

Morpho-cultural variability characterization of *Bipolarisoryzae* causing brown leaf spot of rice in Jammu sub-tropics

ABSTRACT

Extensive fortnightly surveys were undertaken in major rice growing districts of Jammu division to study cultural and morphological variability amongst the isolates of brown leaf spot disease causing fungus (*Bipolarisoryzae*). On the basis of disease severity the 24 isolates (BO₁ to BO₂₄) were divided into three groups (I, II and III). Group 'I' comprised 11 isolates with disease severity value between 51.22-67.44% and were categorized under highly virulent. In group 'II' comprised with disease severity value between 43.17-48.17% and were categorized under moderately virulent isolates. Group 'III' included eight isolates with disease severity value between 26.11-38.17% and were categorized under less virulent isolates. On the basis of colony growth pattern, margin and colour, the isolates were categorized into 4 groups (A, B, C and D). Group A comprised of six isolates had entire margin, circular form, umbonate elevation with smooth surface and black to fluffy growth. Eleven isolates were categorised under group B developed colonies with undulated margin, irregular form, umbonate elevation with grey fluffy growth and greyish colour. Group C comprised three isolates had undulated margin, irregular form, umbonate elevation with smooth surface. Group D contained four isolates developed entire margin, circular form; raised elevation with wrinkled surface, mycelium was grey which turned to black and showed grey to black pigmentation. The largest conidial size was recorded in isolate BO₁ (98.43-101×24.54-25.54µm), followed by BO₄ (98.54-99.43×23.44-26.43µm) and it was minimum in isolate BO₈ (38.87-39.54 × 9.54-10.43µm). The conidia developed mean septa of 4.5-7.4 with straight to curve shaped. The sporulation of different isolates of *B. oryzae* ranged between 6.1-7.6×10⁶ spores/ml.

Comment [G1]: values

Comment [G2]: was

Comment [G3]: values

Comment [G4]: that had an entire margins

Comment [G5]: form

1. INTRODUCTION

Rice production, an agricultural sectors backbone in tropical and sub-tropical countries, including India, the world's 2nd-largest producer and consumer (Naziret *al.*, 2022 and Bhatet *al.*, 2022). Rice cultivation in Jammu and Kashmir region is mostly mono-cropped, with a far higher consumption and importance as a staple grain than other Indian states. Rice is highly essential in the lives of people in the state, despite the fact that the area under the crop cultivation is quite small relative to other Indian states, and hence is very significant in the state economy. In Indian sub-continent including Jammu and Kashmir region, Basmati rice is famous and distinguished all around the world for its appearance and aroma, but unfortunately rice production is reduced because of the biotic and abiotic stresses. Among the biotic constraints, fungal and bacterial diseases play a vital role in damaging health of rice crops and lessening rice production. Brown leaf spot disease caused by *Bipolaris oryzae* is one of the distinctive and most damaging disease of rice in the world, because of the extensive distribution of numerous physiological races (Arshad *et al.*, 2008).

Brown leaf spot in rice, is known to cause major qualitative and quantitative losses (upto 90%) in rice crop, especially when the leaf spotting phase reaches epiphytic dimensions, as it did during the Great Bengal Famine of 1942 (Ghoseet *al.*, 1960). The disease has spread throughout the world's rice-growing regions. It has been discovered to be pandemic in locations with high rainfall, such as the Assam, West Bengal, the Malabar Coast and Himalayas (Abrolet *al.*, 2022). The pathogen attacks the crop from seedling to milky stage. The characteristic

symptoms appear as minute spots on the coleoptile, leaf blade, leaf sheath and glume, being most prominent on leaf blades and glumes. On leaves, typical spots are brown in colour with grey or whitish centre with typical yellow halo over the spot (Abrolet *al.*, 2022). Typically conidia are slightly curved and widest at the middle, conidia are 5-10 septate with the oldest conidium towards base. The causal fungus *B.oryzae* remains in seeds for most of its lifecycle, but can also persist on infested rice stubble and straw. It spreads from plant to plant in the field by the airborne spores. A relative humidity of >89% at 25°C leads to successful inoculation by conidia and infection can be vigorous upon free water on leaf surface (Abrolet *al.*, 2022). Diversity and pathogenicity of the rice brown spot pathogen were investigated earlier by many workers using morpho-cultural characteristics as well as genetic fingerprint analysis (Ouedraogoet *al.*, 2004; Kamal and Mia, 2009; BurgossNazariet *al.*, 2015; Kumaret *al.*, 2016; Bokaet *al.*, 2018). The present paper emphasised on the morpho-cultural characterization of *B.oryzae* and identifying the most virulent isolates.

2. MATERIALS AND METHODS

2.1 Isolation of the pathogen

Naturally diseased leaves of different rice cultivars infected in varied degrees with brown leaf spot were collected from different locations of Jammu sub-tropics including Jammu, Samba, Kathua and Udhampur districts, and were brought to laboratory of the Division of Plant Pathology, SKUAST-Jammu India, for isolation of the pathogenic fungus. The collected samples were critically observed under microscope, to know the presence of pathogen in infected plant part. After

Comment [G10]: agrey

Comment [G6]: Please delete "a"

Comment [G11]: thebase

Comment [G7]: inother

Comment [G12]: throughairborne

Comment [G13]: theleaf

Comment [G8]: Please delete "the"

Comment [G14]: Please delete "on"

Comment [G9]: diseases

Comment [G15]: identified

Comment [G16]: varying

Comment [G17]: spots

confirming the presence of the pathogen under microscope, the diseased tissues from infected plant parts were subjected to isolation. The pathogen *B. oryzae* was isolated by standard hyphal tip isolation procedure and then the culture was maintained on Potato Dextrose Agar (PDA) slants and kept in a refrigerator at 5°C for further use in all the laboratory studies.

2.2 Pathogenicity test

The pathogenicity test of *B. oryzae* (isolates BO₁ to BO₂₄) was determined on susceptible cv. Pusa Basmati-1121 under both greenhouse and field experiments. Rice seedlings were sprayed at 25 days old under greenhouse and field conditions with the spore suspension (3×10^5 spore ml⁻¹) of the 24 isolates of *B. oryzae* separately. The seedlings were sprayed until runoff occurred. Three replicates were used for each isolate.

2.3 Cultural variability

Mycelial disc (5mm) of 10 days old culture of each isolate was transferred to the centre of sterilized Petriplates containing PDA medium and incubated at 25±2°C. Colony character viz. colour and diameter were recorded after ten days of inoculation. Reverse side of cultural plate of each fungal isolate was also observed to record pigmentation on under side of the plate.

2.4 Morphological variability

The morphological variation among different isolates of *B. oryzae* was studied on PDA under *in vitro* conditions. Mono conidial culture of each isolate was first grown on PDA medium and then semi permanent shades were prepared from 10 day old culture were stained with cotton blue in lactophenol. The growth pattern, progressive colony growth and colony colour was

recorded on PDA medium. Morphological features of the pathogen viz., type of mycelia, width of mycelia, sporulation pattern, spore size and shape were recorded.

Spores of *B. oryzae* of all the isolates from the culture were mounted on a clean glass slide. Spores were mixed with lactophenol thoroughly in order to obtain uniform spread, on which cover slip was placed. Spores were measured under high power objective using light microscope (400X). The average size of the spores like length, width and number of septa were recorded. Microphotographs were taken to show the typical spore morphology of the pathogen.

3. RESULTS AND DISCUSSION

3.1 Pathogenicity test

The pathogenicity test of *B. oryzae* (isolates BO₁ to BO₂₄) was determined on susceptible cv. Pusa Basmati-1121 (Table-1). Pathogenicity test was conducted for all the 24 isolates and control pots were maintained by spraying distilled water only. The first symptoms on the affected plant part of rice started with minute pin head shape brown flecks after 4-5 days of inoculation, later such pin head shaped flecks matured into dark brown lesions characteristics of brown spot disease. On the basis of disease severity the isolates were divided into three groups (I, II and III). Group 'I' comprised 11 isolates viz., BO₁, BO₂, BO₃, BO₄, BO₅, BO₈, BO₉, BO₁₂, BO₁₄, BO₁₉ and BO₂₀ with disease severity value between 51.22-67.44% and were categorized under highly virulent. In group 'II' comprised five isolates viz., BO₆, BO₁₁, BO₁₃, BO₁₅ and BO₁₆ with disease severity value between 43.17-48.17% and were categorized under moderately virulent isolates. Group 'III' included eight isolates viz., BO₇, BO₁₀, BO₁₇, BO₁₈, BO₂₁, BO₂₂,

Comment [G19]: alight

Comment [G18]: characters

Comment [G20]: values

BO₂₃ and BO₂₄ with disease severity value between 26.11-38.17% and were categorized under less virulent isolates (Table-2). The pathogen was re-isolated from infected leaves and its morphological characters were compared with the original culture of the pathogen and found similar in all respects i.e., morphological and microscopic. Hence, the causal agent of the brown spot disease was confirmed as *B. oryzae* after confirming by Koch's postulates. However, no such symptoms developed on uninfected leaves even after 12 days of inoculation.

The symptoms observed were in accordance with the description of the

pathogen given by Sobanbabet *al.* (2018) who also reported variation with respect to disease incidence based on pathogenicity test. Similarly, Nazari *et al.* (2015) also conducted pathogenicity test involving 12 isolates of *B. oryzae* under greenhouse conditions and found that isolates were pathogenic to rice seedlings in cv. Tarom. Moreover, Singh *et al.* (2021) also reported variation in virulence among *B. oryzae* isolates based on pathogenicity test on susceptible variety Pusa-1121.

Comment [G21]: of

Comment [G22]: the susceptible

Table 1: Pathogenicity test of different isolates of *B. oryzae* on cv. Pusa Basmati-1121

District	Location	Isolate of Bipolaris oryzae	Disease severity (%)	Virulence pattern
Jammu	Bishnah	BO ₁	51.33 (45.74)	++++
		BO ₂	62.53 (52.23)	++++
	Marh	BO ₃	59.67 (50.55)	++++
		BO ₄	64.20 (53.22)	++++
		BO ₅	58.07 (49.62)	++++
		BO ₆	44.17 (41.63)	+++
		BO ₇	26.11 (30.71)	++
Samba	Vijaypur	BO ₈	54.08 (47.32)	++++
		BO ₉	51.22 (45.68)	++++
		BO ₁₀	38.00 (38.03)	++
		BO ₁₁	48.17 (43.93)	+++
	Ghagwal	BO ₁₂	53.22 (46.82)	++++
		BO ₁₃	43.17 (41.05)	+++
		BO ₁₄	52.11 (46.19)	++++
Kathua	Hiranagar	BO ₁₅	44.89 (42.04)	+++
		BO ₁₆	47.44 (43.51)	+++
	Bilawar	BO ₁₇	35.44 (36.52)	++
		BO ₁₈	38.17 (38.14)	++
	Kathua	BO ₁₉	67.44 (55.19)	++++
		BO ₂₀	52.50 (46.41)	++++
Udhampur	Udhampur	BO ₂₁	35.00 (36.25)	++
		BO ₂₂	32.55 (34.77)	++
	Tikri	BO ₂₃	34.44 (35.92)	++
	Manwal	BO ₂₄	35.17 (36.35)	++

CD (p=0.05)	-	1.28	-
-------------	---	------	---

Table 2: Grouping of isolates of *Bipolaris oryzae* on the basis of pathogenicity test

Group	Isolate	Disease severity (%)	Virulence pattern
Group-I	BO ₁ , BO ₂ , BO ₃ , BO ₄ , BO ₅ , BO ₈ , BO ₉ , BO ₁₂ , BO ₁₄ , BO ₁₉ and BO ₂₀	>50	Highly virulent
Group-II	BO ₆ , BO ₁₁ , BO ₁₃ , BO ₁₅ and BO ₁₆	40-50	Moderately virulent
Group-III	BO ₇ , BO ₁₀ , BO ₁₇ , BO ₁₈ , BO ₂₁ , BO ₂₂ , BO ₂₃ and BO ₂₄	<40	Less virulent

3.2 Cultural variability in different isolates of *B. oryzae* on PDA medium

All the 24 isolates, when grown in sterilized Petri plates on sterilized PDA medium, exhibited great variability for colony diameter, growth pattern, colony margin and colour (Table-3) after 15 days of incubation at 25±1°C. On the basis of colony growth pattern, margin and colour, the isolates were categorized into 4 groups (A, B, C and D); Group A comprised six isolates viz., BO₁, BO₆, BO₉, BO₁₁, BO₂₂ and BO₂₃ and had colony diameter of 85.67, 78.65, 81.41, 63.51, 70.34 and 64.89 mm, respectively. In addition, the isolates had entire margin, circular form, umbonate elevation with smooth surface and black to fluffy growth. Eleven isolates viz., BO₃, BO₅, BO₇, BO₈, BO₁₀, BO₁₄, BO₁₅, BO₁₇, BO₁₈, BO₁₉ and BO₂₀ were categorised under group B having colony diameter of 63.51, 70.34, 73.85, 60.32, 65.11, 81.63, 86.11, 70.43, 71.44, 71.56 and 68.24 mm, respectively. Isolates of this group developed colonies with undulated margin, irregular form, umbonate elevation with grey fluffy growth and greyish colour. Group C comprised three isolates viz., BO₄, BO₁₆ and BO₂₁ and had colony diameter of 86.96, 72.34 and 48.34 mm, respectively. The colonies of the

isolates had undulated margin, irregular form, umbonate elevation with smooth surface. Initially, the mycelium was dirty white and later turned to grey in colour. Group D contained four isolates viz. BO₂, BO₁₂, BO₁₃ and BO₂₄ and had colony diameter of 48.34, 78.84, 58.54, and 71.44 mm, respectively. The colonies developed entire margin, circular form, raised elevation with wrinkled surface, mycelium was grey which turned to black and showed grey to black pigmentation.

The results obtained in the present investigation showing variation in colony colour of *B. oryzae* corroborate with the findings of Kumaret al. (2011) who reported that color of the isolates of *B. oryzae* showed huge variation i.e., black with fluffy growth, grey with fluffy growth, grey with fluffy growth and white spots, grey with suppressed growth. Kumaret al. (2016) grouped *B. oryzae* isolates into 5 categories on the basis of morphology and growth pattern i.e. black with fluffy growth, black with suppressed growth, grey with cottony growth, grey and white mix with cottony growth and white with cottony growth. The margins of colonies varied from circular, undulated, irregular having umbonate to raised elevation along with smooth to

Comment [G24]: diameters

Comment [G25]: anentire margins

Comment [G23]: diameters

wrinkled surface. Nayak and Hiremath (2019) was also reported variation with respect to colony colour (Dark greyish black, light greyish, greyish to white, greyish black to white, black to white colour), mycelial growth (cottony and flat), margin (regular to irregular), sporulation and conidial morphology among *B. oryzae* isolates.

Comment [G26]: the wrinkled surfaces

Comment [G27]: Please delete "was"

Comment [G28]: variations

Table 3: Cultural variation of isolates of *Bipolaris oryzae* on potato dextrose agar medium

Isolate	Radial growth (mm)	Group	Colony characteristics	Pigmentation
BO ₁	85.67	A	Entire margin, circular form, umbonate elevation with smooth surface, black with fluffy growth	Black
BO ₆	78.65			
BO ₉	81.41			
BO ₁₁	63.51			
BO ₂₂	70.34			
BO ₂₃	64.89			
BO ₃	63.51	B	Undulated margin irregular, umbonate elevation with grey fluffy growth	Greyish
BO ₅	70.34			
BO ₇	73.85			
BO ₈	60.32			
BO ₁₀	65.11			
BO ₁₄	81.63			
BO ₁₅	86.11			
BO ₁₇	70.43			
BO ₁₈	71.44			
BO ₁₉	71.56			
BO ₂₀	68.24	C	Undulated margin, irregular form, umbonate elevation, smooth surface, mycelium initially dirty white and later turning to grey	Mixture of grey
BO ₄	86.96			
BO ₁₆	72.34			
BO ₂₁	48.34	D	Entire margin, circular form, raised elevation with wrinkled surface, mycelium grey turning to black.	Grey to black
BO ₂	48.34			
BO ₁₂	78.84			
BO ₁₃	58.54			
BO ₂₄	71.44			

between 9.98-25.04µm. The largest conidial size was recorded in isolate BO₁ (98.43-

3.3 Morphological variability in different isolates of *B. oryzae*

The isolates of *B. oryzae*, grown on PDA culture medium, developed conidial length ranged between 39.20-99.71µm and breadth

101×24.54-25.54µm), followed by BO₄ (98.54-99.43×23.44-26.43µm) and it was minimum in isolate BO₈(38.87-39.54 × 9.54-10.43µm). The conidia developed mean septa

of 4.5-7.4 with straight to curved shaped isolates of *B. oryzae* ranged between 6.1- (Table-4). The sporulation of different 7.6×10^6 spores/ml.

Table 4: Morphological variation of conidia of different isolates of *Bipolaris oryzae*

Isolate	Mean		Size of conidia (um)	Number of septa	Number of conidia/ml (1×10^6)	Shape of Spore
	Length(um)	Breadth(um)	Range			
BO ₁	99.71	25.04	55.34-57.32 x 12.22-15.23	7.1	7.4	Curved
BO ₂	56.33	13.72	59.08-60.43 x 10.25-11.23	6.6	6.9	Straight
BO ₃	59.75	10.74	98.54-99.43 x 23.44-26.43	4.5	6.6	Curved
BO ₄	98.98	24.93	82.56-84.34 x 15.63-33.21	5.6	7.2	Curved
BO ₅	83.45	24.42	57.21-58.44 x 12.54-14.33	6.9	7.6	Straight
BO ₆	57.82	13.43	89.43-90.11 x 14.32-15.43	5.9	7.2	Curved
BO ₇	86.77	14.87	38.87-39.54 x 9.54-10.43	6.4	6.3	Curved
BO ₈	39.20	9.98	95.87-99.32 x 18.45-21.32	4.9	6.5	Curved
BO ₉	97.59	19.88	51.39-55.34 x 14.32-16.43	6.1	7.2	Curved
BO ₁₀	53.36	15.37	80.32-85.39 x 19.20-20.23	6.3	6.1	Curved
BO ₁₁	82.85	19.71	89.21-93.33 x 23.54-24.32	5.2	7.2	Curved
BO ₁₂	91.27	23.93	59.23-60.12 x 12.32-14.34	6.9	6.4	Curved
BO ₁₃	59.67	13.33	89.33-92.12 x 12.56-14.32	5.0	7.4	Curved
BO ₁₄	90.72	13.44	69.32-71.65 x 12.23-15.77	4.8	7.6	Curved
BO ₁₅	70.48	14.00	83.34-87.33 x 11.34-13.34	5.6	6.9	Straight
BO ₁₆	85.33	12.34	78.44-89.34 x 9.54-10.55	4.9	6.2	Straight
BO ₁₇	83.89	10.04	80.34-81.44 x 12.33-14.32	5.0	6.9	Curved
BO ₁₈	80.89	13.32	39.33-42.56 x 12.33-14.33	7.4	7.5	Curved
BO ₁₉	40.94	13.33	59.23-60.12 x 12.32-14.34	7.3	6.5	Curved
BO ₂₀	59.67	13.33	89.33-92.12 x 12.56-14.32	6.7	7.2	Straight
BO ₂₁	90.72	13.44	69.32-71.65 x 12.23-15.77	7.1	7.2	Curved
BO ₂₂	70.48	14.05	89.21-93.33 x 23.54-24.32	5.8	7.2	Curved
BO ₂₃	91.27	23.93	98.43-101 x 24.54-25.54	5.4	7.2	Curved

BO ₂₄	59.67	13.33	55.34-57.32 x 12.22-15.23	6.4	6.5	Curved
------------------	-------	-------	---------------------------	-----	-----	--------

Existence of variability among the isolates of *B. oryzae* with respect to conidial size was well documented in earlier studies. Ou (1985) reported that size of conidia of *B. oryzae* isolates varied from 45-106 x 14-17 µm in India. Jaiganeshet *al.* (2019) reported that the colour of the conidia was brown to light brown and it was slightly curved with a bulge in the middle and tapering towards the ends. They also reported that the size of the conidia varied from 29.3-33.2 µm length and 13.5-14.8 µm width.

4. CONCLUSION

The pathogenicity test of *B. oryzae* isolates was determined on susceptible rice cultivar Pusa Basmati-1121. The disease severity ranged between 26.11-67.44 per cent, 11 isolates of *B. oryzae*, with higher disease severity (51.22-67.44%) were categorized as under highly virulent, whereas five and 8 isolates with disease severity between 43.17-48.17 and 26.11-38.17% were moderately and less virulent, respectively.

All the 24 test isolates exhibited great variability when cultured on PDA medium with colony colour varying from black, grey and whitish grey. The margins of colonies were circular, irregular and undulated and the colonies showed umbonate and raised elevation along with smooth and wrinkled surface. On the basis of colony growth pattern, margin and colour, the isolates were categorized into 4 groups (A, B, C and D). Group A comprised six isolates *viz.*, BO₁, BO₆, BO₉, BO₁₁, BO₂₂ and BO₂₃ whereas, 11 (BO₃, BO₅, BO₇, BO₈, BO₁₀, BO₁₂, BO₁₄, BO₁₅, BO₁₇, BO₁₉ and BO₂₀), 3 (BO₄, BO₁₆ and BO₂₁) and 4 (BO₂, BO₁₃, BO₂₃ and

BO₂₄) isolates were categorized under group B, C and D, respectively.

The isolates of *B. oryzae*, grown on PDA culture medium, developed conidial length ranged between 39.20-99.71µm and breadth between 9.98-25.04µm. The conidia developed mean septa of 4.5-7.4 with straight to curve shaped. The sporulation of different isolates of *B. oryzae* ranged between 6.1-7.6×10⁶ spores/ml.

References:

1. Abrol S, Singh S, Singh V, Basu U, Singh R, Singh A, Ahanger Sa, Mehta A, Singh S, KakraliyaDp, Bhagat S. Effect Of Agro-Met Conditions On The Progression Of Brown Leaf Spot Disease In Basmati-370 Rice. Asian Jr. of Microbiol. Biotech. Env. Sc. 2022;24(2):335-340
2. Abrol S, Singh SK, Mehta A, Ahanger SA, Basu U, Vaid A, Singh R, Singh AK, Singh VB. Distribution pattern and prevalence of brown spot of rice (*Bipolaris oryzae*) in Jammu region. The Parma Innovation.2022;11(2): 732-736
3. Arshad HM, Khan JA, Jamil FF. Screening of rice germplasm against blast and brown spot diseases. Pakistan Journal of Phytopathology (Pakistan). 2008;25: 84-90
4. Bhat TA, Kanth RH, Jan B, Nazir A, Ahanger SA, Mir MS, Naikoo NB, Fayaz S, Dar KA, Gul A, Mansoor T. Real-Time Nitrogen Application of Rice Varieties Based on Leaf Colour Chart under System of Rice Intensification in

Comment [G32]: lengths

Comment [G33]: ranging

Comment [G29]: thesusceptible

Comment [G30]: Please delete "under"

Comment [G31]: surfaces

- Temperate Climate. Agronomy. 2022;12(9):2229.
5. Boka A, Bouet A, Tiendrebeogo A, Kassankogno AI, Ouedraogo I, Nda GN, Denezon OD, Adiko A. Pathogenic variability of *Bipolarisoryzae* causing leaf spot disease of rice in West Africa. *International Journal of Phytopathology*. 2018;7(3):103-10.
 6. Ghoze RL, Ghatge MB, Subramamanyan V. Rice in India (revised edition). New Delhi, India, Indian Council of Agricultural Research. 1960;474
 7. Jaiganesh V, Kannan C. Studies on the cultural characters and pathogenicity studies of brown leaf spot of rice caused by *Helminthosporiumoryzae* (Syn: *Bipolarisoryzae*). *Plant Archives*. 2019;19:585-7.
 8. JaiganeshMM, Mia MA. Diversity and pathogenicity of the rice brown spot pathogen, *Bipolarisoryzae* (Breda de Haan) Shoem. in Bangladesh assessed by genetic fingerprint analysis. *Bangladesh Journal of Botany*. 2009;38(2):119-25.
 9. Kumar A, Solanki IS, Akhtar J, Gupta V. Morpho-molecular diversity of *Bipolarisoryzae* causing brown spot of paddy. *Indian Journal of Agricultural Sciences*. 2016;86(5):615-20.
 10. Kumar P, Anshu V, Kumar S. Morpho-pathological and Molecular Characterization of *Bipolarisoryzae* in Rice (*Oryzaesativa*). *Journal of Phytopathology*. 2011;159(1):51-6.
 11. Nayak MS, Hiremath SV. Cultural, morphological and molecular characterization of *Bipolarisoryzae* causing brown leaf spot of rice in Northern Karnataka. *Journal of Pharmacognosy and Phytochemistry*. 2019;8(2):1235-9.
 12. Nazari S, Javan-Nikkhah M, Fotouhifar KB, Khosravi V, Alizadeh A. *Bipolaris* species associated with rice plant: pathogenicity and genetic diversity of *Bipolarisoryzae* using rep-PCR in Mazandaran province of Iran. *Journal of Crop Protection*. 2015;4(4):497-508. Ou SH. Rice diseases. IRRI; 1985.
 13. Nazir A, Bhat MA, Bhat TA, Fayaz S, Mir MS, Basu U, Ahanger SA, Altaf S, Jan B, Lone BA, Mushtaq M. Comparative Analysis of Rice and Weeds and Their Nutrient Partitioning under Various Establishment Methods and Weed Management Practices in Temperate Environment. *Agronomy*. 2022;12(4):816.
 14. OuedraogoI, Correll JC, Boza EJ, Cartwright RD, Lee FN, Sankara P. Pathogenic, molecular, and genetic diversity among *Bipolaris*, *Drechslera*, and *Exserohilum* species on rice. *BR Wells Rice Research Studies*. Fayetteville, AR, USA, AAES Research Series. 2004;529:111-9.

Comment [G34]: It doesn't appear in the text.

Comment [G35]: It doesn't appear in the text.