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RESEARCH ARTICLE

Suitability of Indigenous Rice (*Oryza sativa* L.) Cultivars in Garhwal Hills of Uttarakhand Himalayas based on Seed Quality Parameters

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Hill agriculture systems of Garhwal Himalayas harbour wealth of rice landraces contributing to the agricultural biodiversity of the region. These landraces are an integral part of traditional cultivation systems for these have evolved against the adversities of agroclimatic conditions and have proven their suitability in the prevailing agro-climate of the region. However, intrusion of the high external-input intensive agriculture systems to increase crop productivity is posing great threat to the agro-biodiversity of the crop in the region. This wealth needs to be conserved for sustaining the traditional agriculture through implementation and integration of eco-friendly approaches suiting to the local conditions without harming the crop diversity. In the present study, the comparative suitability of certain widely cultivated landraces confined to mid Himalayan hills in the Garhwal region of Uttarakhand, India, was investigated on the basis of seed quality parameters. Local cultivars China-4, Lal dhan and Rikhwa showed considerably high germination (>90%) despite high levels of seed infection (>35%) like the improved varieties Prasad, PD-10, PD-11 and VL-62. Local cultivars China-4 and Lal dhan showed maximum germination to the range of >90% with high seedling vigour (1500- 2077). The study concluded that local cultivars/landraces showing higher seed vigour despite higher levels of discoloration and seed infection are better suited for cultivation in mid-hills of Uttarakhand.

Key Words: Indigenous, Landraces, Rainfed, Seed quality, Seedborne inoculum.

Introduction

Hill agriculture cropping systems of Uttarakhand falling under Indian Himalayan region, harbour rich crop biodiversity. Rice (*Oryza sativa* L.) traditionally being grown as a major food crop in the region under irrigated condition in the valleys along the river banks as well as under rainfed conditions on hilly terrains, possesses wide genetic variability of landraces cultivated since time immemorial It is locally termed as 'dhan' derived from the literary word 'dhanya' meaning prosperity and is an integral part of folk culture of the region. Under rainfed cultivation, wide array of traditional varieties/landraces is cultivated, making it the largest on-farm repository of traditional varieties in Garhwal Himalaya (Mehta *et al*., 2014). On-farm crop diversity and wild relatives constitute the genetic resources that are the basic requirement for crop improvement to deal with environmental stresses, plant diseases and pests under the climate change scenario. Traditional farming systems have played great role in preserving the crop biodiversity which operate through the human knowledge and cultural practices and have shaped the existing diversity worldwide (Bellon 1991).

This on-farm crop biodiversity of local germplasm, the landraces cultivated since ages, are potentially able to withstand the adverse conditions and are the valuable genetic resource from climate change point of view by virtue of their adaptability to the existing agricultural system. These genetic resources need to be integrated with improved eco-friendly agricultural technologies to improve their performance. Seed treatment is one such low cost technology with high impact on yield however, seed treatment must be recommended based on the level of seedborne inoculum particularly in case of seedborne diseases. Seed borne inoculum not only deteriorates the seed quality but also initiates many crop diseases in the

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field. In case of rice, blast, leaf spot and sheath rot are major seed borne diseases in rainy (*Kharif*) season rice crop in hill regions of Uttarakhand.

Most of the rice growing areas of hilly regions in the state are under local cultivars. Rice (*Oryza sativa* L.), mainly grown in *Kharif* season (April–October) in hilly cropping systems of Uttarakhand, shows tremendous genetic diversity in the region (Rana *et al.,* 2009; Mehta *et al.,* 2014; Agnihotri and Palni, 2007). It is mostly taken as upland rainfed crop in mid and high hills (1200-2500m asl). Natives of the hilly regions traditionally grow different rice cultivars (landraces) as mixed crop (Zhardhari, 2001). The farmers of the region cultivate several landraces of paddy evolved through centuries as a result of climatic selection pressure as well as the wisdom involved in farmers' selection. These landraces are preferred by the farmers of the region over modern high yielding varieties owing to their desirable attributes such as pest resistance, drought-tolerance, high nutritive value, flavour, medicinal properties etc. It is estimated that about three-quarters of the original varieties of agricultural crops have been already lost from the farm fields between 1950 and 1995 (FAO 1997). Therefore, maintaining the crop diversity, collection, characterization, and conservation of traditional indigenous germplasm/ landraces is very essential.

Though monocropping and line sowing of improved varieties is being popularized in some regions of the state, most of the area is still under landraces. The state has 0.3 million ha area under rice cultivation which covers irrigated as well as rainfed rice in hilly areas. The average productivity of the state is as low as 20.39 q/ha. The major constraints to paddy production and productivity in hills are non-availability of quality seed, inadequate irrigation, cold stress and diseases like blast, brown spot & leaf and sheath blight. The farmers keep the seed in their household seed stores and sow it without any seed treatment. Dominance by traditional varieties/landraces (about 65%) is reported under rainfed condition (Mehta *et al.*, 2014). The production technologies of these preferred landraces need to be refined to increase the production and productivity of the crop through adoption of eco-friendly agricultural technologies suitable for the sustainable crop production system without harming the agroecosystems. Improving the seed quality of local germplasm with use of suitable seed treatment chemical or agent is such a technology which advocates minimal use of chemical pesticides at the initial stage itself to restrict the pathogens at the beginning. Good quality seed with low seedborne inoculum load has a role in increasing the production as the seedborne inoculum not only plays important role in deteriorating seed quality but also initiates many seedborne diseases in field. However there is paucity of information on status and level of seed borne inoculum in local cultivars and popular varieties of paddy grown in the region. Therefore, a study was conducted with ten landraces popularly grown in the region and 17 paddy varieties some of which are recommended for the hill regions, to assess the level of seedborne inoculum and its effect on seed quality parameters under mid-hill conditions of Garhwal region of Uttarakhand. The locally grown varieties and landraces were assessed for level of seedborne inoculum and their effect on seed quality parameters. Several fungal plant pathogens like *Bipolaris, Drechslera, Curvularia, Pyricularia* and *Aspergillus* spp. were found associated with seeds.

Materials and Methods

The seed samples of different rice varieties recommended for hill regions were collected from Department of Genetics & Plant Breeding, G.B. Pant University of Agriculture & Technology, Pantnagar and *Vivekananda Parvatiya Krishi Anusandhan Sansthan*, Almora, Uttarakhand, The landraces were collected from fields of local farmers of villages Ranichauri, Jagdhar, Dargi, Weed, Maun, Sabli, Chamba and Nagani in Tehri Garhwal, Uttarakhand (Fig.1). The details of the collection sites and the study material are presented in Tables 1 and Table 2.

Table 1. Geographical location of the villages under the study

S. No.	Place/ Village	Geographical Coordinates		
		Latitude	Longitude	Altitude (m)
1	Chamba	30º 20´ 45.00´´ N	78º 23´ 38.00´´ E	1574
2	Dargi	30º 19´ 13.12´´ N	78º 24´ 30.55´´ E	1722
3	Jagdhar	30º 19´ 24.73´´ N	78º 23´ 55.68´´ E	1504
4	Maun	30º 18´ 12.64´´ N	78º 23´ 44.50´´ E	1651
5	Nagni Sera	30º 18´ 45.51´´ N	78º 20´ 30.00´´ E	1064
6	Sabli	30º 19´ 36.47´´ N	78º 23´ 19.00´´ E	1330
7	Weedh	30º 18´ 49.33´´ N	78º 24´ 56.17´´ E	1617
8	Ranichauri Campus	30º 18´ 44.00´´ N	78º 24´ 42.00´´ E	1815

Seed discolouration percentage was counted on the basis of number of discoloured seeds in each sample.

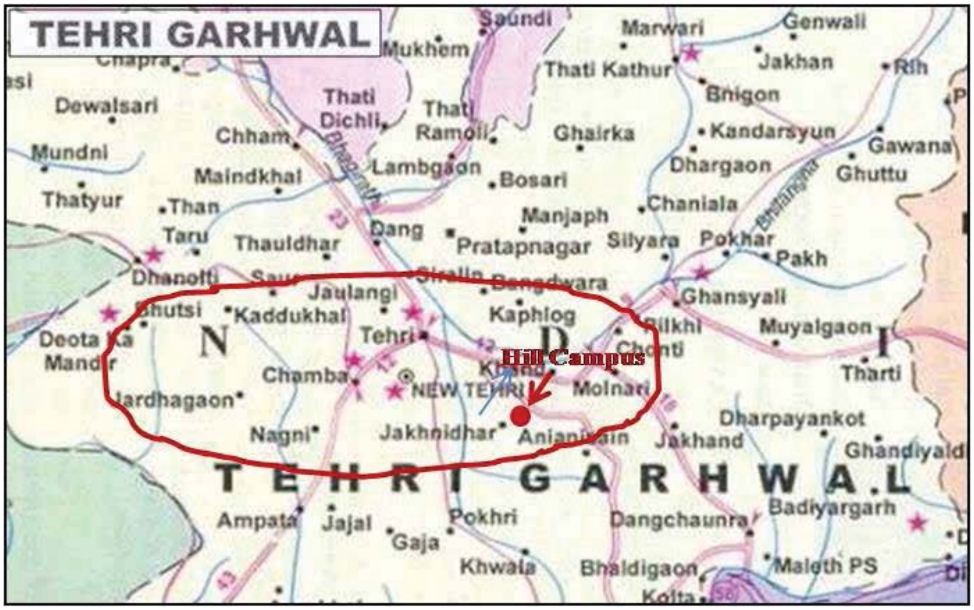

Fig. 1 Geographical location of seed collection villages of the area under study

Table 2. List of rice landraces and varieties collected for the study

S. No.	(a) Land Races	Cultivation condition
1.	China-4	Irrigated
2.	Bauna Dhan	Irrigated
3.	Garuda-Fine	Rainfed
4.	Garuda (Coarse)	Rainfed
5.	Gorakhpuri	Irrigated
6.	Hansraj	Irrigated
7.	Lal Dhan	Irrigated
8.	Raj	Rainfed
9.	Rikhwa (Coarse)	Rainfed
10.	Rikhwa (Fine)	Rainfed
	(b) Varieties	
1.	IR-8	Irrigated
2.	Govind*	Irrigated
3.	Manahar	Irrigated
4.	Prasad*	Irrigated
5.	PD-4	Irrigated
6.	PD-6*	Irrigated
7.	PD-10	Irrigated
8.	PD-11*	Irrigated
9.	PD-12	Irrigated
10.	Pant Sugandh Dhan-15 (PSD-15)	Irrigated
11.	PD-16	Irrigated
12.	Pant Sugandh-17 (PS-17)	Irrigated
13.	VL-62*	Irrigated
14.	VL-82*	Irrigated
15.	VL-206*	Rainfed
16.	VL-221*	Rainfed
17.	PRR-2	Rainfed

* Varieties recommended for hill regions

Seed infection was detected by standard Blotter Paper method and fungi associated with discoloured seeds were isolated by standard Agar Plate method (ISTA 1993) and percentage was calculated. Fungi associated with discolorations, observed in standard Agar Plate method, were isolated, purified and identified by observing the characteristics of fungal colony on PDA, sporulation, conidial characteristics, fruiting structures, etc. developed on the seed surface with the help of identification manuals (Mathur and Cunfer 1993). Seed germination percentage was estimated by using standard Rolled Paper Towel method (ISTA 1999). Test weight was taken for 1000 seeds. The seedling vigour index was calculated by the formula given by Abdul-Baki and Anderson (1973).

Seedling Vigour Index = Germination (%) × Seedling length (cm)

The data obtained was subjected to statistical analysis.

Results and Discussion

Germination percentage of locally cultivated landraces like China-4 (93%), Rikhwa (92%) and Lal dhan (91%), was recorded higher than varieties like VL-206 (91%), PD-10 (88%) and IR-8 (84%). Among varieties, the test weight (1000 seed weight) was recorded maximum for VL-82 (3.26g) followed by PD-4 (2.668). However among landraces, it was maximum for Bauna Dhan (2.56g) followed by Hansraj 2.509g (Table 3a and 4a). It was positively correlated with Seed Vigour (Table 5).

Table 3(a). Seed quality parameters of different rice landraces

S. No.	Landraces	Germination (%)	Root Length (cm)	Shoot Length (cm)	Test weight (1000 grain wt.) (g)	Seed Vigour Index
1	China-4	93	9.47	8.77	2.358	1691.19
2	Bauna Dhan	68	6.92	7.35	2.561	976.88
3	Garura (Fine)	82	8.55	9.52	2.284	1480.92
4	Garuda Coarse	62	11.38	11.90	2.237	1451.67
5	Gorakhpuri	82	8.82	7.90	2.457	1362.88
6	Hansraj	48	8.72	8.08	2.509	811.62
7	Lal Dhan	91	8.65	14.22	2.319	2077.53
8	Raj	68	6.17	8.10	1.693	966.88
9	Rikhwa (Coarse)	92	11.80	10.65	2.477	2065.77
10	Rikhwa (Fine)	35	6.25	5.83	1.516	421.51

Table 3(b). Seed health parameters of different rice landraces

S. No.	Landraces	Seed Discoloration (%)	Seed Infection (%)
1	China-4	21	35
2	Bauna Dhan	27	40
3	Garuda (Fine)	25	00
4	Garuda Coarse	14	10
5	Gorakhpuri	24	00
6	Hansraj	22	10
7	Lal Dhan	12	25
8	Raj	15	45
9	Rikhwa (Coarse)	11	15
10	Rikhwa (Fine)	6	35

Table 4(a). Seed quality parameters of different rice varieties

S. No.	Varieties	Germination (%)	Root Length (cm)	Shoot Length (cm)	Test weight (1000 grain wt.) (g)	Seed Vigour Index
1	IR-8	84	6.70	5.20	2.144	1015.69
2	Govind	79	10.61	8.58	2.005	1516.61
3	Manahar	77	11.08	7.48	2.032	1426.12
4	Prasad	95	4.55	7.53	1.913	1149.37
5	PD-4	72	7.08	8.60	2.668	1141.11
6	PD-6	72	6.30	8.15	1.793	1041.81
7	PD-10	88	7.27	8.12	2.234	1355.54
8	PD-11	81	10.20	8.25	2.437	1492.62
9	PD-12	77	6.99	9.55	2.440	1272.92
10	Pant Sugandh Dhan-15	66	7.93	7.78	1.843	1037.36
11	PD-16	67	8.92	7.38	2.319	1097.57
12	Pant Sugandh-17	58	7.40	5.25	1.948	724.53
13	VL-62	88	8.75	9.28	2.430	1587.10
14	VL-82	85	7.68	9.78	3.260	1488.20
15	VL-206	91	4.40	6.63	2.345	1004.71
16	VL-221	80	9.35	9.88	2.481	1532.12
17	PRR-2	66	11.56	10.86	2.021	1480.12

* Each digit is a mean of three replications

Higher root length in landraces / varieties of rainfed conditions was observed as compared to varieties. It was maximum in Rikhwa (11.8 cm.), followed by Garuda (coarse) and PRR-2 (11.6cm). Higher seed vigour was observed in Lal Dhan, Rikhwa, China-4 as compared to Govind, Manahar, PD-11, VL-62, Vl-221 etc. Seed vigour was maximum (2065.77) in Rikhwa followed by the most popular local cultivar under irrigated condition *i.e.* China-4 (1691.19).

Inoculum load, in terms of per cent seed discolouration and per cent seed infection, and seed quality parameters of all the varieties and landraces were determined to assess the impact of seed borne fungi on seed quality. Seed discolouration ranged from 6 per cent to 27 per cent resulting in 0 to 40 per cent seed infection in local cultivars. For rice varieties it ranged from 6 per cent (VL-221) to 51 per cent (Prasad) resulting in seed infection in the range of 0 per cent (IR 8 and VL-82) to 50 per cent (VL-62). Per cent seed discolouration and seed infection (Table 3b and 4b) was lower for varieties grown under rainfed conditions (VL 206 and VL 221) (Fig.2a and 2b).

Fig. 2(a). Types of seed discolouration in rice landraces

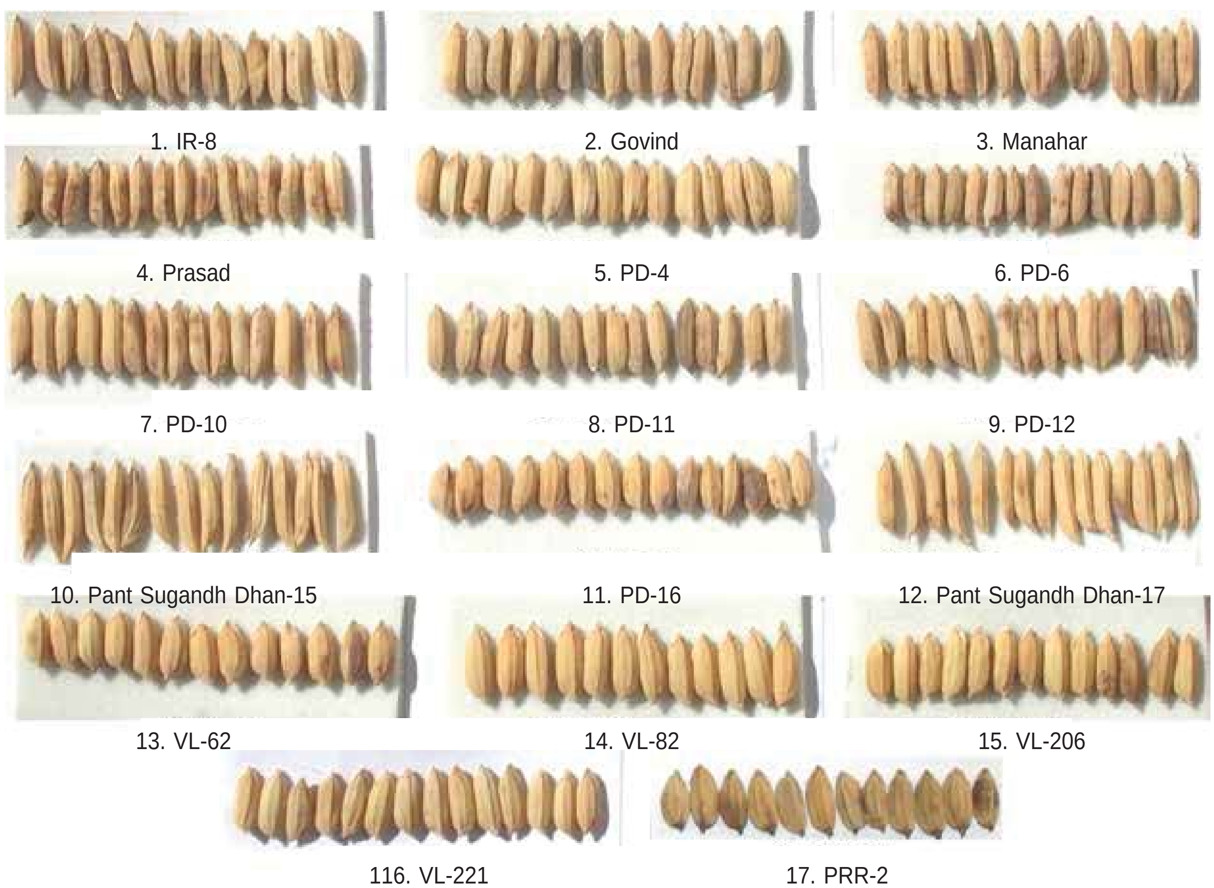

Fig. 2(b). Types of seed discolouration in rice varieties

Seed discoloration, an indicative of seedborne inoculum, showed positive correlation with seed infection as reported earlier (Querijero *et al.,* 1993) and infected seeds exhibited association of fungi like *Bipolaris* sp., *Drechslera* sp., *Curvullaria* sp., *Pyricularia* sp. and *Aspergillus* sp., in confirmation with earlier reports (Misra *et al.,* 1990; Ou 1985; Querijero *et al.,* 1993, Srinivas and Ramakrishna 2002; Srinivas and Ramakrishna 2005). Bhat *et al.* (2009) reported eight fungal genera associated with glume discolouration of paddy including species of *Helminthosporium, Curvularia, Pyricularia and Aspergillus* as reported in the study.

Highest seed vigour was recorded for landraces like Lal dhan (2077.53) followed by Rikhwa (course) (2065.77) and China-4 (1691.19) with high germination (>90 per cent) which was more than in case of the improved varieties like VL-62 (1587.1), VL-221 (532.12), PD-11 (1492.6). Among varieties, germination was observed in Prasad (95%), Vl-206 (91%) and VL-62 (88%). The seedling root length was recorded maximum for land races like Rikhwa-coarse (11.8 cm), Garuda coarse (1.38 cm), China-4 (9.47 cm) and Lal dhan (8.65 cm). The maximum root length was observed in case of PRR-1 (111.6 cm), Manahar (11.08 cm), Govind (10.61 cm) and PD-11 (10.2 cm) varieties. The extensive root system in case of landraces as compare to improved varieties makes them able to withstand water stress under rainfed conditions. Bisht *et al.* (2007) have reported extensive root system, grain yield and recycled biomass in case of one of the popular landraces Lal dhan.

The data presented in Table 6 indicated that per cent germination showed negative correlation to the per cent seed infection however, root length was negatively correlated to per cent seed infection and per cent seed discolouration, indicating that per cent seed discolouration an indicative of seed infection, was responsible for reducing the seed germination as reported earlier (Misra *et al.,* 1990). Similar observations were made by Ou, (1985) and Querijero *et al.* (1993). Per cent seed infection and per cent seed discolouration showed negative correlation with seed vigour. The results of genetic and phenotypic coefficient of variability and heritability estimation (table 6) showed minimum heritability of root length (2.59%) indicating that root length is influenced by environmental conditions *i.e.* moisture stress under rainfed condition and cannot be preferred for selection as it has been reported that characters with high heritability could be used as powerful tool in selection process as these characters are less influenced by the environment (Panse & Sukhatme, 1995). However, a few landraces cultivated since ages by the locals and improved varieties released for the rainfed agricultural system showed their adaptability to the changing climate in terms of root length and high seedling vigour.

The study revealed that seed discoloration, an indicative of seedborne inoculum, reduced the seed vigour. Germination percentage, root length and shoot length were adversely affected by seed discolorations (Fig. 3). Higher root length observed in landraces indicated their suitability for cultivation under rainfed conditions. Therefore, local cultivars with extended / deep root-system (e.g. Rikhwa-coarse, Garuda-coarse, China-4 and Lal dhan), can better withstand the water scarcity and show higher seed vigour despite higher levels of discoloration and seed infection and can be better suited for cultivation with appropriate seed treatment, under rainfed condition in mid-hills of Uttarakhand. The suitability and preference of indigenous landraces, owing to their tolerance/ resistance to existing biotic and abiotic stresses and superior nutritional traits has been well documented (Agnihotri *et al.,* 2007; Maikhuri *et al.,* 2001). The native microfloras are also likely to play an important role in naturally restricting the seed borne pathogens (Srinivas and Ramakrishna 2003; Srinivas and Ramakrishna 2005) in the crop micro-ecosystems.

Table 4(b). Seed health parameters of different rice varieties

S. No.	Varieties	Seed Discoloration (%)	Seed Infection (%)
1	IR-8	26	00
2	Govind	21	35
3	Manahar	26	20
4	Prasad	51	20
5	PD-4	15	15
6	PD-6	29	55
7	PD-10	40	20
8	PD-11	26	50
9	PD-12	41	25
10	Pant Sugandh Dhan-15	27	25
11	PD-16	26	35
12	Pant Sugandh-17	13	10
13	VL-62	10	50
14	VL-82	10	00
15	VL-206	7	05
16	VL-221	6	00
17	PRR-2	30	45

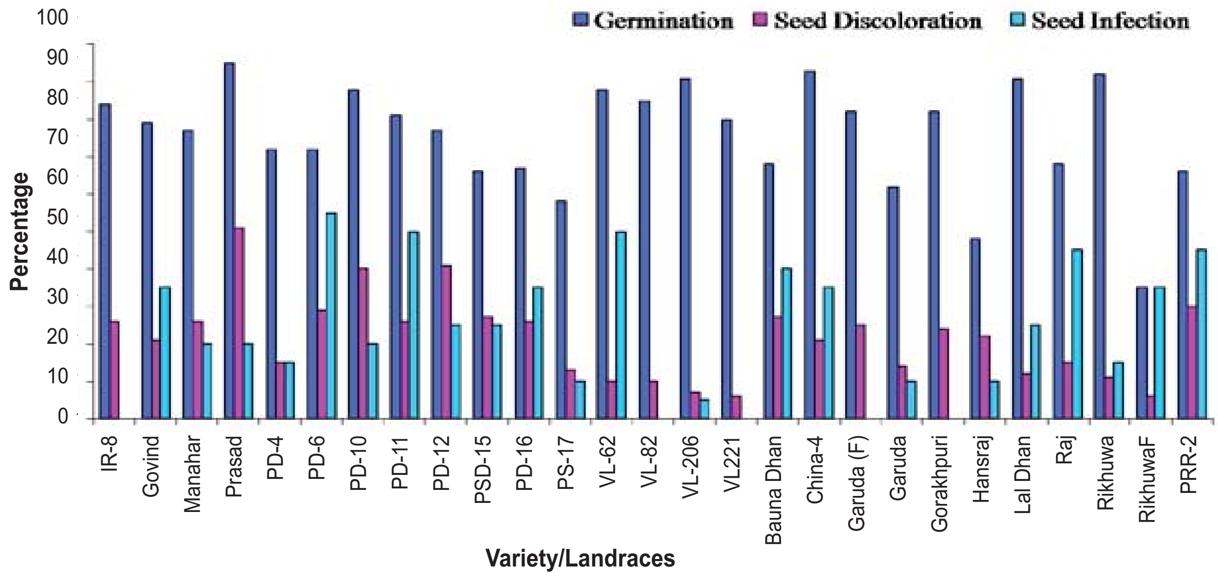

Fig. 3. Effect of seed discolouration and infection on seed germination

Table 6. Genetic and Phenotypic Coefficients of Variability in Rice

	Mean	Range	Genetic Coefficient of Variability	Phenotypic Coefficient of Variability	Heritability
Germination %	75.81	35-95	18.37	19.41	89.53
Root Length (cm)	9.75	4.4-11.8	18.17	22.83	2.59
Shoot Length (cm)	8.54	5.2-14.2	19.77	25.44	60.41
Test weight(g)	2.12	1.52- 3.26	53.16	56.86	87.41
Seed Vigour	1284.1	422- 2078	30.81	27.48	79.53

The rainfed agro-system of Garhwal Himalaya is well-known as the largest repository of traditional varieties. Furthermore, in view of rapid drop in the crop diversity over the past few decades, it is the need of the hour to conserve these landraces that are being protected by local farmers, to conserve crop diversity of the region.

Conclusion

The traditional landraces have shown better preferences owing to their inbuilt and adapted traits suitable to the agroclimatic situation of mid Himalayas. However, modern agricultural technologies which have been proved to improve the crop yields to great extent, at the same time have also resulted in considerable loss of agricultural biodiversity in the region for last three-four decades. Therefore, it is a cause of concern to conserve the existing crop diversity to stop genetic erosion and to maintain the sustainability of hill agroecosystems. The local germplasm, the landraces being cultivated for centuries, are well suited to rainfed hill agriculture. The higher root length in case of landraces as compare to improved varieties seems to be a desirable attribute to make them suitable to tolerate the moisture stress posed under rainfed agriculture system of hill region. However, the high level of seedborne infection in landraces needs to be managed and minimized to improve their performance. These landraces need to be conserved and brought to the forefront of sustainable hill agricultural system, with adoption of eco-friendly agricultural technologies like seed treatment with eco-friendly bio-fungicides, botanicals or safe chemical fungicides for management of the initial seedborne infection to improve the germination and overall performance.

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