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Evaluation of red rice (*Oryza sativa* L.) local germplasm collected from Himachal Pradesh

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Abstract

Rice with red bran layer is called red rice. Most of the Indian states consume white rice however, in some states like Kerala and Himachal Pradesh red rice is also consumed. Red rice is preferred because of its special features of medicinal value and culinary properties. An experiment was conducted at Rice and Wheat Research Station, Malan to evaluate thirty red rice local germplasm collected from different areas of Himachal Pradesh for six agro-morphological traits viz. days to 50% flowering, days to 75% maturity, plant height (cm), total number of tillers per plant, panicle length and grain yield (q/ha). Analysis of variance revealed that there was sufficient variability for grain yield and agro-morphological traits. Total tillers per plant were significantly and positively correlated with grain yield. High heritability and moderate genetic advance were observed for plant height while, high heritability coupled with low genetic advance was observed for rest of the traits. Moderate GCV and PCV were recorded for plant height and grain yield. Moderate genetic advance was recorded for plant height only. Broadly all the local germplasm were dispersed into two clusters i.e. cluster 1 and cluster 2. Cluster 1 consisted of 3 lines viz. Bayal -k, Bayal -1 and Bayal -p while, cluster 2 contained 27 lines. Cluster 2 was subdivided into two clusters, cluster 2A and cluster 2B consisted of 6 and 21 lines, respectively. Based on agro-morphological traits, cluster 1 and 2 were distant clusters, so lines from these clusters could be selected for hybridization programme. On the basis of mean performance, local germplasm lines ie. Kali Jhini 1, HPR 2800 and Lal Jhini were selected and can be used in breeding programme for the improvement and development of new red rice cultivars.

Key words: Cluster analysis, genetic advance, heritability, parameters of variability, red rice.

Rice is grown worldwide over an area of 160.76 million hectares with total production of 740.08 million tonnes (Anonymous 2018). In India rice is grown in an area of 43.70 million ha with production of 110.15 million tonnes and productivity of 2416 kg/ha (Anonymous 2018). In Himachal Pradesh, the crop occupies an area of 62.76 thousand ha with a production of 135.48 thousand tones (Anonymous 2018-19). However, in addition to common rice, red rice is specialized rice with medicinal and culinary properties. Red rice grows faster and produces more tillers and seeds as compared to cultivated rice (Estorninos *et al.* 2002). Red and black rice varieties have more deposition of anthocyanin pigmentation in pericarp, seed coat or aleurone layer (Chaudhary 2003). Loci *Rc* responsible for brown pericarp and seed coat and *Rd* for red pericarp and seed coat are jointly responsible for red seed colour (Kato and Ishikawa 1921). Red pigmented rice grain contains pro-anthocyanidin, a condensed tannin (Oki *et al.* 2002) and red pigment serves as a powerful antioxidant. Traditional red grained varieties possessed significantly higher antioxidant capacity and total phenolic content both in bran and brown rice (Gunaratne *et al.* 2013).

In Himachal Pradesh, rice is grown in diverse agro-climatic conditions and there is a great variability among the red rice landraces. Hence, to develop high yielding red rice cultivars, characterization of available germplasm with respect to yield and yield

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contributing characters is a pre-requisite. Variance of relatively highly heritable quantitative trait provides an estimate of genetic diversity (Rabbani *et al.* 1998) and assessment of genetic diversity and variability could lead to identification of superior genotypes which can be utilized in breeding programme. Hence, present study was undertaken to determine correlation coefficient between yield and yield components in red rice local germplasm for selection of desirable plant types for their effective utilization in breeding programmes.

Materials and Methods

Thirty local red rice germplasm collected from different rice growing areas of Himachal Pradesh (zone II) including two checks (HPR 2720 and HPR 2795) were evaluated for six agro-morphological traits at CSK Himachal Pradesh Agricultural University, Rice and Wheat Research Station, Malan during *kharif* 2018. Nursery of the test genotypes were raised on dry, clean seedbeds. Thirty days old seedlings were transplanted in randomized complete block design in two replications with a single plant/hill. Recommended package of practice was followed to raise the crop. The detailed information about the local germplasm collected is listed in Table 1. The data were recorded on five randomly selected competitive plants for agro-morphological traits viz. days to 50% flowering, days to 75% maturity, plant height, total tillers/plant, panicle length and grain yield/plot. The data were analyzed using free online software OPSTAT for calculating mean value, analysis of variance (ANOVA), correlation, heritability (broad sense), genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV). Cluster analysis was conducted using Ward's method (Mohammadi and Prasanna 2003) based on mean value of each trait using software SPSS version 16.0 for windows.

Results and Discussion

Analysis of variance revealed that there was significant variability for days to 50% flowering, days to 75% maturity, plant height (cm), number of tillers/plant, panicle length (cm) and grain yield (q/ha). Presence of variability was attributed to diverse source of local germplasm and as has been reported by Talukdar *et al.* (2017), it allowed great scope for selection of promising lines in the present germplasm. ANOVA for yield and agro-morphological traits under study is given in Table 2.

Table 1. List of local germplasm along with place of collection (Zone II of Himachal Pradesh)

S. No.	Place of Collection	Genotypes	S. No.	Place of Collection	Genotypes
1	Bir	Kalu Dhan-p	16	Dadh	Jhini Green/White
2	Malan	HPR 2795 (c)*	17	Dadh	Jhini-Dadh
3	Malan	HPR 2800	18	Dhaloon Pathiarkar Range	Local Parmal
4	Panjala	Sathu Dhan	19	Dhaloon Pathiarkar Range	Local Jhumka
5	Malan	HPR 2720(c)*	20	Mandi	Rohru Local
6	Sudhedh local	Sudhedh Local	21	Bayal	Bayal –dh
7	Sudhedh Dharamshala	Kaluna Dhan	22	Bayal	Bayal –k
8	Sudhedh Dharamshala	Ram Jwain	23	Bayal	Bayal –c
9	Jadrangal	Chinu Dhan	24	Bayal	Bayal –de
10	Rakh Gopalpur	Red China	25	Bayal	Bayal –l
11	Jadrangal	Kali Jhini -j1	26	Bayal	Bayal –p
12	Jadrangal	Parmal Dhan	27	Bayal	Bayal –s
13	Jadrangal	Kali Jhini -j2	28	Karsog	Karsog Local
14	Bhagotla	Lal Jhini	29	Chachia	Kali Jhini 1
15	Dadh	Jhini Red/Black	30	Chamotu	Kali Jhini 2

Zone II of Himachal Pradesh ranges from 651 -1800 amsl, includes district Chamba, Mandi, Kangra, Kullu, Rampur tehsil of Shimla, Sirmaur and Solan * (c) checks

The estimated value of range, parameters of variability (PCV and GCV), heritability (broad sense) and genetic advance (GA) as percentage of mean for different traits are presented in Table 3. A wide range of variability was observed for all the traits. A comparison of GCV and PCV of various traits are depicted in Fig. 1. GCV and PCV help in prediction of variation in germplasm which helps in formulation of an efficient breeding programme (Shahidullah *et al.* 2010). High heritability for days to 50% flowering, 75% maturity, plant height and panicle length indicated that these traits were under genetic control and fewer genes control these traits (Fu and Somers 2009; Mohammadi *et al*. 2010) hence, to improve these traits breeding programmes without progeny test may be used. Traits with high heritability allow effective selection (Amiri *et al.* 2018).

Table 2. Analysis of variance for yield and agro -morphological traits

Source of variation	Degree of freedom	50% flowering	75% maturity	Plant height (cm)	Tillers/plant	Panicle length (cm)	Yield (q/ha)
Replication	1	43.35	0.06	6.70	1.23	5.43	40.39
Treatment	29	114.17**	103.28**	693.90**	4.03**	24.39**	68.60**
Error	29	17.83	10.89	28.52	1.14	2.00	2.00

** significant at P=0.01

Table 3. Range, heritability, GCV, PCV and genetic advance of different traits

S. No.	Traits	Range	GCV	PCV	Heritability	GA
1	Days to 50% flowering	85.00-108.50	7.18	8.40	72.98	12.21
2	Days to 75% maturity	113.50-142.50	5.29	5.88	80.91	12.59
3	Plant height (cm)	76.15-142.20	16.91	17.62	92.10	36.06
4	No. of Tillers/plant	5.40-11.10	14.69	21.17	48.17	1.63
5	Panicle length (cm)	14.47-31.66	13.95	15.14	84.79	6.34
6	Yield (q/ha)	22.30-46.36	20.14	20.74	94.33	11.54

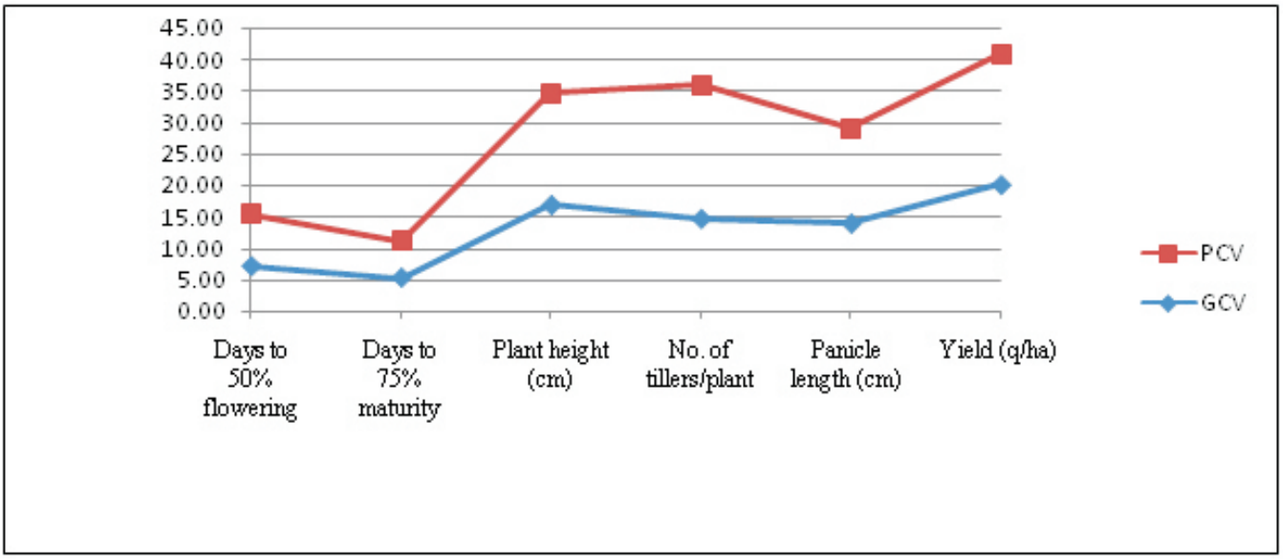

Fig. 1 Comparison of GCV and PCV of different traits in 30 local red rice genotypes

Days to 50% flowering: Earliness is a desirable trait in rice to reduce biotic and abiotic stress. Days to 50% flowering of different genotypes ranged from 85.00 to 108.50 days with a mean of 96.65 days. Lines Bayal –s was found significantly superior to standard check HPR 2720. Additionally, twenty seven germplasm lines were at par with the best performing check HPR 2720. A wide range indicated sufficient variability was present and can provide better scope for improvement in terms of earliness.

Days to 75% maturity: Days to 75% maturity of different genotypes ranged from 121 to 140 days with a mean of 128.30 days. Among the red rice local germplasm twenty three genotypes were at par with the best performing check, HPR 2720.

Plant height: Plant height of different genotypes ranged from 83.55 to 140.40 cm with a mean of 128.33 cm. Genotypes, Sudhedh Local, Kaluna Dhan, Lal Jini, Jhini red and Dhaloon Pathiarkar were found significantly superior to the standard check, HPR 2795. Additionally, thirteen lines were found to be at par with the best performing check, HPR 2795.

Total tillers/plant: Total tillers/plant ranged from 5.15 to 9.85 with a mean of 7.80. Among test red rice germplasm twenty three lines were at par with the standard check, HPR 2795.

Panicle length: Panicle length of the test genotypes ranged from 18.02 to 27.18 cm with a mean of 23.98 cm. Twenty six germplasm lines were found to be at par with standard check, HPR 2795.

Grain yield: Grain yield ranged from 23.30 to 46.36 q/ha with a mean of 28.64 q/ha. Genotypes HPR 2800, Ram Jwain, Parmal Dhan, Lal Jhini, Jhini white, Jhini-Dadh and Kali Jhini 1 significantly outyielded the standard check HPR 2795 and 22 genotypes were at par with the standard check HPR 2795. Based on the mean performance of local germplasm lines, genotypes Kali Jhini 1, HPR 2800 and Lal Jhini were selected as the best local red rice germplasm for utilization in breeding programme for the improvement and development of new red rice cultivars.

Parameters of variability

Simple selection method could not be used for improvement of traits with small genetic variance (Ghafoor *et al.* 2001) hence, estimation of parameter of variability is required in breeding programmes. Estimates of both GCV and PCV were low for 50% flowering and 75% maturity while, GCV estimates were low and PCV was moderate for total tillers/plant and panicle length. Moderate GCV and PCV were observed for plant height and grain yield. The mean grain yield was the highest in genotype Kali Jhini (46.34) followed by 39.54 and 35.91q/ha in HPR 2800 and Lal Jhini, respectively. Heritability is a measure of genetic relationship between parents and their offsprings, it is widely used to determine the degree to which a trait may be transmitted from parents to its offsprings. Broad sense heritability estimates provide information on relative magnitude of genetic and environmental variation in the population (Marwede *et al.* 2004). High heritability and moderate genetic advance were observed for plant height while high heritability coupled with low genetic advance was observed for rest of the traits. A comparison among heritability and GA of various traits under study are depicted in Fig. 2. Magnitude of GCV was lower than the corresponding PCV for all the traits as reported by Kumar *et al.* (2014) and Devi *et al.* (2017), denoting that apparent variation is not only due to genotypes but also due to influence of environment. Similar results were also reported by Kumar *et al.* (2020). A wide difference between GCV and PCV implied their vulnerability to environmental fluctuations however, its narrow difference revealed their resilience to environmental fluctuations.

Correlation studies

Total tillers/plant were significantly positively correlated with grain yield among the six traits studied hence, it can be used to increase grain yield in breeding programmes (Aghaee *et al.* 2010). Correlation coefficient, shows an association among the traits which are not sufficient to describe their relationship when it is needed (Toker and Cagirgan 2004). Days to 50% flowering showed positive correlation with 75% maturity, plant height and panicle length at both genotypic and phenotypic level. Days to 75% maturity depicted positive correlation with plant height, panicle length and total tillers/plant at both the genotypic and phenotypic level. Plant height had positive correlation with panicle length at both genotypic and phenotypic levels whereas, it was positively correlated with tillers/plant at genotypic level only. Total tillers/plant

showed positive correlation with panicle length at both genotypic and phenotypic level (Table 4).

Genetic diversity

The test germplasm were dispersed into two clusters i.e. 1 and 2 (Fig. 3). Cluster 1 comprised three genotypes and cluster two was subdivided into clusters, 2A and 2B. Cluster 2A comprised six germplasm lines and 2B consisted of rest of twenty one genotypes. On the basis of ago-morphological traits cluster 1 and 2 were distant clusters, so the local germplasm lines from these clusters could be identified/extracted for hybridization programme. Genotypes in nearby clusters could be harnessed for back cross breeding programme (Khodadadi *et al*. 2011) hence, genotypes Sathu Dhan and Karsog Local can be used for backcross breeding. The highest genetic distance observed between genotypes Sathu Dhan and Bayal -p germplasm lines showed that the hybrid of germplasm with maximum distance resulted in the high yield and the cross between this germplasm can be used in breeding programmes to achieve maximum heterosis (Rahim *et al*. 2010).

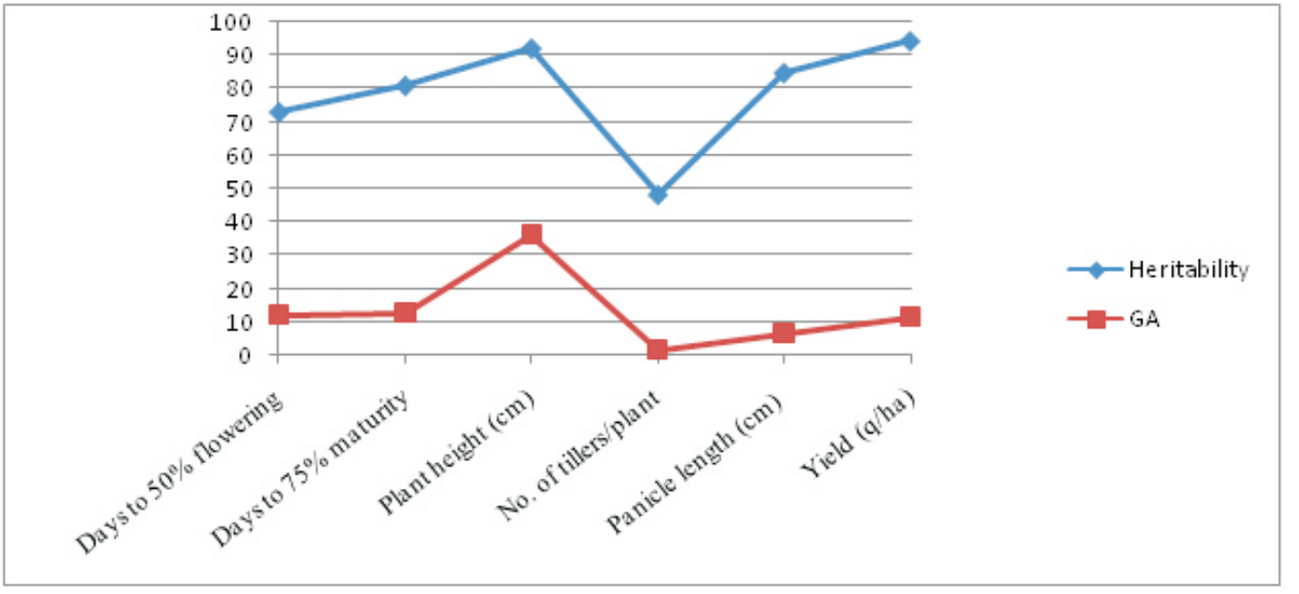

Fig. 2 Comparison of heritability and genetic advance of different traits

Table 4. Genotypic and Phenotypic correlation coefficient among yield and yield attributing traits

		75% maturity	Plant height	Tillers/plant	Panicle length	Yield
50% Flowering	P	0.831**	0.280*	0.196NS	0.451**	0.203NS
	G	0.903**	0.305*	0.157NS	0.497**	0.232NS
75% maturity	P		0.350**	0.268*	0.363**	0.013NS
	G		0.375**	0.382**	0.392**	0.006NS
Plant height	P			0.239NS	0.383**	-0.066NS
	G			0.300*	0.443**	-0.050NS
Tillers/plant	P				0.299*	0.316*
	G				0.283*	0.506**
Panicle length	P					0.036NS
	G					0.023NS

*,** and NS significant at P<0.05, P≤0.01 and non significant, respectively

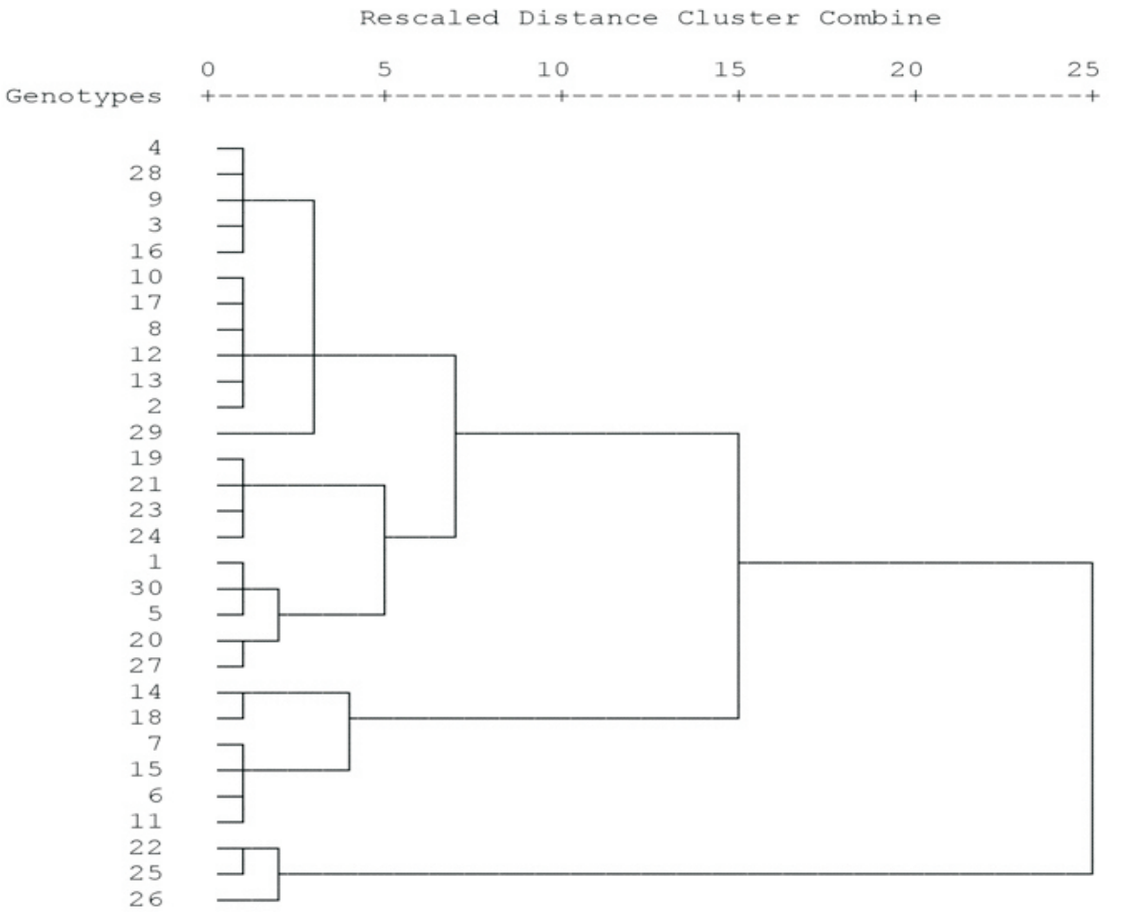

Fig. 3 Cluster diagram of thirty local red rice germplasm for six variables studied using hierarchical cluster analysis (Ward's method)

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