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Research Article

Screening of local, improved and hybrid rice genotypes against leaf blast disease (*Pyricularia oryzae*) at Banke district, Nepal

*Basistha Acharya[2], Sunder Man Shrestha[1], Hira Kaji Manandhar[1] and Bedanand Chaudhary[3]

[1]Agriculture and Forestry University, Rampur, Chitwan
[2]Nepal Agricultural Research Council, Regional Agricultural Research Station, Khajura, Banke, Nepal
[3]Nepal Agricultural Research Council, National Rice Research Programme, Hardinath, Dhanusha, Nepal
[*]Correspondence: basisthacharya1@gmail.com
ORCID: https://orcid.org/0000-0002-2444-1674

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ABSTRACT

Rice (*Oryza sativa*) is the major cereal crop of Nepal which is being faced by the devastating rice blast disease caused by *Pyricularia oryzae* Cavara. An experiment was conducted to screen rice genotypes against leaf blast disease under disease conducive upland nursery at Regional Agricultural Research Station (RARS), Khajura, Banke, Nepal during July to November, 2016. A total of 101 rice genotypes (comprising of local, improved and hybrid) including resistant and susceptible check were screened in a randomized complete block design with two replications. Disease scoring was done beginning from the 20th days of sowing by using the disease rating scale 0-9. Amongst the tested 101 rice genotypes, 28 genotypes were found resistant, 15 genotypes were moderately resistant, 16 genotypes were moderately susceptible, 39 genotypes were susceptible and 3 genotypes were highly susceptible to leaf blast. The information revealed from this study could be helpful for rice leaf blast disease management and utilizing these resistant and moderately resistant genotypes for further resistance breeding program.

Keywords: Hybrid rice, Improved rice, Local rice, Resistant, Rice blast, Screening, Susceptible

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INTRODUCTION

Rice (*Oryza sativa*) is the major cereal crop of Nepal which is being cultivated by more than 114 countries (FAO, 2011) and it feeds more than 50% of the world population (Zhang et. al., 2014). In Nepal, rice ranks first with an area of 1.4 million ha and production of 4.3 million ton and second to wheat among the cultivated cereals in the world with an area of 159.8 million ha and production of nearly 740.9 million tons (FAO STAT, 2018). A total of 78 inbred rice genotypes have been released and 33 hybrid rice varieties have been registered for commercial cultivation in Nepal (MoAD, 2015/16). Rice only accounts for more than 50% of the total calories of Nepalese people (Kharel et al., 2018: Gadal et al., 2019). To feed ever increasing population, rice production in Nepal has to be increased over 6.0 million tons by 2020 to meet the growing demand of ever increasing population (Kharel et al., 2018). Rice is cultivated at altitudes ranging from 60 to 3050 m above seas level. This variability permits farmers in flexibility for adoption of many varieties (Shrestha et al., 2012).The production of rice is affected by biotic and abiotic stress. Among the biotic stresses, rice blast is the most destructive fungal disease, which can lead to losses in rice yield up to 70 to 80% (Miah et al., 2013; Nasruddin et al., 2013). Blast is locally known as “Maruwa Rog” in Nepali.

Plant got highest disease incidence at maximum tillering stage then gradually declined, mainly due to adult plant resistance (Yeh et al., 1986; Koh et al., 1987). Collateral and alternate hosts along with the rice growing area from lowland Terai (<100 masl) to high hills (3000 masl) in the country are the most important sources of inoculums (Shahi and Hue, 1979). More extended dew periods and frequent moisture stress in upland rice contribute to increase disease incidence (Ou, 1985).

Symptoms of leaf blast typically consist of elongated diamond-shaped lesions with gray or whitish centers and brown or reddish brown margin followed by stunted growth, reduced number of bearing panicles and weight of individual grains. Infection of stem nodes results in barren panicles; late neck infection (after grain filling) results in 'broken necks'. In the same manner, panicle and neck blast also reduces rice milling yield, bulk density of the grain and increases fissured kernels (Candole et al., 1999).

Host resistance is the best way to manage the disease as it is convenient, preferable cost effective, sustainable, safe and practical means of plant protection for resource-poor farmers (Sharma, 1995; Ou, 1985; Bonman et al., 1992). Governance of blast disease is done by major genes which often are found to be broken down under field conditions (Kiyosawa, 1982; Bonman et. al., 1988). Hence, search for new sources of resistance should be continued to mitigate the situation. There are many local as well as introduced genotypes that are resistant and susceptible to blast in Nepal (Pradhanang, 1988; Chaudhary, 1995; Manandhar et al., 1992; Manandhar, 1984; 1987). Effective and efficient screening techniques are keys in successful breeding program for blast resistance. Thus, it is an urgent need to innovate new sources of resistance mainly partial resistance and promote their expansion on planting system for future assurance (Castano et al., 1990; Haq et al., 2002; Chandrashekara et al., 2010).

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The relative field resistance of leaf blast of Nepalese local rice genotypes, is not well known; so, local, improved and hybrids being cultivated in mid-western Nepal were chosen for screening against leaf blast disease. For identification of the durable new sources of resistance and their deployment against rice blast disease, screening of 101 rice genotypes including checks (resistant and susceptible) were evaluated for quantitative resistance to leaf blast at Regional Agricultural Research Station, Khajura, Banke during 2016.

MATERIALS AND METHODS

Plant materials

Three sets of rice genotypes collected from different sources were used for conducting the experiments. The first set comprised of 70 local genotypes, second set comprised of 20 improved genotypes and the third set included 8 hybrid rice genotypes. Masuli and Shankharika cultivars were used as susceptible check and Sabitri as resistant check. The genotypes details were as follows:

Table 1. List of 101 rice genotypes included in the study at Khajura, Banke, 2016

Genotypes	Parantage / Accession	Group
Darmali	NGRC 02106	Local
Pokharel dhan	NGRC 02107	Local
Hari bhakte	NGRC 02108	Local
Jaran seto	NGRC 02109	Local
Kalo jaran	NGRC 02110	Local
Jhlingi dhan	NGRC 02111	Local
Rato dhan	NGRC 02112	Local
Damari dhan	NGRC 02113	Local
Kalnathe dhan	NGRC 02114	Local
Dehradune	NGRC 02115	Local
Dhunge dhan	NGRC 02116	Local
Jhayale ghaiya	NGRC 02117	Local
Jhayale ghaiya-1	NGRC 02118	Local
Rate ghaiya	NGRC 02128	Local
Anadi	NGRC 02133	Local
Seto gunde	NGRC 02134	Local
Simtaro dhan	NGRC 02135	Local
Nibai dhan	NGRC 02136	Local
Gaure dhan	NGRC 02137	Local
Shyamjira	NGRC 03005	Local
Anadi-1	NGRC 03009	Local
Anadi-2	NGRC 03010	Local
Radha dhan	NGRC 03073	Local
PR 413 dhan	NGRC 03074	Local
Tilki dhan	NGRC 03087	Local
Dhan	NGRC 03263	Local
Jhinna dhan	NGRC 03265	Local
Anadi-3	NGRC 03266	Local
Dedwa	NGRC 03271	Local
Karangi	NGRC 03296	Local

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Genotypes	Parantage / Accession	Group
Goral	NGRC 03306	Local
Karmuli	NGRC 03307	Local
Simtharo	NGRC 03328	Local
Bhatte	NGRC 03349	Local
Kalanamak	NGRC 03369	Local
Shyamjira-1	NGRC 03370	Local
Anjana	NGRC 03388	Local
Basmati	NGRC 03389	Local
Khajuwa	NGRC 03390	Local
Karangi dhan	NGRC 03429	Local
Rahimanawa	NGRC 03430	Local
Rahimanawa-1	NGRC 03431	Local
Gopale dhan	NGRC 04951	Local
Dhan-1	NGRC 04952	Local
Soto gude	NGRC 04953	Local
Gude dhan	NGRC 04954	Local
Arabis dhan	NGRC 04955	Local
Deradune-1	NGRC 04956	Local
Arabis dhan-1	NGRC 04957	Local
Masuli dhan	NGRC 04958	Local
Jire dhan	NGRC 04959	Local
Mabilili dhan	NGRC 04960	Local
Dhan-2	NGRC 04961	Local
Dhan-3	NGRC 04962	Local
Dhan-4	NGRC 04963	Local
Dhan-5	NGRC 04964	Local
Dhan-6	NGRC 04965	Local
Dhan-7	NGRC 04966	Local
Gude dhan-1	NGRC 04967	Local
Dhan-8	NGRC 04968	Local
Jire dhan-1	NGRC 04969	Local
Gude seto	NGRC 04970	Local
Arabais dhan-2	NGRC 04971	Local
Dhan-9	NGRC 04972	Local
Arabais dhan-3	NGRC 04973	Local
Sano mansaro	NGRC 04974	Local
Arabais	NGRC 04975	Local
Dhan-10	NGRC 04976	Local
Srijana	NGRC 05043	Local
Saandaar	NGRC 05044	Local
Sukha dhan-1	IR55419*2/WAYRAREM	Improved
Sukha dhan-2	IR55419*2/WAYRAREM	Improved
Sukha dhan-3	IR55419*2/WAYRAREM	Improved
Sukha dhan-4	IR55419*2/WAYRAREM	Improved
Sukha dhan-5	IR72022-46-2-3-3-2/SWARNA	Improved
Sukha dhan-6	IR72022-46-2-3-3-2/IR57514-PMI-5-B-1-2	Improved
Hardinath-2	IRAT112/IR50	Improved
Lalka basmati		Improved

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Genotypes	Parantage / Accession	Group
Ghaiya-1		Improved
Radha-11	Selection of TCA 80-4	Improved
Tarahara-1	IR70181-26-PMI 2-9-1-1/IRRI 105	Improved
Rampur mansuli	Lal nakanda/IR30	Improved
Radha-7	Janaki/Masuli	Improved
Ram dhan		Improved
Hardinath-1	BG 951//3348/BW 288-1-3	Improved
Janaki	Peta 3/TN1/Remadja	Improved
Swarna sub-1	Swarna*3/IR49830-7-1-2-3	Improved
Radha-4	BG34-8/IR2071-635-1	Improved
Black rice		Improved
Makwanpur-1	PETA 4/TN1	Improved
Loknath-505		Hybrid
GK-marshal-135		Hybrid
Tara gold-1112		Hybrid
US-312		Hybrid
DY-69		Hybrid
Garima-1115		Hybrid
Champion		Hybrid
Aakash-1115		Hybrid
Sabitri	IR1561/IR1737	Improved/Resistant check
Sankharika		Landrace/Susceptible check
Masuli		Improved/ Susceptible check

Experimental design

The experiment was laid out in alpha lattice design with two replications during 2016 at RARS, Khajura, Banke, Nepal. A total of 101 rice genotypes including checks (resistant and susceptible) were evaluated in the blast disease screening nursery under upland conditions having the individual plot size of 500 cm^2. Susceptible and resistant checks were planted after every 10 test entries to check uniformity of infection. The mixtures of several susceptible cultivars (Masuli, Shankharika and Jumli marshi) were planted in inoculum plot and also as spreader rows surrounding the test entries to ensure presence of inoculum consisting of diverse races of the blast pathogen. Natural dispersal of the pathogen in the test lines was allowed from spreader rows planted around the nursery. The spreader row was used to trap the inoculum from the inoculum plot to spread the disease to the test plot naturally. To create a blast congenial environment, the screening nursery was designed as per the international specifications as described by Jennings et al. (1979).

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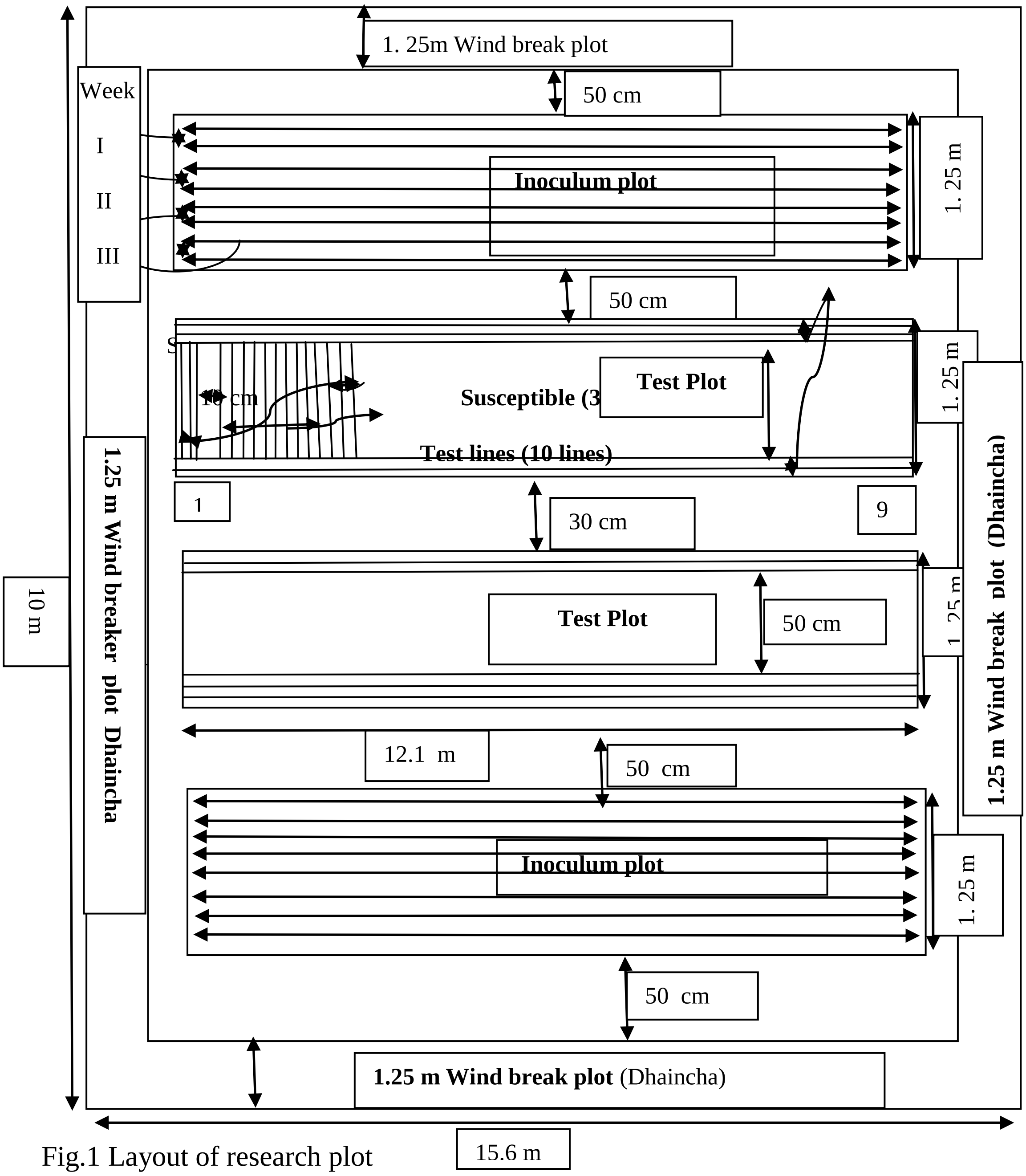

Fig.1 Layout of research plot

Cultural practices

Five gram of seeds of each test rice genotypes was taken and sown in the dry seed bed by line sowing method. Then rice seed was covered with shallow layer of pulverized soil. Farm yard manure @ 10 t/ha, was mixed into soil two weeks before dhaincha sowing, and chemical fertilizers were applied through urea and diammonium phosphate, respectively @ 120: 40: 0 N: K_2O: P_2O_5 kg/ha. Half dose of nitrogen and full dose of phosphorus was applied as a basal

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dose at the time of final land preparation and remaining half nitrogen was applied at two split doses: one fourth at 15 days after sowing (DAS) and remaining one fourth at 25 DAS.

Since rice seedling requires comparatively large amount of water, irrigation was done at weekly interval. Manual weeding was done two times at 25 DAS and 35 DAS, irrigation was done as per requirement for vigorous crop growth. Other intercultural operations were done as required.

Disease assessment

The observations on disease appearance were recorded from each row of the screened genotypes along with the resistant and susceptible check varieties planted after every ten varieties. Disease scoring was done beginning from the 20th days of sowing by using the disease rating scale 0-9 (IRRI, 2002).

Table 2. Disease rating scale (0-9) used to score leaf blast in field at Khajura, Banke, 2016

Scale	Infection	Host response
0	No lesions observed	Highly resistant (HR)
1	Minute brownish non-sporulating spots of pin point size under lower leaves.	Resistant (R)
2	Round, slightly prolonged necrotic gray spots, of 1-2 mm in diameter, with a well-defined brownish margin, little sporulating lesions mostly found on the lower leaves.	Moderately resistant (MR)
3	Spot same as in 2, but with a notable number of spots on the upper leaves.	Moderately resistant (MR)
4	Typically, heavy sporulating blast spots with 3 mm or more in length causing less than 2 % infection on leaf.	Moderately susceptible (MS)
5	Typical blast lesions of 3 mm or longer infecting 2-10 % of the leaf area	Moderately susceptible (MS)
6	Typical blast lesions of 3 mm or longer infecting 11-25 % of the leaf area	Susceptible (S)
7	Typical blast lesions of 3 mm or longer infecting 26-50 % of the leaf area	Susceptible (S)
8	Typical blast lesions of 3 mm or longer infecting 51-75 % of the leaf area	Highly susceptible (HS)
9	Typical blast lesions of 3 mm or more longer infecting more than 75 % leaf area	Highly susceptible (HS)

The data obtained from the experiments were grouped into five categories as a resistant (R), moderately resistant (MR), moderately susceptible (MS), susceptible (S) and highly susceptible (HS) types to determine the resistance and susceptibility of rice genotypes.

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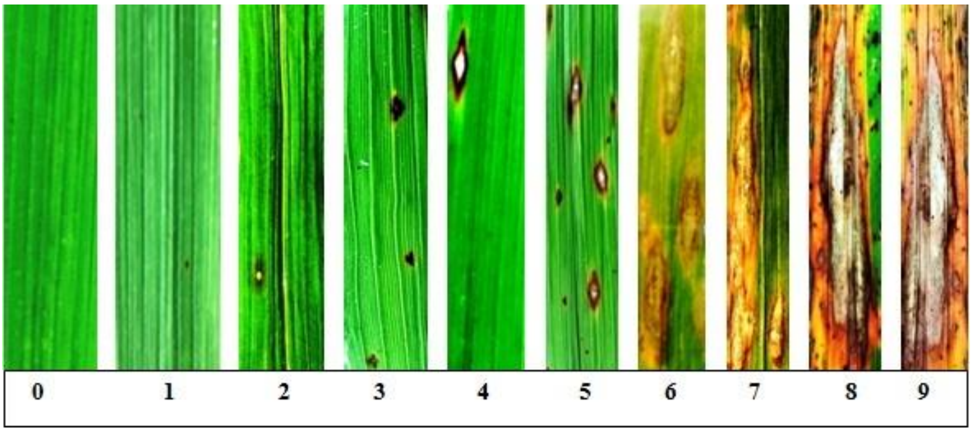

Figure 2. Leaf blast disease scoring scale 0-9

The score 0 was considered as highly resistant reaction whereas 1 as resistant, 2-5 moderately resistant, 6-7 as susceptible and 8-9 were considered highly susceptible.

Based on the scored value from estimation of the leaf area infection the severity % was calculated per plot by using the following formula:

$$\text{Leaf blast severity (\%)} = \frac{\text{Score recorded}}{9} \times 100$$

The effect of disease severity on rice variety was integrated into area under disease progress curve (AUDPC) for the quantitative measure of epidemic development, disease severity and rate of progress which has no unit. AUDPC values were computed, from leaf blast severity as per the procedure of Shanner and Finney (1977) and Shrestha *et al.* (2019) using the following formula:

$$\text{AUDPC} = \sum_{i=1}^{n-1} \left[\frac{X_{(i+1)} + X_i}{2}\right] (T_{i+1} - T_i)$$

Where,

Xi = disease severity on first date

Ti= date on which the disease was scored

n= number of observations

Statistical analysis

The recorded data were tabulated in excel data sheet and subjected to analysis by using the reference of Gomez and Gomez (1984). The data were processed to fit into R-studio and analysis was conducted using R 3.4.1 (R Core Team, 2017) and the agricolae version 1.1-8 package (Mendiburu, 2014). Based on ANOVA result, Duncan's multiple range test (DMRT) was performed to compare the genotypes. The treatment means were compared by the Least Significant Difference (LSD) test at 5% level (Gomez & Gomez, 1984; Kandel & Shrestha, 2019; Baral *et al.*, 2016; Shrestha, 2019).

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Resistance and susceptibility of rice genotypes
The genotypes were categorized into five categories based on the following AUDPC values:

Table 3. Categories of rice genotypes based on mean AUDPC value

Mean AUDPC	Category	Symbol
> 420	Highly susceptible	HS
271-420	Susceptible	S
181-270	Moderately susceptible	MS
91-180	Moderately resistant	MR
<90	Resistant	R

RESULTS AND DISCUSSION

Meteorological information
The weather parameters, i.e. relative humidity, rainfall and solar radiation varied during the study. Maximum, minimum temperature and relative humidity were recorded as 45.06^0C, 15.62^0C and 89.23%, respectively and the rainfall ranged from 0-128 mm. The highest rainfall was recorded during the month of July and decreased gradually from the month of August and was least at the end of August.

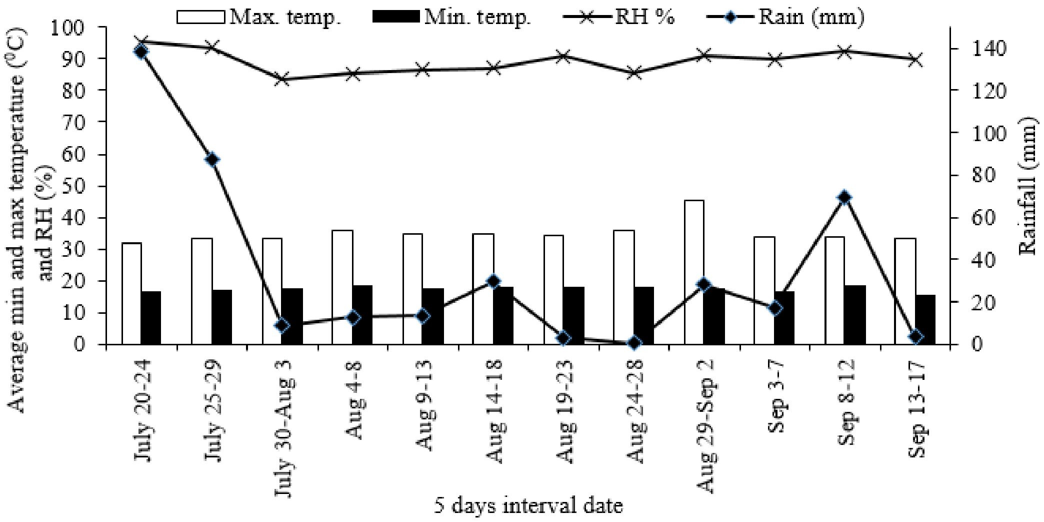

Figure 3. Meteorological data during experimental period (July 20 to September 17, 2016) at RARS, Khajura, Banke

Category of rice genotypes on the basis of mean AUDPC values
Observation of disease was taken for four times at 5 days intervals beginning from 20 days after sowing and AUDPC values were calculated. Rice genotypes showed variation in disease development as they were from different genetic background. On the basis of mean AUDPC values, rice genotypes were categorized into five categories, i.e. resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible.

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Table 4. Mean AUDPC and category of rice genotypes in field at RARS, Khajura, Banke, 2016

Genotypes	Mean AUDPC	Category
Sabitri	6.48^{J} ±9.16	Resistant
PR-413 dhan	12.96^{J} ±0	Resistant
Arabais dhan-2	12.96^{J} ±0	Resistant
Srijana	12.96^{J} ±0	Resistant
Dhan-10	19.45^{J} ± 9.14	Resistant
Pokharel dhan	25.92^{J} ±18.33	Resistant
Dhunge dhan	25.92^{J} ±18.33	Resistant
Janaki	25.92^{J} ±18.33	Resistant
Radha-4	25.92^{J} ±18.33	Resistant
US-312	25.92^{J} ±18.33	Resistant
Champion	25.92^{J} ±18.33	Resistant
DY-69	32.40^{IJ} ± 27.49	Resistant
Aakash-1115	32.41^{IJ} ± 9.16	Resistant
Khajuwa	38.89^{IJ} ± 18.32	Resistant
Sukha dhan-4	38.89^{IJ} ± 0	Resistant
Hardinath-1	38.89^{IJ} ± 0	Resistant
GK – marshal – 135	38.89^{IJ} ± 0	Resistant
Tara gold 1112	38.89^{IJ} ±0	Resistant
Arabais	45.37^{HIJ} ±27.49	Resistant
Hardinath-2	45.37^{HIJ} ±9.16	Resistant
Jhinna dhan	51.85^{GHIJ} ±0	Resistant
Basmati	51.85^{GHIJ} ±0	Resistant
Swarna sub-1	51.85^{GHIJ} ± 0	Resistant
Rampur mansuli	58.33^{FGHIJ} ± 9.16	Resistant
Karmuli	58.33^{FGHIJ} ± 27.49	Resistant
Arabisdhan-1	64.81^{EFGHIJ} ± 18.33	Resistant
Loknath-505	64.81^{FGHIJ} ± 36.66	Resistant
Ghaiya 1	71.29^{DEFGHIJ} ± 45.8	Resistant
Anjana	97.2^{CDEFGHI} ± 9.16	Moderately resistant
Dhan-1	110.18^{CDEFGH} ± 27.49	Moderately resistant
Tarahara-1	110.18^{CDEFGH} ± 27.49	Moderately resistant
Anadi-2	116.66^{BCDEFG} ± 18.33	Moderately resistant
Bhatte	123.15^{BCDEF} ± 9.16	Moderately resistant
Kalanamak	123.15^{BCDEF} ± 9.16	Moderately resistant
Ram dhan	123.15^{BCDEF} ± 9.16	Moderately resistant
Sukha dhan-6	129.63^{zABCD} ± 18.32	Moderately resistant
Makwanpur-1	136.11^{zABCD} ± 64.16	Moderately resistant
Simtharo	142.59 ^{zABC} ± 54.99	Moderately resistant
Sukha dhan-1	142.59^{zABC} ± 54.99	Moderately resistant
Shyamjira-1	149.07^{yzABC} ± 64.16	Moderately resistant
Dhan-7	155.55^{xyzABC} ± 54.99	Moderately resistant
Mabilili dhan	155.56 ^{xyzABC} ± 0	Moderately resistant
Saandaar	162.04^{wxyzABC} ± 9.16	Moderately resistant
Radha-11	181.48^{vwxyzAB} ± 36.66	Moderately susceptible
Dhan-5	194.44^{uvwxyzA} ± 36.66	Moderately susceptible
Dhan-4	200.92^{uvwxyz} ± 18.33	Moderately susceptible
Anadi	213.89^{tuvwxy} ±64.16	Moderately susceptible
Lalka basmati	213.89^{tuvwxy} ± 82.49	Moderately susceptible
Arabisdhan	220.37^{stuvwx} ± 54.99	Moderately susceptible
Deradune -1	220.37^{stuvwx} ± 54.99	Moderately susceptible
Radha-7	220.37^{stuvwx} ± 18.32	Moderately susceptible
Shyamjira	226.85^{rstuvw} ± 9.16	Moderately susceptible
Rahimanawa-1	226.85^{rstuvw} ±45.83	Moderately susceptible
Dhan -2	233.33^{qrstuv} ± 36.66	Moderately susceptible

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Genotypes	Mean AUDPC	Category
Dhan-6	239.81^{pqrstuv} ± 27.49	Moderately susceptible
Sano mansaro	239.81^{pqrstuv} ± 15.82	Moderately susceptible
Sukha dhan – 2	239.81^{pqrstuv} ± 27.49	Moderately susceptible
Black rice	246.29^{opqrstuv} ± 18.33	Moderately susceptible
Dhan-8	252.78^{nopqrstu} ±9.16	Moderately susceptible
Darmali	272.22^{mnopqrst} ± 18.33	Susceptible
Karangi	278.70^{lmnopqrst} ± 82.49	Susceptible
Goral	278.70^{klmnopqrs} ± 9.17	Susceptible
Gopaledhan	285.18^{klmnopqrs} ±18.33	Susceptible
Gude dhan-1	285.18 ^{klmnopqrs} ±18.33	Susceptible
Jire dhan	285.19^{klmnopqrs} ± 0	Susceptible
Anadi -3	291.66^{jklmnopqr} ± 27.49	Susceptible
Sukha dhan-3	291.66^{jklmnopqr} ±27.49	Susceptible
Karangi dhan	291.67^{jklmnopqr} ± 9.16	Susceptible
Rato dhan	298.15^{jklmnopq} ±18.32	Susceptible
Sukha dhan-5	298.15^{jklmnopq} ± 18.32	Susceptible
Masuli	304.63^{ijklmnop} ± 45.83	Susceptible
Arabais dhan-1	304.6 3^{ijklmnop} ±9.16	Susceptible
Radha dhan	311.11^{jklmnopq} ±0	Susceptible
Hari bhakti	317.59^{ghijklmn} ±27.49	Susceptible
Dehradune	317.59^{ghijklmn} ±45.82	Susceptible
Dhan	317.59^{ghijklmn} ± 18.33	Susceptible
Rahimanawa	317.59^{ghijklmn} ±27.49	Susceptible
Jhlingi dhan	324.07^{ghijklm} ±18.33	Susceptible
Dhan-3	324.07^{ghijklm} ±36.66	Susceptible
Jire dhan-1	324.075 ^{klmnopqrs} ±18.33	Susceptible
Garima-1115	324.075^{ghijklm} ±18.33	Susceptible
Kalo jaran	330.55^{fghijklm} ±27.49	Susceptible
Jhayale ghaiya-1	330.5^{fghijklm} ±27.49	Susceptible
Gude seto	330.55^{fghijklm} ± 45.82	Susceptible
Damari dhan	337.03^{efghijklm} ± 18.33	Susceptible
Dhan-9	337.03^{efghijklm}± 18.33	Susceptible
Simtaro bhan	343.51^{efghijkl} ± 27.49	Susceptible
Tilki dhan	350 ^{defghijk} ±54.99	Susceptible
Dedwa	350^{defghijk} ±18.32	Susceptible
Soto gude	395.37^{defghijk} ±27.49	Susceptible
Jaran seto	356.48^{defghij} ±9.16	Susceptible
Nibai dhan	369.44^{defghi} ±27.49	Susceptible
Anadi -1	375.92^{defgh} ±18.33	Susceptible
Gaure dhan	382.41^{defg}±9.6	Susceptible
Seto gunde	395.37^{def} ±27.49	Susceptible
Kalnathe dhan	401.85 ^{cde} ±0	Susceptible
Jhayale ghaiya	401.85^{cde} ±36.66	Susceptible
Rate ghaiya	414.81^{bcd} ± 18.33	Susceptible
Gude dhan	466.67^{abc} ± 0	Highly susceptible
Masuli	473.15^{ab} ± 45.83	Highly susceptible
Shankharika	492.59^{a} ± 36.66	Highly susceptible
Grand mean	206.18	
LSD	69.65	
P value	***	
CV%	17.02	

AUDPC: Area under disease progress curve, CV: Coefficient of variation, LSD: Least significant difference, Means followed by the same letter in a column are not significantly different by DMRT at 1% level of significance, SEn (±) indicates standard error of mean.

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The mean AUDPC value ranged from 6.48 to 492.59 among the genotypes. Of the total 101 rice genotypes screened in the nursery, based on AUDPC value, none of the genotypes was highly resistant to the disease. However, 28 genotypes viz. Sabitri, PR-413 dhan, Arabais dhan-2, Srijana, Dhan-10, Pokharel dhan, Dhunge dhan, Janaki, Radha-4, US-312, Champion, DY-69, Aakash-1115, Khajuwa, Sukha dhan-4, Hardinath-1, GK Marshal-135, Tara gold-1112, Arabais, Hardinath-2, Jhinna Dhan, Basmati, Swarna Sab-1, Rampur Mansuli, Karmuli, Arabisdhan-1, Loknath-505, and Ghaiya-1 were found resistant. Similarly, 15 genotypes viz. Anjana, Dhan-1, Tarahara-1, Anadi-2, Bhatte, Kalanamak, Ram dhan, Sukha dhan-6, Makwanpur-1, Simtharo, Sukha dhan-1, Shyamjira-1, Dhan-7, Mabilili dhan, and Saandaar were moderately resistant, 16 genotypes viz. Radha-11, Dhan-5, Dhan-4, Anadi, Lalka basmati, Arabisdhan, Deradune-1, Radha-7, Shyamjira, Rahimanawa-1, Dhan-2, Dhan-6, Sano mansaro, Sukha dhan-2, Black rice, and Dhan-8 were moderately susceptible. Similarly, 39 genotypes viz. Darmali, Karangi, Goral, Gopaledhan, Gude dhan-1, Jire dhan, Anadi-3, Sukha dhan-3, Karangi dhan, Rato dhan, Sukha dhan-5, Mansuli dhan, Arabais dhan-1, Radha dhan, Hari bhakte, Dehradune, Dhan, Rahimanawa, Jhlingi dhan, dhan-3, Jire dhan-1, Garima-1115, Kalo jaran, Jhayale ghaiya-1, Gude seto, Damari dhan, Dhan-9, Simtaro dhan, Tilki dhan, Dedwa, Soto, gude Jaran Seto, Nibai dhan, Anadi-1, Gaure dhan, Seto gunde, Kalnathe dhan, Jhayale ghaiya, and Rate ghaiya were susceptible and 3 genotypes viz. Gude dhan, Masuli, Shankharika were highly susceptible to leaf blast. Significantly lowest AUDPC value was obtained in resistant check Sabitri (6.48) followed by Srijana (12.96), which was at par with PR 413 Dhan (12.96) and Arabais dhan-2 (12.96). However, the highest AUDPC value was found in susceptible check variety Shankharika (492.59) and Masuli (473.15) followed by Gude dhan (466.67). The treatments were compared using Duncan’s multiple range test (DMRT).

Cluster analysis

Rice genotypes were classified into five cluster groups namely cluster I (resistant genotypes), cluster II (moderately resistant), cluster III (moderately susceptible), cluster IV (susceptible), cluster V (highly susceptible) having similarity in disease reactions amongst 101 rice genotypes based on AUDPC value in field experiment. In cluster I, 28 genotypes were grouped as resistant, which represents 27.72% of the total genotypes. In cluster II, 15 genotypes were grouped, as moderately resistant which represents 14.85% of the total genotypes. In cluster III, 16 genotypes were grouped as moderately susceptible which represents 15.84% of the total genotypes. In cluster IV, 39 genotypes were grouped as susceptible, which represents 38.61% of the total genotypes where as in cluster V, 3 genotypes were grouped which represents 2.97% of the total genotypes as highly susceptible.

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Table 5. Cluster analysis of rice genotypes based on value of mean AUDPC at RARS, Khajura, 2016

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Cluster I	0.000	95.460	186.243	293.194	440.409
Cluster II		0.000	91.456	197.754	346.719
Cluster III			0.000	108.065	255.405
Cluster IV				0.000	157.257
Cluster V					0.000

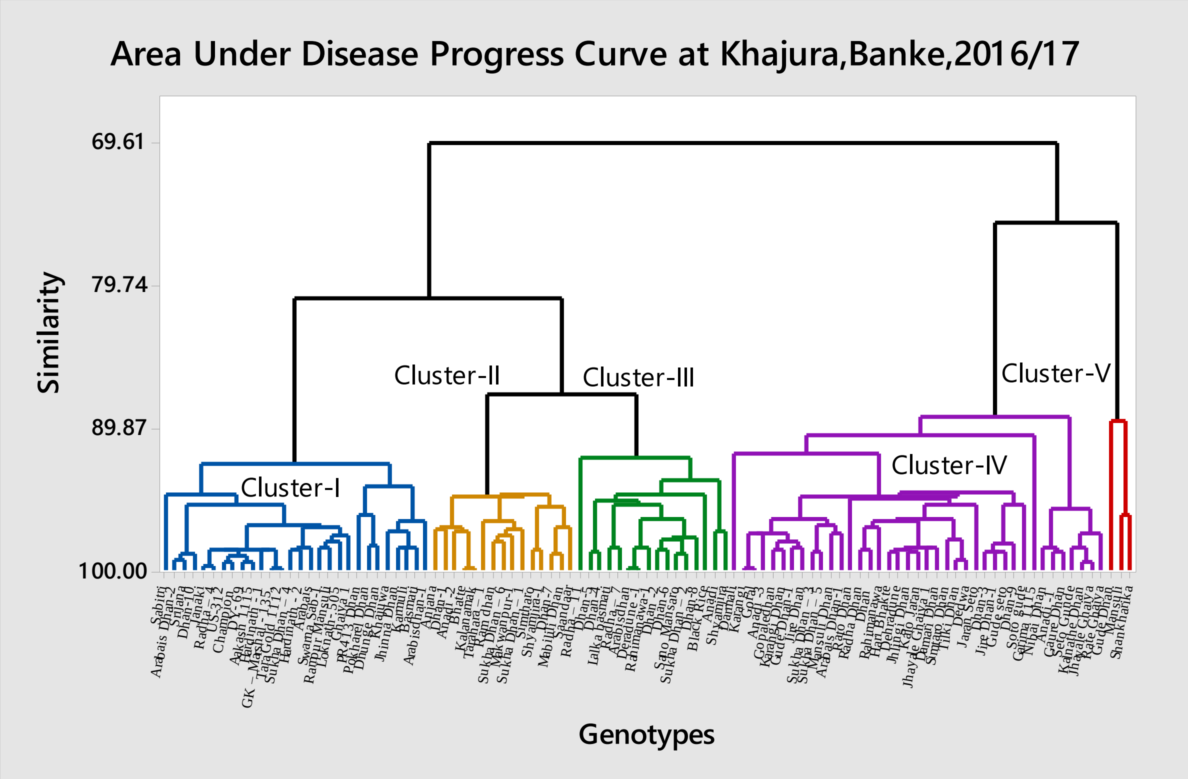

Figure 7. UPGMA dendogram based on AUDPC of 101 rice genotypes, at Khajura, Banke, 2016

Experiment was conducted in upland to create the favourable conditions for disease development as there is influence of water stress to enhance the disease as reported by Bonman and Mackill (1988), Gill and Bonman (1988). The rice genotypes varied significantly in mean AUDPC values at 20, 25, 30 and 35 days after sowing (DAS). The conducive environment for disease development might have caused rapid disease development and the highest disease pressure in the screening plot. Due to the different genetic makeup of the genotypes most of them showed variable responses against the pathogen. The resistant check rice genotype Sabitri showed least AUDPC value (6.48), however, the highest AUDPC value was recorded in susceptible check Shankharika (492.59) and Masuli (473.15).

The variations in the blast severity was observed in between the genotypes suggesting that the pathogen was host genotype-specific. The weather of the research site during the period was almost favourable for blast disease development i.e. temperature (15-45^{0}C), high humidity

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CONCLUSION

In Nepal most of farmers are resource poor hence the resistant cultivar plays an important role in blast disease management. The relative field resistance of leaf blast of Nepalese local rice genotypes is not well known; for this reason, local, improved and hybrids being cultivated in mid-western Nepal were chosen to examine and screen out for resistance to leaf blast disease. The investigation was attempted to evaluate exotic and indigenous rice genetic resources for reactions to blast disease. From the present experiment, it can be concluded that due to different genetic background the genotypes varied significantly for leaf blast severity and AUDPC. The results revealed that among the 101 rice genotypes screened against leaf blast, none of the genotypes was found immune to *P. oryzae*. Variation on disease severity among the genotypes was observed which might be due to variation in the genetic diversity of rice genotypes. Those genotypes (Shankharikha, Masuli, Gude dhan) showing highly susceptible reaction to leaf blast in the field experiment could be used as susceptible check for leaf blast research programme in Nepal. Those genotypes (Sabitri, PR-413 dhan, Arabais dhan-2, Srijana, Dhan-10, Pokharel dhan, Dhunge dhan, Janaki, Radha-4, US-312, Champion, DY-69, Aakash-1115, Khajuwa, Sukha dhan-4, Hardinath-1, GK Marshal-135, Tara gold-1112, Arabais, Hardinath-2, Jhinna Dhan, Basmati, Swarna Sab-1, Rampur Mansuli, Karmuli, Arabisdhan-1, Loknath-505, and Ghaiya-1) showing resistant reaction, could be utilized as a source of resistance for breeding and also be promoted to yield evaluation trials for desirable agronomic traits to recommend farmers for cultivation. These identified resistant genotypes need to be characterized for their resistance genes. Resistance to leaf blast also depends upon the races of the *Pyricularia*. Hence, evaluation of genotypes in different environmental conditions and with different isolates is required before recommendation for release.

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Authors contributions

S. .M. Shrestha, H.K. Mandhar, B. Chaudhary guided research and revised the article for the final approval of the version to be published. B. Acharya conducted the trial and recorded data, analyzed and wrote the final manuscript.

Conflict of interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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