae*	+
10.	Chenopodium	*Chenopodium album*	*Amaranthaceae*	+
11.	Nutgrass	*Cyperus rotundus*	*Cyperaceae*	-
12.	Mexican prickly poppy	*Argemone mexicana*	*Asteraceae*	-
13.	Parthenium	*Parthenium hysterophorus*	*Papaveraceae*	-

+ = Infetced; - = uninfected

DISCUSSION

A. Survey and collection of diseased samples

During *Rabi*, 2019-20 a survey was conducted in five key chickpea growing districts of Rajasthan to access the prevalence of dry root rot disease. A total of 135 fields across 25 villages in five districts namely Bikaner, Churu, Jhunjhunu, Hanumangarh and Sri-Ganganagar were surveyed for the incidence of the DRR disease in chickpea. The highest average incidence was recorded in Bikaner (27.64 %) followed by Churu (26.66 %), Jhunjhunu (25.63 %), Sri-Ganagnagar (20.55 %) and the lowest mean PDI in Hanumangarh (18.89 %). The survey revealed that the disease was prevalent in most of field, especially in continuously cropped chickpea fields under prolonged drought and high temperature conditions. However, localized environmental conditions and agronomic practices play a crucial role in disease occurrence and distribution. Our findings are in accordance with the results of Kadam *et al.* (2018) who had carried out an extensive survey in chickpea growing areas of eight district of Marathwada regions during *Rabi* season, 2014-15 to know about the prevalence, incidence and severity of dry root rot. Soil and plant samples were collected and reported highest disease incidence in Latur district (23 %) and lowest in Aurangabad district (10.20 %). Pratap and Godara (2022) have also been surveyed ten major chickpea growing districts of Rajasthan in 2014-15 and 2015-16. They conclude in their investigation that overall range of disease incidence in all the districts vary from 5.75 to 12.51 per cent with an average of 9.15 per cent in Rajasthan.

B. Host range of the pathogen

During *Rabi*, 2020-21, a pot experiment was conducted to evaluate the host range and pathogenicity of a highly virulent *R. bataticola* isolate ($RBbk_1$) on eight field or vegetable crops and five weed species. Among field crops, Mustard (*Brassicaceae*), Wheat (*Poaceae*), Barley (*Poaceae*) and Psyllium husk (*Plantaginaceae*) showed susceptibility. As did all tested vegetables *viz*., Pea (*Fabaceae*), Onion (*Liliaceae*), Tomoato (*Solanaceae*) and brinjal (*Solanaceae*) indicating the pathogens broad host range across multiple plant families. Among weeds only *Avena fatua* (*Poaceae*) and *Chenopodium album* (*Amaranthaceae*) were susceptible, suggesting they could serve as alternative hosts in the absence of chickpea crop. The pathogen re-isolated from the infected roots of tested plants and found to be identical to the mother culture of pathogen in all characteristics. These findings confirm *R. bataticola's* extensive host adaptability and its significance as a persistent, economically important pathogen in semi-arid regions. Previous studies have also been confirmed a similarly wide host range for *R. bataticola*, supporting these findings. Yang *et al*. (1992) conducted histopathological studies on *R. solani* and observed that in susceptible canola plant tissues, numerous infection hyphae emerged from specialized structure known as infection cushions. Ghoneem *et al.* (2007) were the first to report root rot caused by *Rhizctonia solani* and wilt disease caused by *Fusarium* sp., which resulted in typical pre-emergence and post-emergence seedling mortality in blond psyllium husk in Egypt. Ferrucho *et al.* (2012) reported that *Rhizoctonia solani* is the main causal agent of potato stem canker and black surf disease in Colombia. Sharma-Poudyal *et al*. (2015) documented that *Rhizoctonia* infections in pea crops can cause significant stunting and yield reduction, with losses reaching up to 75 per cent. Gade *et al.* (2018) have also been reported that *R. bataticola* is distributed in diverse climatic conditions from arid to tropical regions and it has a wide host range with more than 500 species, including legume and cereal plants belongs to family *Poaceae*. Abbas *et al*. (2019) conducted a study on antagonistic effect of *Bacillus* sp. against *Rhizoctonia solani* causing several stem and root diseases and reported that the species cause considerable yield losses worldwide, ranging from 10 per cent to over 50 per cent in susceptible crops such as potatoes and rice, posing a serious threat to food security and substantial raising production costs. Similarly, Mishra *et al.* (2021) carried out studies on the host-pathogen interaction pathways through RNA-seq analysis in response to *Rhizoctonia bataticola* Infection and found that the pathogen causes dry root rot disease in emerging seedlings over 500 cultivated legumes, cereals, oilseeds and wild plant species.

SUMMARY AND CONCLUSION

Survey, collection, isolation, purification, identification and pathogenicity of the pathogen. A systematic roving survey conducted during *Rabi*, 2019-20 across five key chickpea producing districts of Rajasthan *viz.*, Bikaner, Churu, Jhunjhunu, Hanumangah and Sri-ganagnagar revealed widespread incidence of dry root rot. Among the surveyed location Bikaner recorded the highest average per cent disease incidence (PDI) of 27.64 per cent with Bhaderan village showing the maximum individual field incidence of 36.21 per cent. In contrast, Hanumangarh exhibited the lowest average PDI (18.89 %) with Dhani charnan village recording a minimum PDI (8.38 %). Across all 125-field surveyed, the overall mean PDI was 23.87 per cent indicating substantial disease prevalence.

Host range of the pathogen. A host range study was conducted during the *Rabi*, 2020-21 under pot experiment to evaluate the susceptibility of various field and vegetable crops and weed species to a highly virulent isolate of *R. bataticola* ($RBbk_1$). Among the field crops mustard (*Brassica juncea*), wheat (*Triticum aestivum*), barley (*Hordeum vulgare*) and psyllium (*Plantago ovata*) exhibited clear susceptibility, confirming their potential as an alternate host. Similarly, all tested vegetables pea (*Pisum sativum*), onion (*Allium cepa*), tomato (*Solanum lycopersicum*) and brinjal (*Solanum melongena*) also demonstrated positive host reaction.

Out of five weed species tested, wild oat (*Avena fatua*) and bathua (*Chenopodium album*) were found susceptible, suggesting their role as an important alternative hosts and potential pathogen reservoirs in

chickpea growing areas, especially during off seasons. However, *Cyperus rotandus*, *Argemone Mexicana* and *Parthenium hysterophorus* remained uninfected, indicating resistance to the pathogen.

CONCLUSIONS

1. Survey studies confirmed the widespread occurrence of dry root rot in major chickpea growing districts of Rajasthan. The overall mean PDI recorded across all 125 surveyed fields was 23.87 per cent.
2. *R. bataticola*, a soil borne pathogen has a broad host range, infecting multiple field and vegetable crops across six plant families (Brassicaceae, Poaceae, Plantaginaceae, Fabaceae, Liliaceae and Solanaceae). Among weed species such as *Avena fatua* and *Chenopodium album* also acted potential source as alternative hosts in the fallow period.

RECOMMENDATIONS

- Regular Surveillance: Continued monitoring in major chickpea zones is essential to detect outbreaks early.
- Crop Rotation: Avoid successive cultivation of susceptible crops like wheat, mustard, and tomato in infected fields.
- Weed Management: Control of alternate hosts like *Avena fatua* and *Chenopodium album* during fallow periods can help minimize inoculum build-up.
- Soil Health: Implement practices like deep plowing, solarization, and organic amendments to suppress soil-borne pathogens.

FUTURE SCOPE

1. Development of Resistant Varieties: Given the wide host range and high virulence of *R. bataticola*, future research should focus on screening and developing chickpea cultivars with genetic resistance to the pathogen, particularly suited for arid and semi-arid environments.
2. Surveillance Expansion and Mapping: Continuous and wider geographical surveillance with the integration of GPS and GIS tools can facilitate real-time disease mapping and monitoring, enabling prompt interventions.
3. Alternative Hosts and Off-season Management: Since several weed species and rotational crops serve as alternate hosts, further investigations into their role in pathogen survival and spread during non-cropping seasons are needed to break the disease cycle effectively.
4. Farmer Awareness and Extension: Future work should include participatory approaches to educate farmers about early detection, cultural practices, and IDM methods, thereby increasing adoption rates and minimizing yield losses.

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