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Assessment of brown spot disease incidence and severity in rice cultivation across different region of Chhattisgarh

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Abstract
Rice (*Oryza sativa* L.) is a vital crop globally, feeding over half of the world's population. In India, the state of Chhattisgarh is a major rice-producing region, known as the "rice bowl of India." However, rice cultivation is plagued by various diseases, with brown spot disease, caused by *Bipolaris oryzae*, being one of the most devastating. This study presents a comprehensive survey conducted in 2022 across eight rice-growing districts in Chhattisgarh to assess the severity and distribution of brown spot disease.
The survey revealed that the disease incidence varied significantly across districts, with the highest incidence recorded in Runiyadih at 79.3% and the lowest in Bagtarai at 45.61%. The Plant Disease Index (PDI) ranged from 25.14% in Achoti(Dhamtari), to 87.47% in Parsada, (Raigarh). Severe infections led to significant reductions in grain and tiller numbers, as well as individual grain weight and quality, resulting in yield losses ranging from 30% to 43%. In contrast, moderately infected crops experienced lower losses of 12%, and lower disease grades showed non-significant losses. The overall yield decline fluctuated between 18.75% and 22.50%.Factors influencing disease severity include limited access to nitrogen-based fertilizers, water supply, and climatic conditions, with rainfall and high humidity favoring disease development. Climate change and initial conducive conditions further exacerbate the disease's spread. The study emphasizes the need for farmers to adopt resistant rice cultivars and calls for further research to better understand the various factors affecting disease incidence and intensity in different agro climatic zones. This research aims to assist farmers in minimizing losses due to brown spot disease and improving rice production levels in Chhattisgarh.

Keywords: Brown spot disease, *Bipolaris oryzae*, rice, disease survey, Chhattisgarh, disease severity, disease incidence, yield losses

Introduction
Rice (*Oryza sativa* L.) stands as the second largest crop grown in the world in terms of both area and production and extensively consumed staple food globally, catering to over half of the world's population. An estimated 3.5 billion individuals worldwide rely on rice, providing about 20% of their daily calorie needs (Maclean *et al*., 2013) [10]. Notably, over 90 percent of the world's rice production and consumption occurs in Asian countries.
In India, the state of Chhattisgarh is widely recognized as the "rice bowl of India." This region encompasses a geographical area of 13.51 million hectares, with 5.9 million hectares dedicated to cultivation. Among these, rice covers 3.70 million hectares, yielding a production of 6.15 million tons and a productivity rate of 16.63 quintals per hectare. However, rice crop attacked by number of diseases, including those of fungal, bacterial, and viral origins.
"Among these, brown spot disease in rice, caused by *Bipolaris oryzae* is historically significant and one of the most serious and devastating disease and prevalent in every rice cultivation region across India, (Gangopadhyaya in 1983 and Ou in 1985) [4, 15]. This disease carries substantial significance in several countries, and it has been documented to result in massive reductions in grain yield, sometimes reaching up to 90%. The first documented report of the presence of brown spot disease on rice was discovered in Madras (Sudraraman, 1919) [20]. This is especially notable when the leaf spotting phase intensifies to an epidemic scale, as witnessed during the Great Bengal Famine in 1942, (Ghose *et al*. in 1960) [5]. This disease is particularly prevalent in environments characterized by limited water supply, often compounded by nutritional imbalances, particularly a deficiency in nitrogen, (Baranwal *et al*. in 2013) [1].
These features mentioned above are commonly associated with fields of resource-poor farmers, leading to the term "poor farmer's disease" (Zadoks, 2002) [24]. In India, brown spot is prevalent throughout the subcontinent (Reddy *et al*., 2010) [16].

The disease results in both quantitative and qualitative losses in grain yield, (Savary *et al*. 2000) [17]. In the current scenario, the disease is widespread across rice cultivation areas, causing significant yield losses, second only to Blast disease (Sharma *et al*., 2008) [23]. Kamal and Mia (2009) [7] observed yield losses ranging from 18.75% to 22.50% when timely control measures are not implemented.

Furthermore, there is evidence that brown spot is becoming more severe in drought-prone regions (Savary *et al*., 2005) [18]. In India, the disease severity is notably higher in areas where direct-seeded rice is practiced, such as Bihar, Jharkhand, Madhya Pradesh, Orissa, Chhattisgarh, Assam, and West Bengal (Sunder *et al*., 2014) [21]. Implementing proper control measures, such as using resistant cultivars, chemicals, biological approaches, and cultural tactics, can effectively reduce yield losses.

Therefore, the current survey was carried out in the primary rice cultivation regions of Chhattisgarh state to gain insight into the disease severity & Surveillance of the disease was conducted to gather comprehensive data on the distribution of the disease, the extent of its occurrence, and its severity.

Materials and Methods

To assess the current status of brown spot disease in the Chhattisgarh, a comprehensive and systematic survey was conducted in kharif season of 2022 in various farmer's fields at different rice growing districts of Chhattisgarh i.e Raipur, Dhamtari, Balodabazar, Rajnandgaon, Kanker, Jagdalpur, Sarguja Surajpur. Information pertaining to the visited locations, disease severity, crop growth stage, and cultivated rice varieties was documented and is presented in Table 1. In every village, 6 paddy fields were chosen at random for evaluation.

In each field, 25 plants were chosen randomly, and disease severity was assessed using the SES scale developed by IRRI in 1996 (as shown in Table 1).

Symptoms on the sheath, stem, and leaf sections, as well as the presence of signs on the disease isolate, were documented at each observation point during the survey. Additionally, data regarding plant characteristics and geographical coordinates (longitude/latitude) were gathered.

Disease incidence

At each particular location, a 1m² disc was randomly placed in the paddy fields to select four observation sites for disease assessment. Ten plants were then randomly chosen at each location where the disc had landed, and the total incidence of brown spot-infected leaves was recorded. To calculate disease incidence, the formula proposed by Meya *et al*. in 2015 [12].

$$\text{Disease incidence } \frac{n}{N} \text{ X } 100\%$$

Here, 'n' represents the number of leaves with brown spots, and 'N' signifies the total number of leaves observed. The disease incidence for each location was determined as the average across ten sites, and the average disease incidence for each site was calculated as the average across ten plants.

Disease severity

The disease severity was calculated using below mentioned formula by Mckinney (1923) [13].

$$\text{PDI} = \frac{0(\text{X0}) + 1(\text{X1}) + 2(\text{X2}) + \ldots\ldots + \text{n}(\text{Xn}) \times 100}{\text{X0} + \text{X1} + \text{X2} + . + \text{Xn} \times \text{maximum grade}}$$

Where,

0, 1, 2, n = score

X0, X1, X2, Xn = number of entries or

The percentage of disease index (PDI) was determined using Wheeler's method (1969) [22].

$$\text{PDI} = \frac{\text{Sum of all disease ratings}}{\text{Total no. of leaf Observed} \times \text{maximum scale grade}} \times 100$$

Disease scoring

SES scale for disease scoring

Score	Description
0	No disease observed
1	Less than 1%
2	1-3%
3	4-5%
4	6-10%
5	11-15%
6	16-25%
7	26-50%
8	51-75%
9	76-100%

Results symptomatology

Leaf symptom includes typical brown spots with grey or whitish centre, oval to cylindrical in shape mimicking the sesame seeds. Multiple spots merge together, the leaves eventually wither and take on a scorched appearance, ultimately leading to their demise. Infected glumes, shown the production of shrunken and discoloured grains.

Morphologically pathogen shows bipolar germination and have conidiophore and single terminal spore on it. The fungus appeared initially as white mycelium, later turn dark brown with septation and conidiophore arises singly or group, multi-septate, brown in colour which bears conidia on the tips. Conidia were curved or slightly curved; initially hyaline and later on maturity turns brown in colour, fusiform with hilum at base.

Bipolaris oryzae is responsible for inducing grain discoloration (Bhat *et al*., 2009) [2]. The pathogen causes blighting of coleoptiles, formation of oval, dark brown to purplish-brown spots on the leaves and reduces the photosynthesizing ability of rice plants, ultimately scorching and killing of the leaves. Early senescence of the infected leaves (Klomp, 1977) [8].

Fig 1: Symptoms a) typical brown spot on rice leaf b) Discoloured brownish grains of infected glumes

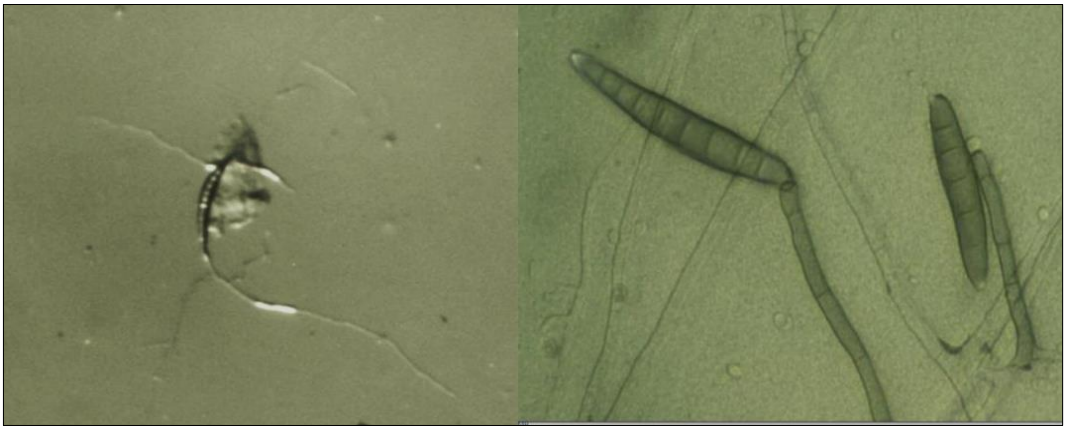

Fig 2: Morphology a) bipolar germination of spores b) fusiform conidia with hilum at base arise from single multi septate conidiophore

Systematically, survey was conducted in eight rice growing districts of Chhattisgarh *viz.*, Rajnandgaon, Raipur, Balodabazar, Dhamtari, Kanker, Jagdalpur and Surguja, Surajpur from September to October 2022. During the survey disease incidence (DI) and disease severity (DS) observed in percentage and disease scoring given per disease leaf samples. Leaf samples were collected to confirm the etiology of the pathogen. Very high disease incidence noticed at paddy fields of Disease Incidence of Brown spot in surveyed locations was ranged from 55 to 70%. Very high disease incidence noticed at paddy fields of Runiyadih (79.3%)& very low were at m Bagtarai (45.61%), the maximum disease incidence range (76-80%) at Runiyadih Kasdol & Chaugai. then (71-75%) were at Balrampur, Nawagaon, Bhafauli, Datrenga, Dhodha, Aturgaon, Tulsi-2, Markel, Betway. Range from (66-70%) were at Bodenar, Siltara, Chhuriya/Gaindatola, Deori, Nimora-1, Kakani, Manjhiguda, Ambagarh Chowki, Simga, Bedmi, Amaguda, Parsadih, Kuthrel. (61-65%) Vyaskongera, Patewa, Mokha, Nakati, Dudhawa. (56-60%) range found at Markatola, Birgao, Ravindranagar, Achoti, Bardhodhi, Nagri. (51-55%), Manpur, Dongargarh /bhanpuri. The lowest disease incidence rate (45-50%) were found at Bhatapara, Bagtarai. The results indicate that, the highest PDI recorded in village Parsada (Raigarh) (87.47%), &Lowest one Achoti Dhamtari (25.14%) &highest mean brown spot PDI recorded in district then Raigarh (72.66±4.67), Sarguja (63.97±3.69), Raipur (62.77±3.47), Jagdalpur (59.30±3.42), Rajnandgaon (58.556±4.68), Kanker (55.832±4.50) Balodabazar (39.22±1.73), and Lowests PDI were recorded in Dhamtari 29.97±1.76).

Table 1: Disease incidence and PDI of brown spot infection on different rice growing region of Chhattisgarh.

Isolates	Districts	Block/village	Agroclimatic zone	Rice variety	Crop stage	Lattitude	Longitude	Disease incidence	PDI
BS-CG-01	Rajnandgaon	Dongargarh/bhanpuri	Chhattisgarh plain	Swarna	Tillering	21.163	80.8808	54.93	67.54
BS-CG-02	Rajnandgaon	Chhuriya/Gainda tola		Mahamaya	Booting	21.0281	81.1116	70.32	47.18
BS-CG-03	Rajnandgaon	Ambagarh Chowki		MTU-1001	Tillering	20.7821	80.7477	68.49	52.53
BS-CG-04	Rajnandgaon	Patewa		Swarna	Tillering	21.2823	81.0975	63.77	71.64
BS-CG-05	Rajnandgaon	Maanpur		Indrani Dhan	Booting	21.8372	81.5879	55.12	53.89
Mean ± S.E								62.526±3.243	58.55±4.68
BS-CG-06	Raipur	Birgaon	Chhattisgarh plain	Mahamaya	flowering	21.3011	81.6286	59.38	54.54
BS-CG-07	Raipur	Datrenga		Bamleshwari	Tillering	21.7341	81.9479	72.85	65.78
BS-CG-08	Raipur	Nakati		Swarna	Tillering	21.1967	81.6117	63.2	72.38
BS-CG-09	Raipur	Nimora -1		HMT	Booting	21.1339	81.7331	69.9	65

BS-CG-10	Raipur	Siltara		Kranti	Tillering	20.831	82.4582	70.54	73.95
BS-CG-11	Raipur	Tulsi -2		Swarna	Tillering	21.5258	81.9589	72.16	58.92
BS-CG-12	Raipur	Kuthrel		Bamleshwari	flowering	21.0557	81.2475	66.38	48.87
								67.34±1.71	62.77±3.47
BS-CG-13	Baloda bazar	Simga	Chhattisgarh plain	MTU-1001	Booting	21.6299	81.6999	67.82	34.87
BS-CG-14	Baloda bazar	Deori		Bamleshwari	Booting	21.759	81.9787	70.08	42.65
BS-CG-15	Baloda bazar	Parsadih		Mahamaya	Booting	21.7908	82.8207	66.41	43.78
BS-CG-16	Baloda bazar	Kasdol		Swarna	Tillering	21.6275	82.4238	77.34	38.46
BS-CG-17	Baloda bazar	Bhatapara		IR-64	Tillering	21.738371	81.948	49.32	36.35
								66.19±4.61	39.22±1.73
BS-CG-18	Dhamtari	Bagtarai	Bastar plateau	Mahamaya	Tillering	20.8342	81.5417	45.61	29.54
BS-CG-19	Dhamtari	Nagri		MTU-1001	Booting	20.3484	81.9593	56.67	32.64
BS-CG-20	Dhamtari	Mokha		Dubraj	Tillering	20.8596	81.5395	63.32	32.56
BS-CG-21	Dhamtari	Achoti		Dubraj	Tillering	21.3174	81.4698	58.21	25.14
								55.95±3.7	29.97±1.76
BS-CG-22	Kanker	Aturgaon	Bastar plateau	MTU-1010	Booting	20.2024	81.5061	72.3	63
BS-CG-23	Kanker	Dudhawa		Mahamaya	Booting	20.2966	81.7404	62.49	50.32
BS-CG-24	Kanker	Markatola		Swarna	Tillering	20.3016	81.3283	60.43	48.97
BS-CG-25	Kanker	Vyaskongera		IR-64	PI	18.7916	80.8166	65..65	69.92
BS-CG-26	Kanker	Nawagaon		MTU-1010	Booting	21.0117	81.8838	73.58	46.95
								67.2±2.99	55.832±4.50
BS-CG-27	Jagdalpur	Manjhiguda		Swarna	Booting	18.7916	80.8166	69.47	50.53
BS-CG-28	Jagdalpur	Markel		Swarna	Booting	19.13695	81.9811	72.12	66.45
BS-CG-29	Jagdalpur	Bodenar		MTU-1010	Tillering	18.8815	81.7202	70.59	62.46
BS-CG-30	Jagdalpur	Amaguda		Sawarna	Tillering	19.0757	82.1607	67.33	57.76
								69.877±1.0	59.30±3.42
BS-CG-31	Sarguja	Kakani	Northern Hills	Mahamaya	booting	23.1663	81.8282	78.45	74.48
BS-CG-32	Sarguja	Batwahi		MTU-1010	PI	23.0805	83.3201	71.89	68.35
BS-CG-33	Sarguja	Chaugai		Jeeraphool	flowering	23.7586	81.7267	69.71	57.85
BS-CG-34	Sarguja	Bardhodhi		Tarunbhog	booting	23.1009	83.2138	57.68	65.39
BS-CG-35	Sarguja	Bhafauli		Swarna	booting	23.2178	83.2747	73.21	53.78
								65.18±3.20	63.97±3.69
BS-CG-36	Raigarh	Kacchar	Northern Hills	Jeeraphool	flowering	23.6555	82.7535	67.65	73.75
BS-CG-37	Raigarh	Bnhar		Tarunbhog	booting	23.4367	82.842	72.8	64.89
BS-CG-38	Raigarh	Parsada		Badshah Bhog	booting	23.3265	82.8536	74.32	87.47
BS-CG-39	Raigarh	Tilaga		Maheswari	flowering	23.4275	82.8673	58.21	76.46
BS-CG-40	Raigarh	Kodtarai		Kranti	flowering	23.5368	82.8225	79.3	60.76
								70.45±3.58	72.66±4.67

Mean ± Standard Error, PDI=percent disease index

Discussion

Brown spot disease, caused by *Bipolaris oryzae*, remains an enduring global concern with detrimental effects on rice cultivation. It results in substantial losses in terms of both acreage and yield. Previous research has suggested that the disease can lead to a reduction in rice yield ranging from 26% to 52% (Chakrabarti, 2001) [3]. In our study, a comprehensive survey of brown spot disease was conducted across eight districts in Chhattisgarh. The highest disease incidence was observed in Runiyadih village, reaching 79.3%, while the lowest incidence was found in Bagtarai at 45.61%. Notably, the maximum Plant Disease Index (PDI) was recorded in Parsada village, Raigarh, at 87.47%, while the lowest PDI was observed in Achoti, Dhamtari, at 25.14%. Severe infections had a significant impact on the number of grains and tillers, as well as the weight and quality of individual grains, resulting in losses ranging from 30% to 43%. In contrast, moderately infected crops experienced a lower loss of 12%, while lower disease grades showed non-significant losses (Ou, 1985). The overall decline in yield fluctuated between 18.75% and 22.50% (Kamal and Mia, 2009) [7]. Various studies, including those by Singh *et al*. (1979) [19], Mia *et al*. (2001) [14], and Chakrabarti (2001) [3], have reported yield reductions ranging from 4.6% to 40%, 3.7% to 29.10%, 9.28% to 24.50%, and 26% to 52%, respectively, in diverse geographical regions.

It's noteworthy that the impact of brown spot disease appears to be more devastating in fields where farmers have limited access to nitrogen-based fertilizers and adequate water supply (Zadoks, 1974) [25]. Rain, overcast weather, and high relative humidity provide favourable conditions for disease development (Magar, 2015) [11]. Climate change and initial conducive conditions significantly contribute to the spread of the disease. Variations in disease distribution among different locations can be attributed to changes in pathogenic variability, ecological factors, inoculum quantity, aggressiveness, the failure of vertical resistance, and traditional cultural practices. Factors such as the number of inoculums, infection during the growth stage, climatic conditions, and resistance all play a role in disease incidence and intensity (Groth and Bond, 2007) [6].

Conclusion

Brown spot disease is a significant threat to rice cultivation in the Chhattisgarh, where rice is major crop. The disease is most severe in Raigarh district, and certain rice varieties like

swarna, kranti, Mahamaya are particularly susceptible. To mitigate the impact of brown spot disease and increase rice yield, it is crucial for farmers to adopt rice cultivars. further research is needed to understand the various factor affecting disease incidence and intensity different agroclimatic zones this research will assist farmers in minimizing losses due to brown spot disease and improving rice production levels.

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