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Assessment of Apparent Infection Rate and Disease Intensity of *Bipolaris oryzae* in Different Cultivars of Rice in Central India

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ABSTRACT

Background and Objective: Brown spot of rice is an important disease causing considerable yield losses in Central India. Screening of improved and local cultivars of rice was conducted in Rewa, Madhya Pradesh, in India for brown spot resistance and improvement in yield characters under irrigated conditions. **Materials and Methods:** Twelve rice cultivars were screened for the mechanism of resistance against brown spots. Among these six were local (Indrajal, Gurmatia, Dehula, Aajaan, Lochai and Newari) and six commercial including Pusa Basmati-1, Vandana, Govinda, Jaya, Kalinga and IR-64. Standard farming practices were applied for optimum crop growth and observation of different mechanisms of the host-pathogen and disease developments in different periodic phases. Brown spot symptoms starting from the date of first appearance approaching maturity were recorded during both years. The assessments were done by estimating the apparent infection rate using standard evaluation systems (0-9 scale) and disease index (DI) of the cultivars was also reported. **Results:** The apparent infection rate increases at weekly intervals till the successful invasion of the pathogen. The cultivars show a remarkable variation in the rate of infection, however, the disease intensity was higher in local races compared to improved varieties. High susceptibility was reported in local races 'Gurmatia' and 'Dehula' and the hybrid 'Pusa Basmati-1' was found moderately susceptible, whereas other varieties also show disease incidence though the degree of susceptibility was comparatively low. Improved mega variety IR-64 expressed minimum DI and maximum yield compared to other tested cultivars. **Conclusion:** Low rainfall and temperature were more conducive for brown spot occurrences in the region. Therefore, the selection of landraces and quality seeds is a decisive factor in minimizing brown spot infection and restricting disease epidemics in the region.

KEYWORDS

Rice brown spot, apparent infection rate, disease index, local cultivars, commercial varieties, *Bipolaris oryzae*

INTRODUCTION

Brown spot of rice caused by *Bipolaris oryzae* (Breda de Haan) Shoemaker is a chronic disease affecting millions of hectares of rice with yield losses varying from 4 to 52%[1]. The epidemics affect crop performance, population density and yield in rice varieties[2]. The disease is widespread affecting lowland cultivars under natural conditions[3], as well as upland, and rain-fed rice systems[4,5]. The environmental

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conditions show a strong influence on disease severity. Even a slight microclimatic alteration and conventional planting favor brown spot incidence[6]. The disease infects both seedlings and mature plants[7]. The infection is more common under water shortage and nitrogen-deficient soil[8]. The symptoms generally occur at vegetative stages during above-normal rainfall in the early season[9] detected at the end of June, reaching its peak in July[10].

The primary symptom of the disease appears on coleoptile and roots after 7-14 days, the first appearing leaf of the seedlings shows symptoms 21 to 28 days after sowing and infected seedlings show brown coloration and die at a later stage. The pathogen causes damage to coleoptiles, reducing the photosynthesis capacity of the crops. The infection is generally noticed from the seedling to the milk stage. The leaf symptom is generally marked by oval to cylindrical shaped brown spots up to 1 cm or even more in susceptible varieties with the grey or whitish center. As the number of spots increases they merge resulting in the death of leaves. The seedlings usually give a slightly burnt appearance and finally die up[11].

Under a high level of infection, the pathogen infects the embryo, endosperm, palea, lemma, rachilla and sterile lemma and ultimately the whole kernel[12]. Thus, the disease causes remarkable physiological and biochemical changes reducing the economic value of the crop[13]. Measuring the severity of disease helps in quantification, analysis and modeling of crop loss at the field level[14]. The knowledge of the atmospheric concentration of airborne spores of brown spots together with a correct examination of the rice crops provides useful information[15], leading to decisions and designing an integrated disease management model[16]. Therefore, this research aimed to study the apparent infection rate of brown spot pathogens and disease severity on traditional and improved varieties of rice cultivars under lowland irrigated ecosystems for designing strategic varietal selection and crop protection in central India.

MATERIALS AND METHODS

Experimental design: Experiments were conducted at Rewa, Madhya Pradesh, in India (24.53°N Latitude and 81.3°E Longitude) during 2019 and 2020. Twelve cultivars including six local (Indrajal, Gurmatia, Dehula, Aajaan, Lochai and Newari) and six commercial (Vandana, Pusa Basmati-1, Govinda, Jaya, Kalinga and IR-64) were tested under natural epiphytotics. The seeds of local and commercial cultivars were collected from the farmers, seed centers and rice research centers College of Agriculture Rewa. The features of the tested variety, ecology and duration are given in Table 1.

The experiments were laid out on a 4-meter plot in a randomized block design (RBD) with 3 replicates. Samplings were transplanted with a lineup of 10 cm between rows and 5 cm between seedlings. Nitrogen fertilization was applied at regular intervals. Standard farming practices were applied for optimum plant growth and monitoring of different mechanisms of the host pathogen. The date of the first appearance of the brown spot symptoms thereafter in different periodic phases approaching maturity was reported.

Table 1: Tested rice varieties and their description

Rice varieties	Description
Indrajal	Landrace, rainfed, low land and 92 days duration
Dehula	Landrace, rainfed and 85 days duration
Gurmatia	Landrace, rainfed and 90 days duration
Ajaan	Landrace, rainfed/ Irrigated and 95 days duration
Lochai	Indigenous, early variety, drought tolerant and 120 days duration
Newari	Indigenous, medium late variety, drought tolerant and 110 days duration
IR-64	Improved, irrigated, semi-dwarf, early variety and 117 days duration
Vandana	Rain fed upland and medium land, semi-dwarf, drought tolerant and 90 days duration
Pusa Basmati-1	Irrigated, semi-dwarf, medium early maturity and 140 days duration
Govinda	Irrigated, aromatic, medium early maturity and 110 days duration
Jaya	Irrigated, dwarf, medium early maturity and 130 days duration
Kalinga	Irrigated, tall, upland, very early maturity and 80 days duration

Table 2: Standard evaluation system for brown spot of rice

Scale	Severity	Category
1	No incidence	Highly resistant
2	Less than 1%	Resistant
3	1-3%	Moderate resistant
4	4-5%	Moderate resistant
5	11-15%	Moderate susceptible
6	16-25%	Moderate susceptible
7	26-50%	Susceptible
8	51-75%	Highly susceptible
9	76-100%	Highly susceptible

Computation of infection rate (r): The apparent infection rate (r/unit/day) was calculated at a weekly interval after the appearance of the first symptom of the disease:

$$r = \frac{\log x_1 - x_0}{t_1 - t_2} 2.303$$

where, x_0 and x_1 denote the disease index on time t_1 and t_2[17].

Disease index (%): The brown spot disease index was calculated using[18]:

$$DI = \frac{\text{Sum of numerical ratings}}{\text{Total number of observations} \times \text{Maximum disease scale}} \times 100$$

Disease rating scale and brown spot resistant category: The development of the brown spot pathogen and its impact on the host, were assessed. Disease incidence and severity were reported from the infected plant parts starting from the first appearance and at one-week intervals during the crop season. The size, shape and color of the lesion caused by fungal invasion were studied during different crop growth stages. Brown spot severity was recorded using a standard evaluation system (Table 2)[19].

RESULTS

The data on apparent infection rate (r/unit/day) in periodic intervals against brown spots are presented in Table 3. The observations on disease progress r/unit/day on different days after sowing were recorded and varietal responses against diseases were carried out. It was observed that the meteorological factors mainly the rainfall played a significant role in the appearance of brown spot diseases. The incidences of disease were higher in local varieties compared to improved varieties.

The tested cultivars show a different degree of disease index (DI). The disease intensity ranges in the band of 33.32 to 61.95 and was reported to be higher in local cultivars than in commercial cultivars. The landrace Gurmatia reported the highest whereas the improved cultivar IR-64 displayed the lowest value of disease index. All the tested varieties show significant variations for the brown spot evaluation scale. Among the tested cultivars, five cultivars Gurmatia, Dehula, Indrajaal, Ajaan and Newari are rated highly susceptible, two cultivars Lochai and Pusa Basmati-1 categorized as moderately susceptible and five cultivars were reported to be moderately resistant against brown spot infection.

The disease started appearing 50 DAS and first symptoms was noted in local highly susceptible variety Gurmatia (0.21), followed by Dehula (0.15/unit/day) and gradually increased with the time period. After the successful invasion of the disease (64-70 DAS) the statistical mean value calculated was highest in Gurmatia, followed by Dehula and Indrajal 0.33, 0.31 and 0.28 r/unit/day, respectively. Among the commercial varieties, the apparent infection rate was highest in Pusa Basmati-1 and least in variety IR-64 as shown in Fig. 1.

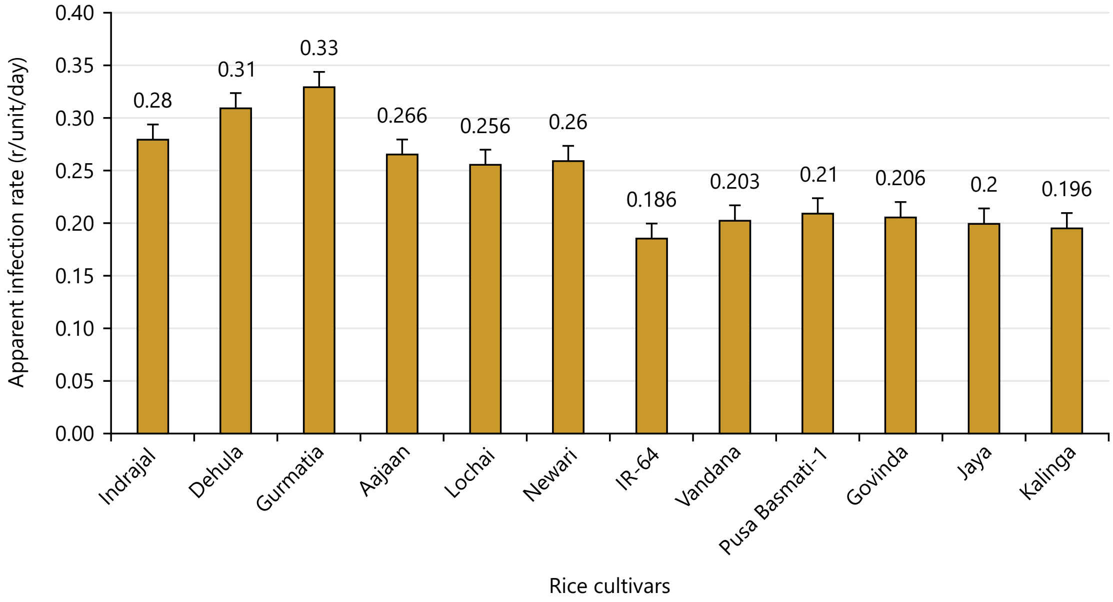

Fig. 1: Mean Apparent Infection rate of rice cultivars

Table 3: Apparent Infection Rate (r/unit/day) and disease index of rice varieties in periodic intervals against brown spot

	Apparent infection rate (r/unit/day)					
Variety	50-56 DAS	57-63 DAS	64-70 DAS	Mean	Disease index (%)	Resistant category
Indrajal	0.07	0.22	0.55	0.28	59.75	Highly susceptible
Dehula	0.15	0.27	0.52	0.31	60.65	Highly susceptible
Gurmatia	0.21	0.22	0.57	0.33	61.95	Highly susceptible
Ajaan	0.07	0.20	0.53	0.266	56.44	Highly susceptible
Lochai	0.05	0.20	0.52	0.256	46.10	Moderate susceptible
Newari	0.06	0.20	0.52	0.26	55.86	Highly susceptible
IR-64	0.01	0.16	0.39	0.186	33.32	Moderate resistant
Vandana	0.02	0.18	0.41	0.203	43.57	Moderate resistant
Pusa Basmati-1	0.02	0.18	0.43	0.21	45.84	Moderate susceptible
Govinda	0.02	0.18	0.42	0.206	43.90	Moderate resistant
Jaya	0.02	0.17	0.41	0.20	38.75	Moderate resistant
Kalinga	0.02	0.16	0.41	0.196	37.86	Moderate resistant
SEM ±	0.018	0.009	0.019	0.014	2.84	
CD (0.05)	0.035	0.015	0.016		0.550	
P≤0.05	NS	NS	NS		NS	

NS: Not significant and CD: Critical distance

DISCUSSION

The brown spot apparent infection rate and disease intensity show contrasting differences in all the tested cultivars. The disease expands swiftly during the 70 to 80 days' crop stage, with high soil temperature and shortage in the water supply. The local landraces were reported to be highly susceptible to brown spot incidence. Brown spots caused by *Bipolaris oryzae* are a seed-borne disease. The incidence of the brown spots is varietal dependent and weather factors play a significant role in the rate of infection and disease severity. The dominance of local landraces is most conducive for spreading of disease under irrigated as well as rain-fed conditions which supports the findings of researchers[20,21]. Further, it was noted that resistant varieties are more competitive in combating disease infection[22].

The improved cultivar IR-64 shows moderate resistance, whereas Pusa Basmati-6 was found moderately susceptible to the disease, which was reported in other studies[23]. The DNA fingerprinting analysis of the pathogen shows a negative correlation between genetic variation and pathogenicity[24]. Other studies reported that in some high-yielding brown spot susceptible varieties single recessive gene possess brown spot resistance which can be genetically manipulated using marker-assisted selection to develop brown spot-resistant rice variety[25].

All the tested cultivars expressed the disease progression with the changes in the growth stage. In practice, the hybrid varieties are generally not prone to diseases with better yield but in this case, hybrid cultivar Basmati was reported to be susceptible to brown spots. In contrast, the local cultivar Lochai performed better as far the partial resistance and yield characters are concerned. Brown leaf spot disease mostly attacks at late vegetative stages[26]. The sunshine hours, wind speed, higher temperature and morning relative humidity favors brown spot severity. The disease expansion decreases with the falling down of maximum and minimum temperature during the progression of crop maturity. The rainfall under different planting methods (conventional, system of rice intensification (SRI) and furrow) does not affect disease severity[27-29]. Poor crop management, direct seeding and water scarcity[30] are most conducive to the spreading of the disease. The availability of nutrients and dry soil also favor brown spot development[31]. A low dose of nitrogen:potassium (0:30) and application of a nutrient solution of iron at 2.5 to 10 ppm concentration promotes brown spot disease[32]. Some studies raised concern about futuristic weather scenarios as phenomena like climate change and global warming result rise in temperature, favoring the growth of brown spot pathogen[32,33].

Brown spot pathogens show an adverse impact on the qualitative and quantitative characteristics of rice crops. The need for countermeasures to reduce brown spot incidence is significant under global warming as it provides all favorable conditions for the growth of pathogens. Host resistance is arbitrated by a complex molecular and biochemical incidence network that determines a range between susceptibility and resistance. The presence of new and more virulent pathogen races is a major constraint to destabilizing resistance in the host. Selecting resistance phenotypes in rice is an important step in defense against the disease. There is a need to evaluate rice cultivars' reactions to brown spot disease in the various agro-ecological zones. Understanding host resistance mechanisms and host-pathogen biochemical interactions for the identification of resistance genotypes, coupled with the selection of brown spot-resistant varieties, is the most economical, simple and effective means to minimize disease incidence in a wide geographical area.

CONCLUSION

The brown spot is a significant disease of rice in central India, causing considerable yield losses and reducing the economic value of the crop. As the disease is seed-borne, therefore the selection of quality seeds becomes important in the disease management program. The assessment of brown spot incidence in rice cultivars helps in understanding the varietal disease progression arising due to adverse climatic conditions and poor agricultural inputs. Further, it helps the growers with resistant and healthy seed selection to minimize disease incidence and enhance crop yield.

SIGNIFICANCE STATEMENT

This paper assesses the conducive conditions for brown spot infection in local as well as commercial varieties of rice in central India. The research benefits from understanding the mechanism of pathogen progression during various phases of crop growth. This research will serve as the selection of rice cultivars by growers to combat brown spot pathogen invasion, the adoption of integrated agricultural approaches, improving yield character and enhancing crop productivity.

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REFERENCES

1. Barnwal, M.K., A. Kotasthane, N. Magculia, P.K. Mukherjee and S. Savary *et al*., 2013. A review on crop losses, epidemiology and disease management of rice brown spot to identify research priorities and knowledge gaps. Eur. J. Plant Pathol., 136: 443-457.

2. Schwanck, A.A., P.R. Meneses, C.R.J. Farias, G.R.D. Funck, A.H.N. Maia and E.M. Del Ponte, 2015. *Bipolaris oryzae* seed borne inoculum and brown spot epidemics in the subtropical lowland rice-growing region of Brazil. Eur. J. Plant Pathol., 142: 875-885.
3. Nneke, N.E., 2012. Screening lowland rice varieties for resistance to brown spot disease in Enyong creek rice field in Akwa Ibom State of Nigeria. Global J. Pure Appl. Sci., 18: 5-10.
4. Mwendo, M.M., M. Ochwo-Ssemakula, J. Lamo, P. Gibson and R. Edema, 2017. Reaction of upland rice genotypes to the brown spot disease pathogen *Bipolaris oryzae*. Afr. J. Rural Dev., 2: 127-133.
5. Mau, Y.S., A.S.S. Ndiwa and S.S. Oematan, 2020. Brown spot disease severity, yield and yield loss relationships in pigmented upland rice cultivars from East Nusa Tenggara, Indonesia. Biodiversitas J. Biol. Diversity, 21: 1625-1634.
6. Dhaliwal, L.K., S.K. Sandhu and S. Kaur, 2019. Effect of microclimatic modification and weather on brown leaf spot of rice. Agric. Res. J., 56: 267-273.
7. Pandey, S., 2015. *In vitro* study of fungicides in controlling *Helminthosporium oryzae* causal organism of leaf brown spot of rice. Int. Res. J. Biol. Sci., 4: 48-51.
8. Abrol, S., S.K. Singh, V.B. Singh, U. Basu and R. Singh *et al*., 2022. Effect of agro-met conditions on the progression of brown leaf spot disease in basmati-370 rice. Asian J. Microbiol. Biotechnol. Environ. Sci., 24: 335-340.
9. Schwanck, A.A. and E.M.D. Ponte, 2014. Accuracy and reliability of severity estimates using linear or logarithmic disease diagram sets in true colour or black and white: A study case for rice brown spot. J. Phytopathol., 162: 670-682.
10. Picco, A.M. and M. Rodolfi, 2002. *Pyricularia grisea* and *Bipolaris oryzae*: A preliminary study on the occurrence of airborne spores in a rice field. Aerobiologia, 18: 163-167.
11. Surendhar, M., Y. Anbuselvam and J.J.S. Ivin, 2022. Status of rice brown spot (*Helminthosporium oryza*) management in India: A review. Agric. Rev., 43: 217-222.
12. van Ba, V. and S. Sangchote, 2006. Seed borne and transmission of *Bipolaris oryzae*, the causal pathogen of brown spot of rice. Agric. Nat. Resour., 40: 353-360.
13. Pandey, S., 2018. Physiological and biochemical changes associated with the development of brown spot diseases in rice leaves. Int. J. Adv. Agric. Sci. Technol., 5: 69-78.
14. Savary, S., P.S. Teng, L. Willocquet and F.W. Nutter Jr., 2006. Quantification and modeling of crop losses: A review of purposes. Ann. Rev. Phytopathol., 44: 89-112.
15. Zhan-Yu, L., H. Jing-Feng, S. Jing-Jing, T. Rong-Xiang, Z. Wan and Z. Li-Li, 2007. Characterizing and estimating rice brown spot disease severity using stepwise regression, principal component regression and partial least-square regression. J. Zhejiang Univ. Sci. B, 8: 738-744.
16. Pandey, S., 2016. Screening of rice cultivars for quantification of apparent infection rate of leaf blast. Middle East J. Agric. Res., 5: 430-434.
17. Van der Plank, J.E., 1963. Plant Disease: Epidemics and Control. Academic Press, Cambridge, Massachusetts, ISBN: 978-0-12-711450-7, Pages: 349.
18. Wheeler, B.E.J., 1969. An Introduction to Plant Diseases. J. Wiley, Hoboken, New Jersey, ISBN: 9780608146713, Pages: 374.
19. IRRI., 2014. Standard Evaluation System for Rice. 5th Edn., International Rice Research Institute (IRRI), Los Banos, Philippines, ISBN-13: 9789712203046, Pages: 57.
20. Pandey, S., A.K. Awasthi and S.K. Tripathi, 2008. Evaluation of plant-derived commercial products for controlling brown spot of rice. Oryza: Int. J. Rice, 45: 255-257.
21. Aryal, L., G. Bhattarai, A. Subedi, M. Subedi, B. Subedi and G.K. Sah, 2016. Response of rice varieties to brown spot disease of rice at Paklihawa, Rupandehi. Global J. Biol. Agric. Health Sci., 5: 50-54.
22. Magar, P.B., 2015. Screening of rice varieties against brown leaf spot disease at Jyotinagar, Chitwan, Nepal. Int. J. Appl. Sci. Biotechnol., 3: 56-60.
23. Hosagoudar, G.N., S. Shaiah, B.S. Kovi and B.S.U. Babu, 2019. Evaluation of host plant resistance for blast and brown spot diseases of Paddy in Hill Zone of Karnataka. Int. J. Curr. Microbiol. Appl. Sci., 8: 1294-1304.

24. Kamal, M.M. and M.A.T. Mia, 2010. Diversity and pathogenicity of the rice brown spot pathogen, *Bipolaris oryzae* (Breda de Haan) Shoem. in Bangladesh assessed by genetic fingerprint analysis. Bangladesh J. Bot., 38: 119-125.
25. Matsumoto, K., Y. Ota, T. Yamakawa, T. Ohno and S. Seta *et al*., 2021. Breeding and characterization of the world’s first practical rice variety with resistance to brown spot (*Bipolaris oryzae*) bred using marker-assisted selection. Breed. Sci., 71: 474-483.
26. Viswanath, H.S., R. Singh, G. Singh, P. Mishra, U.P. Shahi, D.V. Singh and R.S. Sengar, 2021. Impact of agro-met conditions and crop growth stages on the progression of brown spot disease in basmati rice. Int. J. Environ. Clim. Change, 11: 59-67.
27. Abbas, S. and Z.A. Mayo, 2021. Impact of temperature and rainfall on rice production in Punjab, Pakistan. Environ. Dev. Sustainability, 23: 1706-1728.
28. Bommayasamy, N., L.B. Singh and F.H. Rahman, 2020. Effect of planting methods and seedling age on growth, yield and nutrient uptake in rice under high rainfall areas of bay islands. Int. J. Plant Soil Sci., 32: 96-102.
29. Choudhury, F.A., N. Jabeen, M.S. Haider and R. Hussain, 2019. Comparative analysis of leaf spot disease in rice belt of Punjab, Pakistan. Advancements Life Sci., 6: 76-80.
30. Dariush, S., M. Darvishnia, A.A. Ebadi, F. Padasht-Dehkaei and E. Bazgir, 2020. Screening brown spot resistance in rice genotypes at the seedling stage under water stress and irrigated conditions. Arch. Phytopathol. Plant Prot., 53: 247-265.
31. Percich, J.A., R.F. Nyvall, D.K. Malvick and C.L. Kohls, 1997. Interaction of temperature and moisture on infection of wild rice by *Bipolaris oryzae* in the growth chamber. Plant Dis., 81: 1193-1195.
32. Mizobuchi, R., S. Fukuoka, S. Tsushima, M. Yano and H. Sato, 2016. QTLs for resistance to major rice diseases exacerbated by global warming: brown spot, bacterial seedling rot, and bacterial grain rot. Rice, Vol. 9. 10.1186/s12284-016-0095-4.
33. Das, S.K., 2017. Rice cultivation under changing climate with mitigation practices: A mini review. Univ. J. Agric. Res., 5: 333-337.