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Distribution pattern and prevalence of brown spot of rice (*Bipolaris oryzae*) in Jammu region

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Abstract
Bipolaris oryzae (telemorph=*Cochliobolus miyabeanus*) causes brown spot in rice, which is known to cause significant quantitative and qualitative losses in rice crop production and in the country India, the disease has a long history. Under low input management, water stress, and direct planting conditions, the disease had been proved most hazardous. In this study, an extensive survey was conducted in Jammu division of Union Territory of Jammu and Kashmir, India for measurement of disease incidence on many of healthy and diseased leaves by the fungus and percentage of leaf infection was determined as the disease intensity during *kharif* 2018 and 2019. The mean disease incidence and intensity in Jammu division varied between 32.65 to 74.51 and 24.35 to 52.55 per cent, respectively. Total mean incidence and intensity of 58.70 and 36.93 per cent respectively, was recorded during *kharif* 2018. However, during *kharif*, 2019, comparable trend was observed in disease incidence and intensity though the average was slightly higher compared to previous year.

Keywords: *Bipolaris oryzae*, *brown spot*, disease incidence, disease intensity, *water stress*

Introduction
Rice (*Oryza sativa* L.) is considered world's most paramount and widely used up staple food for more than half of the world's population. The estimated population of approximately 3.5 billion depends on rice globally which contribute 20 per cent of their daily calories requirement (Maclean *et al*., 2013) [5]. Jammu and Kashmir is predominantly a mono cropped in rice cultivation with 40 per cent of area in Jammu and 60 per cent of area in Kashmir division. A number of fungal diseases attack the crop in sever to moderate form that causes substantial yield losses. Brown spot disease of rice incited by *Bipolaris oryzae* (*Cochliobolus miyabeanus*) is one most serious and historically significant which resulted in out broke in the Bengal Province during 1943, ended as the Great Bengal Famine (Death starvation) and an estimated demise of 2.1 to 3 million people. The disease accounts 5 per cent yield loss worldwide annually and adversely affected fields show yield loss as high as 45 per cent, thus known to reduce yield qualitative as well as quantitative. The brown spot disease is known to infect all growth stages of crop. During seedling stage, symptoms of brown spotting start to appear on the young as well as on old leaves. Reduction in nutrient absorption and photosynthesis by virtue of reduced leaf size result in less tillering, whereas, infection at later stage may result in reduced grain filling, discolored, spotted and shriveled grains as well. It causes severe damage under cool conditions of summer and especially under nutrient deficient soils and that is the reason it is also known as poor farmers disease.
Experimental results had shown that environmental factors exhibited a direct influence on progression of brown spot disease and persistence of pathogen in soil and seed. The humidity and relative temperature at which seeds are kept for storage also effect the viability of the pathogen (Mia and Safeeulla, 1998; Dallagnol *et al*., 2011) [9]. High leaf wetness, relative humidity of 92.5 per cent and temperatures ranging from 24 to 30 °C are highly favorable conditions for disease development. During the years of heavy rainfall, the disease is known to occur with very less intensity (Singh *et al*., 2005) [15], whereas seasons with limited rainfall, drought like conditions and heavy dew are conducive for severe epidemics (Sherf *et al*., 1947) [13]. Prolonged duration of leaf wetness in rice canopy generally leads to increased lesion density (Percich *et al*., 1997) [11]. Successful inoculation by conidia requires a relative humidity of more than 89 per cent at 25 °C and infection is favored by free water on leaf surface. A relative humidity >89% at 25 °C leads to successful inoculation by conidia and infection can be vigorous upon free water on leaf surface.

Brown spot of rice is the major constraint in rice production in Jammu division and the disease severity often necessitates conducting survey and surveillance of the disease to get widespread information on disease distribution, level of incidence and intensity.

Material and Methods

Survey area

To determine the status of the brown spot disease of rice in Jammu region a comprehensive and systematic survey was carried out to record the incidence and intensity of the disease. Four major paddy growing districts *viz*., Jammu, Samba, Kathua and Udhampur were selected for survey during the two consecutive years of *Kharif* 2018 and 2019. From each district, three blocks were selected and from each block three villages and from each village five fields were selected for recording the disease parameters.

Disease incidence assessment

At each selected location, a $1m^2$ disc was thrown into the paddy fields to choose four sites at random for disease observations. Ten plants were chosen at each place where the disc landed, and the total disease incidence of brown spot-infected leaves were counted. The proposed formula by Meya *et al*., 2015 [7] was used to determine disease incidence:

$$\text{Disease incidence (\%)} = (n/N) \times 100$$

where,

n is the number of leaves with brown spots and the total number of leaves observed is denoted by the letter N.

The disease incidence of respective locations was represented by an average of ten sites, and the average disease incidence of each site was expressed by an average of ten plants.

Disease intensity assessment

So far as disease intensity is considered it was recorded using a 0-9 scale Standard Evaluation System (SES) for rice to score the amount of leaf areas affected by brown spot lesions (Table 1) (Anonymous, 1996) [1]. The percentage of disease index (PDI) was determined using Wheeler's method (1969) [16].

$$\text{Per cent Disease Index (PDI)} = \frac{\text{Sum of all disease ratings}}{\text{Total no. of leaves observed x Maximum grade}} \text{ x } 100$$

Table 1: For documenting the intensity of brown spots on rice leaves, the following 0 to 9 scale was used.

Disease score	Description
0	There are no spots.
1	On lower leaves, little brown speaks of pin point size.
3	A substantial number of small roundish necrotic brown spots, about 1-2 mm in diameter, with a noticeable brown edge, appear on the top leaves.
5	Brown patch with a diameter of 3 mm or greater that infects 4-10 per cenrt of the leaf area.
7	Brown spot with a diameter of 3 mm or greater that infects 26-50 per cent of the leaf area.
9	A typical susceptible brown spot with a diameter of 3 mm or greater infecting more than 75 per cent of the leaf area.

Results

Symptomatology of Brown spot of rice

The incidence of disease shows various types of symptoms in all the stage of crop growth from the seedling to harvesting stage. Another phase appears during the emergence of seedling above the soil. The characteristic symptoms of brown spot on leaves and glumes include light reddish-brown lesion or lesions with a grey center surrounded by a dark to reddish-brown margin, and then by a bright yellow halo. Brown spots are visible on leaves, sheaths pseudostems and on grains. Spots formed on leaves, sheaths are isolated, oblong or oval, dark purplish-brown and are scattered. The size of the spots ranges from 0.7-19 mm in length and 0.4-5 mm in width (Figure 1). During heavy incidence of the disease, the leaves dry up and blighted appearance in rice field. During culms infection, it becomes dark brown with smoky dark growth of the fungus. Panicle (neck) infection shows shrunk and discoloration. The head does not emerge completely from the sheath of the boot leaf and bears discoloured, chaffy spikelets. Spikelet infection shows dark brown spots or patches on the lemma and palea. The infected spikelets bear discoloured and shrivelled grains. The first appearances of brown spot disease incidence were noted in the tested cultivars at 32 days after sowing in the screening nursery. The symptomology studies of the tested cultivars were carried out in the field as well as in laboratory under natural and artificial condition. The meteorological factors *viz*. rainfall, humidity and temperature played a vital role in the appearance of disease. The observations of symptom and disease intensity at different days after sowing were recorded.

Fig 1: Symptoms of brown spot disease on leaves of infected rice plant

Status of brown spot of rice in Jammu Division

With a view to ascertain the status of brown spot diseases of rice in Jammu division extensive fortnightly surveys were undertaken during *kharif* seasons of 2018 and 2019 in major rice growing disticts *viz.*, Jammu, Samba Kathua and Udhampur as a location-specific surveillance. The disease was found rampant on rice crop at all the pre-selected locations varying in proportion during both the years in surveyed districts.

Disease Incidence

From Table-2, it was observed that disease incidence varied within location and among the surveyed districts. The mean disease incidence in Jammu division varied between 32.65 to 74.51 per cent with total mean incidence of 58.70 per cent was recorded during *kharif* 2018. However, during *kharif*, 2019, comparable trend was observed in disease incidence, though the average was slightly higher compared to previous year. During this season, overall range of 31.64-75.83 per cent of disease intensity with an overall mean of 59.56 per cent was recorded in Jammu division.

The highest mean disease intensity of 70.16 and 69.93 per cent was recorded highest in district Samba followed by Kathua (62.27 and 63.31%), Jammu (59.17 and 59.53%) and minimum average was recorded in Udhampur (42.80 and 45.85), respectively during *Kharif* 2018 and 2019. Based on different locations surveyed, maximum disease intensity (77.34 and 75.98%) was recorded in village Basikhurd of block Bishnah (Jammu) followed by Kalwal (74.51 and 75.83%) block Bishnah (Jammu), Badheri (73.65 and 72.54) block Samba (Samba), Uttri(72.90 and 72.78) of block Kathua (Kathua) with least recorded in village Rampur (32.65 and 31.64) of block Bilwar (Kathua) respectively, during 2018 and 2019.

The pooled data of *kharif* 2018 and 2019 revealed overall intensity of brown spot in Jammu division ranged between 32.14 -75.17 per cent with total average mean of 59.13 per cent. The pooled mean disease intensity of 70.05 per cent was recorded highest in district Samba followed by Kathua (62.79%), Jammu (59.35%) and minimum pooled average recorded in Udhampur (44.33%), respectively during *Kharif* 2018 and 2019.

Disease intensity

From Table-3, it was observed that disease intensity varied within location and among the surveyed districts. The mean disease intensity in Jammu division varied between 24.35 to 52.55 per cent with total mean intensity of 36.93 per cent was recorded during *kharif* 2018. However, during *kharif* 2019, somewhat parallel trend was observed in disease intensity, though the average was marginally higher compared to previous year. During this season, overall range of 25.76 to 51.35 per cent of disease intensity with an overall mean of 37.65 per cent was recorded in Jammu division.

The mean disease intensity of 43.39 and 43.75 per cent was recorded highest in district Samba followed by Kathua (40.05 and 39.88%), Jammu (36.58 and 37.51%) and minimum average was recorded in Udhampur (27.69 and 29.48), respectively during *Kharif* 2018 and 2019. Based on different locations surveyed, maximum disease intensity (52.55 and 51.35%) was recorded in village Basikhurd of block Bishnah (Jammu) followed by Kalwal(48.96 and 50.35%) block Bishnah (Jammu), Badheri (47.36 and 49.94) block Samba (Samba), Uttri(47.35 and 49.56) of block Kathua (Kathua) with least recorded in village Chaini (24.46 and 28.66) of block (Udhampur) respectively, during 2018 and 2019.

The pooled data of *kharif* 2018 and 2019 revealed overall intensity of brown spot in Jammu division ranged between 25.31-51.35 per cent with total average mean of 37.65 per cent. The pooled mean disease intensity of 43.57 per cent was recorded highest in district Samba followed by Kathua (39.97%), Jammu (37.05%) and minimum pooled average recorded in Udhampur (28.51%), respectively during *Kharif* 2018 and 2019.

Table 2: Incidence of brown spot of rice in Jammu sub-tropics during *Kharif* 2018 and 2019

District	Location	Village	Disease Incidence (%)		
			2018	2019	Pooled
Jammu	Bishnah	Basi Khurd	77.34	75.18	51.95
		Bamnal	73.32	73.65	46.31
		Kalwal	74.51	75.83	49.66
	Marh	Gajansoo	57.67	58.32	32.01
		Chhuha	63.32	60.45	35.66
		Nagrada	58.21	58.10	32.47
	Akhnoor	Dub	42.30	45.29	27.95
		Pargwal	45.49	47.34	30.55
		Manda	40.43	41.65	26.91
		Mean ± S.E.(m)	59.17±4.72	59.53±4.38	59.35±4.54
		Range	40.43-77.34	41.65-75.83	41.04-76.26
Samba	Vijaypur	Channi	69.43	72.89	44.46
		Bari kamail	72.43	70.20	45.07
		Tholori Brahna	67.80	69.90	39.78
	Samba	Badheri	73.65	72.54	47.65
		Daboh	72.96	72.16	46.18
		Sapwal	69.47	70.38	44.38
	Ghagwal	Ratwana	70.12	67.82	43.00
		Surara	67.59	70.08	42.67
		Khootah	67.33	66.41	39.02
		Mean ± S.E.(m)	70.16±0.90	69.93±0.72	70.05±0.75
		Range	67.33-73.65	66.41-72.54	66.87-73.09
Kathua	Hiranagar	Chanori	64.71	55.04	33.91
		Jangichak	71.89	71.16	46.10
		Tokal	68.45	68.92	43.82
	Bilawar	Dewal	64.68	63.77	36.85
		Ramkot	47.21	50.34	28.50
		Rampur	32.65	31.64	32.15
	Kathua	Uttri	72.80	75.78	48.46

		Sahaar	66.89	70.45	42.45
		Jarai	73.63	74.44	47.52
		Mean ± S.E.(m)	62.27±5.17	63.31±5.33	62.79±5.24
		Range	32.65-73.63	31.64-75.78	32.16-74.29
Udhampur	Udhampur	Kawa	63.32	63.21	36.61
		Sewail	46.67	47.54	27.11
		Barial	56.89	60.25	31.55
	Tikri	Bachhal Jatuan	38.77	41.30	25.86
		Chirayi	42.09	44.88	28.26
		Challyar	37.90	44.40	26.66
	Manwal	Thalora	41.53	45.07	27.90
		Chaini	38.45	39.10	25.31
		Jander	40.13	44.30	28.06
		Mean ± S.E.(m)	42.80±2.24	45.85±2.24	44.33±2.22
		Range	37.90-56.89	39.10-60.25	38.77-58.57
		Overall mean	58.70±2.32	59.56±2.19	59.13±2.24
		Overall range	32.65-74.51	31.64-75.83	32.14-75.17

Table 3: Intensity of brown spot of rice in Jammu sub-tropics during *Kharif* 2018 and 2019

District	Location	Village	Disease Intensity (%)		
			2018	2019	Pooled
Jammu	Bishnah	Basi Khurd	52.55	51.35	51.95
		Bamnal	45.75	46.86	46.31
		Kalwal	48.96	50.35	49.66
	Marh	Gajansoo	31.47	32.54	32.01
		Chhuha	36.46	34.86	35.66
		Nagrada	32.76	32.18	32.47
	Akhnoor	Dub	26.36	29.53	27.95
		Pargwal	28.46	32.64	30.55
		Manda	26.46	27.35	26.91
		Mean ± S.E.(m)	36.58±1.21	37.51±1.98	37.05±1.59
		Range	26.36-52.55	27.35-51.35	26.91-51.95
Samba	Vijaypur	Channi	42.57	46.35	44.46
		Bari kamail	46.46	43.68	45.07
		Tholori Brahna	39.36	40.19	39.78
	Samba	Badheri	47.36	47.94	47.65
		Daboh	46.49	45.87	46.18
		Sapwal	43.88	44.87	44.38
	Ghagwal	Ratwana	43.34	42.65	43.00
		Surara	41.56	43.78	42.67
		Khootah	39.57	38.46	39.02
		Mean ± S.E.(m)	43.39±1.22	43.75±2.82	43.57±2.02
		Range	39.36-47.36	38.46-47.94	39.02-47.65
Kathua	Hiranagar	Chanori	37.46	30.35	33.91
		Jangichak	46.33	45.86	46.10
		Tokal	43.67	43.97	43.82
	Bilawar	Dewal	37.35	36.35	36.85
		Ramkot	27.46	29.54	28.50
		Rampur	32.65	31.64	32.15
	Kathua	Uttri	47.35	49.56	48.46
		Sahaar	41.75	43.14	42.45
		Jarai	46.47	48.56	47.52
		Mean ± S.E.(m)	40.05±1.01	39.88±2.08	39.97±1.5
		Range	27.36-47.35	29.54-49.56	28.50-48.46
Udhampur	Udhampur	Kawa	36.25	36.97	36.61
		Sewail	26.65	27.57	27.11
		Barial	30.55	32.55	31.55
	Tikri	Bachhal Jatuan	24.35	27.36	25.86
		Chirayi	26.98	29.53	28.26
		Challyar	24.82	28.45	26.66
	Manwal	Thalora	27.33	28.46	27.90
		Chaini	24.86	25.76	25.31
		Jander	27.46	28.66	28.06
		Mean ± S.E.(m)	27.69±1.32	29.48±1.95	28.59±1.63
		Range	24.35-36.25	25.76-36.97	25.31-36.61
		Overall range	24.35-52.55	25.76-51.35	25.31-51.35
		Overall mean	36.93±1.92	37.65±1.87	37.65±1.90

Discussion

Brown spot of rice (*Cochliobolus miyabeanus*) is chronic disease of rice throughout the world (Savary *et al*., 2000) [12], and costs millions of acreages of land under rice cultivation in each growing period that is responsible for the reduction of 26 to 52 per cent gain in yield (Chakrabarti, 2001) [2]. Severe infection affected the number of grains and tillers, as well as the weight and grade of individual grains, resulting in huge losses of 30-43 perc ent, relative to12 per cent for moderately infection and non-significant for lower disease grades (Ou, 1985) [10]. It was pragmatic that decrease in overall yield was fluctuated between 18.75-22.50 per cent (Kamal and Mia, 2009) [4]. Singh *et al*. (1979) [14], Mia *et al.* (2001) [8] and Chakrabarti (2001) [2] recorded yield decline of 4.6-40%, 3.7-29.10%, 9.28-24.50% and 26-52% respectively, while assessing the damage caused by brown spot in diverse geographical regions. The disease has been observed to occur more devastating in poor farmers' fields where the is an inadequate nitrogenous based fertilizers and water supply (Zadoks, 1974). During the study it was observed that disease incidence and intensity varied within location and among the districts of Jammu division. The highest disease incidence of brown spot disease (70.16 and 69.93%) and its intensity (43.39 and 43.75%) during *kharif* 2018 and 2019 respectively, was recorded from district Samba, followed by Kathua, Jammu with incidence of 62.27 and 63.31%; 59.17 and 59.53% and disease intensity of 40.05 and 39.88%; 36.58 and 37.51% during *kharif* 2018 and 2019, respectively. Climate changes primarily initial favorable atmosphere plays an important role in the spread of disease. The changes in paternal distribution of incidence and intensity in different location may be due to change in pathogenic variability, ecological situations, inoculum quantity and aggressiveness, failure of vertical resistance and practicing of traditional cultural practices. The number of inoculums, infection during the growth stage, climatic circumstances, and resistance, all have a role in disease incidence and intensity (Groth and Bond (2007) [3]. Rain, overcast weather, and high relative humidity are all conducive to the disease development (Magar, 2015) [6]. Basmati main varieties like Pusa-1509, Sanwal Basmati, K-448, PC-19, Ranbir basmati and Basmati-370 demonstrated a major role in producing inoculum at mature stage and transferring brown spot inoculum to Super Basmati, therefore it may be reduced by good rice stubble, straw, and field sanitation.

Conclusion

Brown spot of rice is a highly prevalent disease in Jammu division where rice being one of the major growing crops. Disease occurrence was in maximum severe form in district Samba and Kathua areas. The incidence and intensity were most recorded in Pusa-1509, Sanwal Basmati, K-448, PC-19, Ranbir basmati and Basmati-370 varieties. The results of this study provide useful information to rice producers, allowing them to employ resistant rice cultivars in the investigated areas of Jammu and it may increase the yield of rice growers. As a result, appropriate steps should be adopted to manage the brown spot disease and to boost rice crop output levels. Furthermore, more research will be required to determine the impact of different factors on disease incidence and intensity levels of rice brown spot in various agro-ecological zones. This study will aid rice growers in reducing output loss due to brown spot.

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