Status of rice diseases in Northern Himalayas: A case study of Himachal Pradesh

Abstract

Rice production around the world is threatened by various disease leading to biotic stress. Surveys during 2022 & 2023 were conducted in eight districts of Himachal Pradesh to assess the status of rice diseases. Seed health status of farmers saved seed was also monitored. Surveys of the crop revealed the occurrence and incidence of varying degrees of diseases viz., bacterial leaf blight, neck blast, sheath rot, false smut, brown spot, narrow brown spot, rice stunting and leaf scald. Association of mycoflorai.e*Ustilaginoideavirens, Pyriculariaoryzae*and *Helminthosporiumoryzae* in farmer saved seed was also observed. The results of this study can be implemented to curtail the yield losses associated with borne diseases and can further improve sustainable rice production in Himachal Pradesh.

Keywords: Seed health, pathogens, diseases, rice, incidence

1. INTRODUCTION

Rice (*Oryzae sativa* L.) is considered as one of the major staple cereal food source for more than half of the world's population and forms a significant component of the energy resource of the human race. According to Udemezue (2018), rice is the world's second most important cereal crop following corn and also one of the food crops mostly grown in tropical and sub-tropical regions of the world. About 522.65 million metric tons (Mmt) of milled rice are produced worldwide each year with 137.83 Mmt being produced in India (USDA, 2024). Rice is an economically and scientifically important crop which is mostly produced and consumed in Asia and African countries (Dede et al. 2019; Islam et al. 2000). With more than 40% of global rice exports, India plays a pivotal role in ensuring food security across the globe. The assessment of seed health standard in rice is very important for farmers and food security as it is a first line approach in managing seed-borne diseases. Furthermore, the quality of planted seeds has a critical influence on the ability of crops to become established and to realize their full yield potential and value (McGee, 1995). Seed-borne diseases may not only introduce new pathogens to affect the quantity or quality of the crop yield but also contaminate the soil permanently (Anselme, 1981). Most crop diseases that are important economically are seed-borne and seed transmitted, including blast disease of rice, bakanae, loose smut, flag smut, karnal bunt, and ear cockle of wheat (Akter and Hossain, 2015). Worldwide, nearly 56 fungal pathogens are reported to infest rice, of which 41 are reported to be seed-borne (Ou, 1985).

Seed health testing to detect seed-borne pathogens is an important step in the management of crop diseases (Ora et al. 2011). It identifies the cause of seed infection that affects the planting value of seed lots. Farmers awareness about the effect of diseased seeds on their production is important and that several routine activities needs to be undertaken during storage to reduce lost. These include dry seed inspection, the standard blotter test for seed infection and contamination, post entry planting for field inspection of undetected plant diseases of seed-borne and seed-contaminated pathogens (Mew and Gonzales, 2002). Seed health testing procedure involves techniques, such as direct examination of dry seeds, examination of germinated seeds, as well as examination of organism (insects and fungal). Therefore, the current survey was carried out to assess seed health status of farmers own saved seeds and to gain insight into the incidence of diseases associated with rice production in varied agro-climatic conditions of Himachal Pradesh.

2. METHODOLOGY

Roving surveys between 2022 and 2023 were undertaken in eight districts of Himachal Pradesh *viz.,*Bilaspur, Chamba, Hamirpur, Kangra, Kullu, Mandi, Sirmour and Una. Various Rice diseases, including false smut, bacterial leaf blight, neck blast, sheath rot, sheath blight, brown spot, and leaf scald, were surveyed. The data on disease incidence and variety infected was collected by assessing upper three leaves of each random tiller from each of the ten random hills from each field and expressed as per cent for each location (Dhruw and Sahu, 2023)

$$\text{Disease Incidence (\%)} = \frac{\quad}{\quad} \times 100$$

The experiments were conducted at the seed pathology laboratory of the Department of Plant Pathology, Chaudhary Sarwan Kumar Himachal Pradesh KrishiVishvavidyalya, Palampur, India between 2022 and 2023 with seeds of seventeen exotic varieties and 1 local variety. Seed samples of exotic varieties include, HPR 2720, Sawa 200, PAC 807 plus, HPR 2612, Az 6508, ShahiDawat, MRP 5632 (Suruchi), PAC 834, HPR 2795, US 312, US 315, Az 6444, Dhanya 834, Varsha Gold, Hyb 25P35, Hyb 257 and Hyb 1067 were obtained from farmers saved seeds to examine the health status. Seed samples were analyzed for the detection of seed borne fungi by following the standard blotter methods by International Seed Testing Agency (ISTA) (Aremu et al. 2021). In Blotter paper method, three pieces of filter paper were soaked in sterilized distilled water and placed at the bottom of 9cm diameter sterilized Petri-dishes after draining out excess water. The experiment was set up in a completely randomized design. Nearly four hundred seed samples were analyzed for presence of seed borne pathogen(s). Seeds of each sample both sterilized (s) and unsterilized (Us), were used in this method with four replications (100 seeds per replication). Sterilization of seeds was done by immersing seeds in sodium hypochlorite solution (1%) for 3 minutes followed by three subsequent washings with distilled water. Seeds were then placed on the moist filter paper at the rate of 10 seeds per Petri dish. The Petri dishes were then incubated at ambient conditions of 25+1□ for seven days. After 7 days of incubation, the seeds were examined for fungal growth under microscope. Slides of different fungal spores encountered were prepared and examined with compound microscope at ×40 magnification to establish identity of each fungus. Percentage occurrence of each fungi noticed was recorded.

3. RESULTS AND DISCUSSION

3.1 Surveys during *Kharif* 2022 and 2023

The results of the disease survey in rice producing areas of Himachal Pradesh revealed that rice seeds collected from various rice growing farmers were infected with fungi organisms which affect the germinability percentage in varying degrees. In 2022, the incidence of false smut, sheath rot was low (5-10%), while high incidence of neck blast disease (15-20%) was observed in Sawa 200 in Kangra district (Figure 1). In Mandi district, the incidence of neck blast was low (10-15%), with a high incidence of false smut disease (20-25%) and sheath rot (15-20%) observed in US 312, US 315 in Balh. In Sirmour district, the incidence of neck blast, sheath rot, sheath blight, brown spot was low (5-10%), with a high incidence of false smut disease (upto 50%). In Una district, the incidence of sheath blight, narrow brown leaf spot was low (3-5%), with a high incidence of sheath rot (10-15%), false smut (upto 30%) observed in Hybrids 25P35, Az 6444 variety (Table 1). In Chamba district, the incidence of false smut, narrow brown leaf spot was low (5-10%), with a high incidence of sheath rot (10-15%) observed in PAC 807 plus variety. In Bilaspur district, the incidence of neck blast was low (1-10%) observed in local grown variety. In Kullu district, the incidence of false smut was low (5-10%), with a high incidence of neck blast (10-15%) observed in local variety. Rice stunting has been observed as an emerging disease in almost all major rice growing areas of Himachal Pradesh affecting almost all the cultivated varieties in the farmers' fields including the hybrids. All the varieties/hybrids *viz.,*Sawa 134, Sawa 234, Buland Raja 88, PR 121were infected with stunting disease. No effect of date of planting was observed on the severity of stunting in most of the rice varieties. Furthermore, during year 2023, bacterial leaf blight, brown spot and false smut incidence was recorded in Sirmour and Kangra districts of Himachal Pradesh. Brown Spot, narrow brown and false smut were also prevalent in all the districts surveyed. However, the incidence of blast was negligible across all the districts with patchy occurrence to an extent of 5 per cent distribution in Kangra and Sirmour districts. Prevalence of other diseases like sheath rot, sheath blight were noticed. Incidence of leaf scald disease was observed in few pockets in surveyed areas of Kangra district in Basmati varieties. Rain, overcast weather, and high relative humidity provide favourable conditions for disease development (Magar, 2015). The intensity of biotic stresses in rice production is increasing at a startling pace because of rapid changes in climate (Jamaloddin et al. 2020). Changing climatic conditions are contributing to the emergence of new virulent pathogen strains and the occurrence of diseases in different localities. Many diseases considered as minor thus far have gained significant economic importance in many rice-growing regions, and are exacerbating their impact (Anderson et al. 2004).

	
Sheath blight of rice	**Smut balls of false smut of rice**
	

Blast of rice	**Brown spot of rice on panicle**

Figure 1: Diagnostic symptoms observed during surveys of different rice diseaseduring *kharif*2022 and 2023

Table 1 Status of diseases in rice hybrids/ improved rice varieties cultivated by farmers in Himachal Pradesh during *kharif*2022 and 2023

Location District/ Blocks (Latitude & Longitude)	Location	Variety	Disease Incidence (%)					
			False Smut	Bacterial Leaf Blight (BLB)	Neck Blast	Sheath Rot	Sheath Blight	Brown Spot (BS)/ Narrow Brown Leaf Spot (NBLS)
Kangra								
Rait (32°11'03"N 76°12'47"E)	Rehlu	HPR 2720	5-10	-	-	5-10	-	-
	Shahpur	Sawa 200	5-10	-	15-20	5-10	-	-
	Shahpur	PAC 807 plus	5-10	-	-	-	-	-
	Dohab	PAC 807 plus	5-10	-	-	-	-	-
Dharamshala (32°13'00"N 76°19'08"E)	Bandi	Sawa 200, PAC 807 plus	10-15	-	5-10	-	-	-
	Gharoh	HPR 2612	-	-	5-10	-	-	-
		HPR 2720	5-10	-	-	5	-	-
	Jadrangal	Local, hybrid	10-15	-	-	5-10	-	-
	Banoi	Az 6508	10-15	-	-	-	-	-
Nagrota Bagwan (32°06'29"N 76°22'56"E)	Chahri	Sawa 200	10-15	-	40-50	10-15	-	-
	Malan	Az 6508	10-15	-	-	-	-	-
	Massal	Sawa 200,	10-15	-	25-30	5-10	-	-

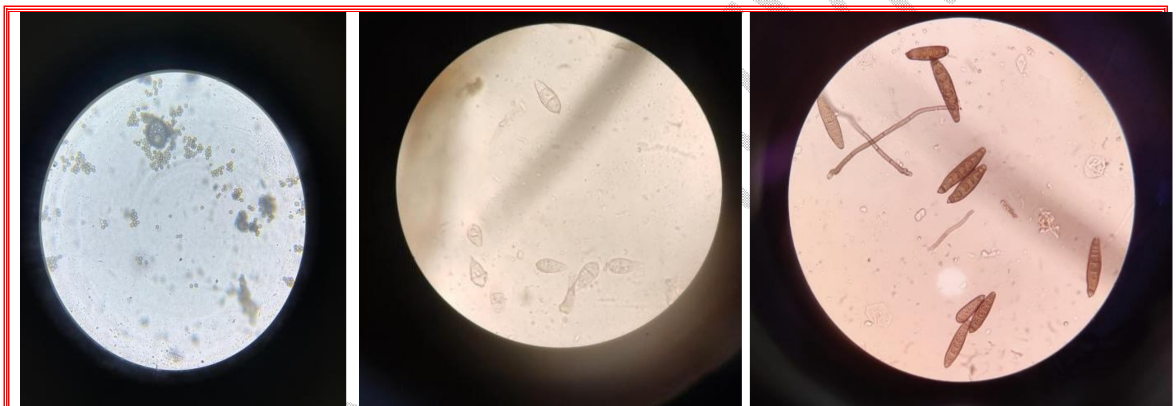
		ShahiDawat						
	Pathiar	MRP 5632 (Suruchi)	10-15	-	-	5-10	-	-
Bhawarna (32°02'41''N 76°29'33''E)	Chimbalhaar	PAC 807 plus	<5	-	-	-	-	-
		HPR 2612	-	-	-	-	-	-
	Bagora	Sawa 200	5-10	-	5-10	5-10	-	-
		PAC 834	5-10	-	-	-	-	-
	Mainjha	PAC 834, Sawa 200	5-10	-	-	5-10	-	-
Mandi								
Sandhol (31°51'31''N 76°39'09''E)	Sandhol	HPR 2795	-	-	-	-	-	-
	Lasrana	Hybrid (Not known)	15-20	-	10-15	15-20	-	15-20 (BS); 40-50 (NBLS)
Balh (31°53'22''N 76°55'15''E)	Galma	US 312	25-30	-	-	5-10	-	10-15 (BS)
	Sundernagar	US 312, US 315	25-30	-	-	5-10	-	-
Sirmour								
Paonta Sahib (30°31'54''N 77°34'02''E)	Dhaulakuan	Az 6444	25-30	-	5-10	5-10	10-15	10-15 BS
	Puruwala	Az 6444, Dhanya 834	25-30	-	5-10	5-10	5-10	10-15
	Surajpur	Az 6444, Varsha Gold	30-35	-	5-10	5-10	10-15	5-10
	Rampur	Hyb 25P35	Up to	-	5	10-15	5-10	5-10

			50%					
	Kolar	Az 6444, Dhanya 834, Varsha Gold	25-30	-	5-10	5-10	10-15	15-20
Una								
Una (31°28'14"N 76°16'07"E)	Rampur	Az 6444	10-15	-	-	-	-	5-10 NBLS/ BS
	Basal	Hyb. 25P35, Az 6444	10-20	-	-	-	-	10 BS
	NangalKhurd	Hyb. 257, Hyb. 1067	25-30	-	-	-	-	10-15 NBLS/ BS
	Nandpur	Az 6444	7-10	-	3	12-15	3	5
	Ispur	Az 6444	3	-	3	12	3	5
	Andora	Hyb. 25P35, Az 6444	8	-	5	10	5	5
	Kuthiari	Hyb. 257, Hyb. 1067	10	-	3	10	5	4
	Chak	Az 6444	5	-	4	10	4	4
	Thathal	Az 6444	5	-	4	8	4	4
Chamba								
Bhatiyat (32°26'57"N 76°00'37"E)	Sihunta	PAC 807 plus	5-10	-	-	10-15	-	5-10 NBLS
Bilaspur								
Bilaspur	Jhandutta	Local	-	-	5-7	-	-	-

(22°04'46"N 82°08'27"E)	Bilaspursadar	Local	-	-	2-3	-	-	-
	Ghumarwin	Local	-	-	10-11	-	-	-
	Nainadevi	Local	-		1-3	-	-	-
Kullu								
Kullu (31°57'16"N 77°06'40"E)	Baragran	Local	10	-	15	-	-	-
	Chhaki	Local	5	-	10	-	-	-
	Naggar Seri	Local	10	-	15	-	-	-
	Haripur	Local	10	-	15	-	-	-

3.2 Seed health status of farmers own saved seeds in Rice

Nearly 400 samples of farmer saved seeds were analyzed for checking the seed health status. In samples collected and analyzed from Hamirpur district revealed 33.33% incidence of false smut and 25.08% incidence of brown spot across varieties such as Sawa 200, Star 795, and LG No. 1. Furthermore, samples from Kangra district exhibited 17.31% incidence of brown spot and 30.77% incidence of false smut, encompassing varieties including HD 3086, HS 562, 5258, GBW 343, 6129, Tanatan, Star795, Sawa 200, LV, 234No., 200 No., and Shriram (Figure 2). In Mandi district, analysis of samples showed 33.33% incidence of false smut and 29.63% incidence of brown spot among varieties such as Tanatan, Star795, Sawa 200, LV, and Chaina. Similarly, Chamba district's samples exhibited a 15.38% incidence of false smut and 7.69% incidence of brown spot across Vijeta 700 and LV varieties. Meanwhile, Una district's samples demonstrated a 50% incidence of false smut and a 20% incidence of brown spot within PR 126 and Star 795 varieties. Lastly, in Sirmour district, examination of samples revealed a 45% incidence of false smut and a 47.5% incidence of brown spot among varieties such as Arize 6444, Pusa 1509, HPR 2795, PR 130, PR126, Lal Killa, Pusa 1121, and Sarvati.



A. Spores of *Ustilaginoideavirens* | **B. Spores of *Pyriculariaoryzae*** | **C. Spores of *Helminthosporiumoryzae***

Figure 2: Microscopic observation of mycoflora associated with false smut, blast and brown spot from farmers saved rice seeds

Seed-borne infections in rice cause 50-80% yield losses, depending on the agroecology, disease severity, and crop susceptibility (Monajjem et al. 2014). Farmers who rely on their farm-saved seeds are likely to contaminate their subsequent seeds for the next planting season in instances where there is seed-borne pathogen transmission from the soil. Most seed-borne diseases caused by the fungi are disastrous as they may decrease seed germination, causing seed discoloration and produce toxins that may be detrimental to man and domestic animals. Association of mycoflora i.e., *Ustilaginoideavirens, Pyriculariaoryzae* and *Helminthosporiumoryzae* in farmer saved seed was also observed (Fig. 2).Distribution of some seed-borne fungi associated with rice seeds has been reported in many countries, including Nigeria (Suleiman and Omafe, 2013); Pakistan (Butt et al. 2011); Egypt (Madbouly et al. 2012); Bangladesh (Ora et al. 2011); Cameroon (Nguefack et al. 2007) and Chad Republic (Serferbe et al. 2016). The results are in agreement with that of Utobo et al. (2011) who reported that *T. padwickii, Ustilaginoideavirens* and *Helminthosporiumoryzae*were the most frequently isolated seed borne fungi irrespective of the source of the rice variety tested in their study. Singh and Brar (2020) recorded minimum neck blast incidence (14 %) in the variety PR 126.Aishwarya et al. (2023) detected and characterized different pathogenic isolates of brown spot and blast disease in Tamil Nadu.

Major resistance genes from different resistance donors have been reported for various rice diseases. To date, over 44 resistance genes have been identified against bacterial leaf blight (Kim and Reinke, 2019). More than 100 distinct blast-resistance genes have been reported across different rice chromosomes, of which 21 have been cloned (Devi et al. 2020). However, no single resistance gene confers resistance to sheath blight. Two major sheath blight QTLs (qShB9-2 and qSBR11-1) have been reported to contribute more than 10% to sheath blight resistance (Jamaloddin et al. 2021). But, thus far, genetic diversity for high resistance/tolerance of sheath blight has not been reported in either cultivated rice or its wild relatives (Bonman, 1992). For bacterial leaf streak (BLS), no major resistance genes (R-genes) have been identified (Bossa-Castro et al. 2018). These resistance genes, though identified in different studies, play a highly connected role in enabling rice to combat invading pathogens. Consequently, the presence or absence of resistance genes significantly influences disease incidence in rice plants infected by various pathogens.

4. CONCLUSION

Roving survey and laboratory experiments were conducted between 2023 and 2024 to determine the occurrence of seed borne-fungi over both the year under study. Standard blotter method was used for assessment. Fungi detected were *Ustilaginoideavirens, Pyriculariaoryzae* and *Helminthosporiumoryzae.*It is evident from the study that seed-borne fungi were associated with all the rice cultivars sampled from the study area. There was high prevalence of storage fungi associated with the rice seeds partly because of the storage practices employed by the farmers. The need to emphasize the role of healthy seed in establishment of a healthy crop is highlight with this work.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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