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Short Communication

Disease Reaction of Rice Landraces from North Western Himalayas for Blast under Different Production Systems

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Abstract

***Magnaporthe oryzae*, the rice blast fungus, is one of the most important pathogens affecting rice crop around the world, causing considerable crop losses. The present study was undertaken with 20 landraces of rice collected from different rice growing areas of Himachal Pradesh to assess the influence of blast disease under two different production systems, *viz*; Natural Farming system (NF) and conventional inorganic system to identify rice blast-resistant sources. Under the NF system, five and four genotypes exhibited resistance to leaf blast and neck blast, respectively while under conventional inorganic system, only two and three genotypes showed resistance to the respective diseases. Notably, none of the genotypes showed a highly susceptible reaction under the NF system, whereas two genotypes, *i.e.* Gosha and Karad were highly susceptible under the conventional system. These results highlighted the potential of NF in managing rice blast and provide valuable information for breeding programs focused on developing blast-resistant rice varieties suitable for different production systems.**

Keywords: Land Races, Production systems, Rice blast resistance, Natural farming

Rice, consumed by over half of the global population, provides a substantial portion of daily dietary calories, making it a crucial nutritional staple (Keerthivarman *et al.* 2019). However, rice production often faces a decline due to the onslaught of blast disease triggered by the filamentous fungus *M. oryzae* (anamorph *Pyricularia oryzae*). The blast pathogen affects plants at every stage of their growth and development. In favourable environmental conditions, it can reduce grain yield by up to 90% and damage leaves, nodes, and panicles through leaf blast, nodal blast, and neck blast, respectively (Singh *et al.* 2015).

More than 50 host species in the *Poaceae* family, including rice, wheat, finger millet, pearl millet, and foxtail millet, have been reported to be infected by *M. oryzae* worldwide (Jeevan *et al.* 2021). Epidemics of blast illness have struck most of the world's rice-growing regions, including India (Ariya-anandech *et al.* 2018). India saw multiple fatal blast disease outbreaks in Himachal Pradesh, Tamil Nadu, Andhra Pradesh, and Haryana between 1980 and 1987 (Yadav *et al.* 2019).

Chemical fungicides have been instrumental in managing different diseases, but they have significant drawbacks such as high costs, ineffectiveness under high disease pressure, and the potential to inadvertently enhance the pathogen's resistance (Sharma *et al.* 2010 & 2025). As a result, utilizing host resistance, particularly through R genes, emerges as the most cost-effective and environmentally friendly approach to combat rice blast disease. Currently, researchers have identified approximately 146 R genes, with 36 successfully cloned and characterized for their resistance to leaf blast (Sahu *et al.* 2022). However, despite their broad-spectrum resistance to leaf blast, these cloned R genes have not been thoroughly examined for their efficacy against

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neck blast disease, which represents the most severe stage of the illness. Nevertheless, some progress has been made in understanding neck blast resistance, with the identification of 14 QTLs and a few R genes such as *Pi-jnw1, Pi68(t), Pi25(t), Pb1, Pi64*, and *Pi25(t)*. The presence of numerous retro-transposons and repetitive DNA in the *M. oryzae* genome may contribute to genetic changes that affect the pathogen's virulence and host range, potentially leading to the evolution of new, more virulent races. Consequently, existing blast-resistant rice cultivars face a constant risk from the emergence of these new pathogenic races.

Given this challenge, harnessing the genetic diversity of local rice germplasm becomes essential. The Indian rice germplasm collection contains a significant amount of genetic variation (Yadav *et al.* 2019). One strategy to combat this menace involves the cultivation of local rice varieties. Local germplasm not only boasts remarkable nutritional and antioxidant profiles but also showcases resistance to blast disease. Landraces exhibit a significantly wider genetic diversity compared to modern varieties, making them valuable contributors to broadening the genetic base of modern cultivars.

Adding to the complexity, nitrogen fertilization plays a decisive role in blast epidemiology. While nitrogen deficiency can trigger phytotoxic responses linked to pathogenicity gene expression in *M. oryzae* (Galhano & Talbot 2011). In contrast, excessive nitrogen significantly enhances disease incidence and severity by increasing tissue susceptibility and canopy density (Bregaglio *et al.* 2017).

This link between nitrogen and blast highlights the relevance of exploring rice production under alternative farming systems. In India, rice is cultivated under diverse practices such as conventional high-input farming, organic farming, and zero budget Natural Farming (NF). NF is considered a "triple-win opportunity" as it reduces input costs, enhances farm incomes, and promotes climate-resilient agriculture (Asokan *et al.* 2020). Being adaptable to all agro-climatic zones (Harini *et al.* 2021). The phrase zero budget refers to zeronet cost of production of all crops (Shyam *et al.* 2020). NF relies on locally available natural inputs such as cow dung, cow urine, jaggery, and incorporates formulations like *Beejamrutha*, *Jeevamrutha*, and biocides such as *Neemastra*, *Agniastra*, and *Brahmastra*.

Keeping this context in view, the present study was undertaken to evaluate the endurance levels of 20 red rice landraces against blast disease. The objective was to identify resistant genotypes and assess how different production conditions particularly conventional and NF systems-affect disease occurrence, thereby providing insights into sustainable strategies for rice blast management.

The experimental material consisted of 20 diverse red rice landraces collected from various rice-growing regions of Himachal Pradesh. For raising the crop under a conventional inorganic system, the recommended package of practices was followed by applying 90 kg N, 40kg P and 40 kg K per hectare. Whole of the dose of P and K was applied at the time of field preparation, while N was applied in two split doses (half dose at three weeks after transplanting and the second 3-4 weeks after the first application).

For raising the crop under the NF system, *Ghanjivamirtha* at 500 kg/ha was applied at the time of final field preparation, which acted as a substrate for the useful microorganisms to stimulate their growth in the field. It was prepared by mixing 100 kg of cow dung with 5 litres of cow urine, 5 kg of jaggery, 1kg of pulse flour, and 500 g of fertile soil. It was accompanied by foliar application of *Jivamurtha* at 21-day intervals until maturity of the crop. Weeds were controlled by manual weeding.

All twenty genotypes were raised in four rowed plots of 3m lengths with line to line and plant to plant spacing of 20cm and 15cm, respectively, in both production conditions. The nursery sowing and transplanting of the material were done on the same date under both systems to nullify the effect of sowing date on the performance of rice genotypes.

The test genotypes were screened under natural epiphytotic conditions in the field using the Standard Evaluation System (SES) of the International Rice Research Institute (IRRI), which employs a 0-9 scale as depicted in Table1.

The genotypes were also assessed for neck blast under natural field conditions during the *Kharif* season of 2022 using the Standard Evaluation System (SES) of the International Rice Research Institute as 0 (No incidence), 1 (< 5%), 3 (5-10%), 5 (11-25%), 7 (26-50%) and 9 (>50%).

The evaluation of 20 rice genotypes under both Natural Farming (NF) and conventional high-input

systems has revealed significant variability in resistance to leaf blast disease. Out of the 20 genotypes evaluated, HPR 2720 and HPR 2795 exhibited complete resistance to leaf blast in both conditions (Table 2), underscoring their potential as sources of stable resistance for breeding programs. Meanwhile, *Lal Nakanda*, *Solan Basmati*, and *Parmal Byada* displayed moderate resistance exclusively under NF, which suggests that the lower disease pressure of NF systems may help certain genotypes perform better than under higher input systems. The majority of genotypes exhibited susceptibility to varying degrees. None of the genotypes showed a highly susceptible reaction in the NF system, while *Karad* and *Gosha* were found highly susceptible under a conventional high-input system, highlighting the possible role of reduced nitrogen availability and reduced plant stress in the natural system suppressing disease severity. The conventional system showed more susceptible genotypes (13), namely *Deval, Ramjuwain, Achhoo, Byla, Phulpatas, Matali Chohortu, Lal Nakanda, Totu, Kalhaina, Bongaldhan, Jattoo and Begmi*, compared to NF(6), namely *Deval, Chohortu, Gosha, Byla, Jattu* and *Karad*. This aligns with the findings that nitrogen management can profoundly influence rice blast severity (Bregaglio *et al.* 2017).

Table 1. Disease rating scale for leaf blast screening (SES, IRRI, 2013)

Scale	Description/ Symptoms
0	No lesions observed
1	Small brown specks of pin-point size or larger brown specks without sporulating center.
2	Small roundish to slightly elongated, necrotic grey spots, about 1-2 mm in diameter, with a distinct brown margin. Lesions are found on the lower leaves.
3	Lesion type is the same as in scale 2, but a significant number of lesions are on the upper leaves.
4	Typical susceptible blast lesions, 2 -3 mm or longer, infecting less than 4% of the leaf area.
5	Typical blast lesions infecting 4-10% of the leaf area.
6	Typical blast lesions infection 11-25% of the leaf area.
7	Typical blast lesions infection 26-50% of the leaf area.
8	Typical blast lesions infection 51-75% of the leaf area and many leaves are dead.
9	More than 75% leaf area affected.

Response of Rice Genotypes to Neck Blast in Different Conditions

Among the genotypes tested, HPR 2720, HPR 2795, and *Bhrigudhan* consistently exhibited resistant reactions to neck blast in both production systems (Table 3), highlighting their value as stable sources of genetic resistance suitable for cultivation across varied agroecological conditions. Their stable resistance under contrasting management suggests the presence of durable resistance genes effective against the pathogen populations. As many as 14 genotypes *viz, Begmi, Phulpatas, Solan*

Table 2. Response of rice genotypes to leaf blast in different conditions

	Conventional Chemical Input System		NF System	
	Genotypes	**% Age**	**Genotypes**	**% Age**
Immune	-			
Resistant	HPR 2795, HPR 2720	10	HPR2720,HPR 2795	10
Moderately resistant	-		*Parmal Byada Lal Nakanda, Solan Basmati*	15
Moderately susceptible	*Parmal Byada, Solan Basmati, Bhrigudhan*	15	*Bongaldhan, BhrigudhanTotu, Kalhaina, Phulpatas, Matali, Achhoo,Ramjuwain, Begmi*	45
Susceptible	*Phulpatas, Deval, Ramjuwain, Achhoo, Byla, Matali, Chohortu, Lal Nakanda, Totu, Kalhaina, Bongaldhan, Jattu, Begmi*	65	*Deval, Chohortu, Gosha, Byla, Jattu, Karad*	30
Highly susceptible	*Karad, Gosha*	10	-	

Table 3. Response of rice genotypes to neck blast in different production systems

	Conventional Chemical Input System		NF System	
	Name of Genotypes	**% Age**	**Name of Genotypes**	**% Age**
Immune	-	-	-	-
Resistant	HPR 2720, HPR 2795,	10	*Bhrigudhan*, HPR 2795, HPR 2720	15
Moderately resistant	*Bhrigudhan*	5	*Parmal Byada*	5
Moderately susceptible	*Phulpatas, Solan Basmati, Byla, ParmalByada*	20	*Begmi, Phulpatas, Solan Basmati, Byla,Totu, Achhoo Jattu,Kalhaina, Ramjuwain, Deval, Matali, Chohortu, Bongaldhan, Lal Nakanda*	70
Susceptible	*Matali, Chohortu, Deval, Bongaldhan, Ramjuwain, Kalhaina, Lal Nakanda,Totu, AchhooBegmi, Jattu*	55	*Gosha, Karad*	5
Highly susceptible	*Karad,Gosha*	10	-	-

Basmati, Byla,Totu, Achhoo, Jattu,Kalhaina, Ramjuwain, Deval, Matali, Chohartu, Bongaldhan and *Lal Nakanda*, were found moderately susceptible to neck blast under the NF system. Under conventional inorganic systems, genotypes such as *Phulpatas, Solan Basmati, Byla, and Parmal Byada* also displayed moderate susceptibility, possibly due to enhanced plant vigour and dense canopy structure induced by high nitrogen fertilization, which favours the pathogen. Moreover, 11 genotypes (*Matali, Chohortu, Deval*, *Bongaldhan, Ramjuwain, Kalhaina, Lal Nakanda, Totu, Achhoo, Begmi* and *Jattu*) exhibited susceptible reaction under the conventional inorganic system, whereas only *Gosha* and *Karad* showed susceptibility under NF, with these two genotypes being highly susceptible in the inorganic system. These results are supported by Bregaglio *et al.,* (2017) they concluded that excessive nitrogen fertilisation increases plant tissue susceptibility and promotes dense rice canopies, both of which correlate with higher incidence and severity of leaf and panicle blast. Dense canopies not only enhance tissue vulnerability but also create a favourable microclimate for pathogen development, thereby facilitating disease establishment and spread (Pangga *et al.* 2013). In contrast, the comparatively lower incidence of susceptibility observed under Natural Farming (NF) may be attributed to its agroecological advantages, particularly the reduced nitrogen inputs and improved soil health conditions. These factors likely suppress disease development or delay pathogen proliferation, thereby contributing to the enhanced resistance stability of genotypes cultivated under NF (Spence *et al.* 2014).

CONCLUSION

Rice leaf blast disease, caused by *M. oryzae* is a major biotic stress affecting rice cultivation in India. In this study, rice genotypes were evaluated under different production systems, revealing variable disease responses. Most genotypes grown under the Natural Farming (NF) system exhibited resistant or moderately susceptible reactions, whereas under the conventional system, the majority showed susceptible to highly susceptible responses. These resistant and moderately resistant genotypes, combined with favourable agronomic traits, represent valuable donor parents for leaf blast resistance breeding programs aimed at developing improved rice varieties.

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