Adaptive Variations in Different Populations of Two Locally Common Rice Landraces of Uttarakhand State for Morphological Traits

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Abstract

Variations due to environmental adaptations among different populations of two locally common landraces Jaulia and Thapachini from niche environments of Uttarakhand Himalaya were studied. Wide variations for various agronomic traits like grain yield per plant, number of grains per panicle, grain length and width, etc. among different populations of both landraces were recorded. Agronomically superior types in populations of both named landraces could be identified. The multivariate analysis also revealed that landraces could readily be improved by identifying and intercrossing the promising genotypes under farmer management.

Key words: Rice (*Oryza sativa* L.), adaptive variations, locally common landraces

Introduction

A large number of rice landraces are maintained in traditional production system of Uttarakhand Himalayas (Bisht *et al*. 2006, 2007; Kumar *et al*. 2010; Pandey *et al*. 2011). About 300 rice landraces have been collected from parts of the region during recent past (2001-2007) and are being maintained ex situ in National Genebank at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi. Among the traditional landraces grown in middle and higher Himalayan ranges of Uttarakhand, a few are common and majority are rare. The locally common varieties are those varieties that appear to be particularly important for farmers for certain specific objectives. One might expect them to have a high proportion of locally common alleles of adaptive significance and therefore to be particularly important for conservation and particularly interesting for users (Jarvis *et al*. 2000; Bisht *et al*. 2006, 2007; Kumar *et al*. 2010).There are two measures to classify each landrace according to whether or not it is widespread (occurs in more than a few fields) versus localized (restricted to a few fields), and secondly whether it is common (here defined as grown at least on some farms, in large numbers, in above-average field sizes) versus rare (in small fields only). Jaulia (upland) and Thapachini (irrigated) are two important locally common landraces of Uttarakhand state. As rice has a long history of cultivation in this region we expect evolutionary and adaptive changes in different populations of same named landrace in different niche environments under farmer management. Evolutionary changes in the above named locally common landraces of rice from the region have been reported in earlier investigations (Kumar *et al*. 2010). Adaptations due to environmental variations in different populations of these two landraces have been investigated in this paper. It would suggest possibility of using the useful genetic variations in these landrace populations for improved yield and a better utilization of these products in agriculture.

Materials and methods

The experimental material comprised six populations each of two locally common landraces Jaulia and Thapachini assembled during 2006-07 cropping season from different niche environments spanning about 3000-4000 km^2 geographical area and altitudes ranging from 900 to 1700 masl of Uttarakhand Himalayas following appropriate sampling strategy. The passport information on the origin of accessions is given in Table 1. The impact of improved modern varieties, in general, is low in the region and largely traditional agriculture is practiced.

These populations were grown for morphological diversity in an on-farm field experiment at NBPGR Regional Station, Bhowali (Uttarakhand) situated at about 1,800 masl. All populations were planted on $4m^2$ plots in a complete randomized block design with three replications during the rainy season of 2007 and

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2008 following standard agronomic practices. Five control varieties developed through institutional breeding programmes for Himalayan region viz. VL 206, VL 207, VL 208, VL 209 and Majhera 7, were also included in on-station trials for comparison. From each plot 10 plants were randomly chosen for recording data on morphological and agronomic traits. Observations on 20 characters, 14 quantitative and 6 qualitative were recorded. Data on quantitative traits were statistically analyzed for range and pattern of variations using INDOSTAT statistical software developed at the INDOSTAT Services, Hyderabad. Classification (cluster analysis) and ordination (principal components analysis) analyses were performed. Skewed data on quantitative traits were transformed before multivariate analysis. Ward's minimum variance clustering method was used to classify accessions in discrete clusters (Sneath and Sokal 1973). The scores for various character states of different accessions were converted to a binary code before analysis using qualitative traits. Principal components analysis was performed using quantitative traits. The phenotypic frequencies of both quantitative and qualitative characters were also analysed by the Shannon-Weaver information index (H) in order to estimate the diversity of each character in both named landrace populations. The index was calculated as presented by Negassa (1985) and Engels (1991):

$$H' = -\sum_{i=1}^{n} p_i \log_e p_i$$

where p_i is the proportion of the accessions in the i^{th} class of an *n*-class character.

Results

The range of variations for important quantitative traits has been presented in Table 2. Wide variations for various agronomic traits like grain yield per plant, number of grains per panicle, grain length and width, etc. were recorded among different populations of both landraces. Many of the Jaulia landrace populations performed better than that of Thapachini and the control varieties. Barring presence of aroma and presence of awn, not many variations were recorded for other qualitative traits viz. panicle exertion, seed coat colour, husk colour and threshability in landrace populations of respective landraces. One population each of Jaulia (IC 548363) and Thapachini (IC 556512) were agronomically superior to all others, even better than the control varieties.

In clustering pattern, two populations of Jaulia (IC 548373 and IC 548353) formed a distinct cluster. One more population of Jaulia (IC548363) was also very distinct and did not cluster with other populations. Similarly one population of Thapachini (IC556509) was very distinct from all other populations. Rest other populations of Jaulia and Thapachini together with all the control varieties formed a major cluster. This cluster could be further sub-divided into two sub-clusters. The control varieties forming a compact group at sub-cluster level (Fig 1).

The diversity indices for quantitative characters in both Jaulia and Thapachini are presented in Table 3. For some characters, plant height (cm), penultimate leaf length (cm), panicle length (cm) and number of grains / panicle both named landraces found equally diverse. Jaulia landraces were found less diverse for flag leaf width (cm), days to 80% maturity, grain length (cm) and yield per plant (g) as compared to Thapachini landraces. Whereas, they were found more diverse for flag leaf length (cm), penultimate leaf width (cm), 100-grains weight (g) and number of tillers/plant than Thapachini landraces. Based on landrace-wise pooled diversity over all the characters, both landraces were found equally diverse.

Principal components analysis performed on quantitative traits revealed that the first three most informative components accounted for 71.97 % variance (Table 4). It also presented the characters with greater weightings in each of the three principal component axes. Important characters with greater weightings in principal component axis I include plant height, grains/panicle and days to maturity. Important characters with greater weightings in principal component axis II include grain width. The principal components analysis in general confirmed the groupings obtained through cluster analysis (Fig 2).

Discussions

The landrace populations differed significantly among themselves with respect to yield potential (Table 2). Not many variations were, however, recorded for qualitative traits. Different populations of the two common landraces, in general, were at par or superior to control varieties in grain yield depicting wider environmental adaptation of the common landraces even for yield related traits. Much evidence and experience attests that landraces are adapted to their local environments (Frankel *et al*. 1995). If they come from marginal environments, they are known to match or better the performance of advanced cultivars in those marginal environments.

Assessment of landrace populations for comparative yield and for components of yield is important for both the immediate local use of the material in participatory reselection and breeding programs, and the wider valuation and use of the germplasm. For example, Moghaddam *et al*. (1997) analyzed the genetic variation for yield, its components, and other developmental traits in lines extracted from seven landraces of bread wheat from Iran. They found most of these characters had high levels of genetic variance. They concluded the landraces could readily be improved by identifying and inter-crossing the promising genotypes.

The clustering pattern did not group populations of same named landrace together. It is important for us to understand how farmers make use of their crops' agro-morphological characteristics in different capacities particularly selecting among the plants in the crop populations to maintain the desirable characteristics and to increase the prevalence of other valued traits in the population over time (Jarvis *et al*. 2000). Gathering this information requires investigations and discussions with farmers at different stages of plant growth throughout the growing season.

Genetic diversity and divergence, in fact, require assessment for two sets of attributes, analogous to the characterization and evaluation data of genetic resources (Brown 2000). The first set is marker diversity, or the extent of differences between individual copies of genes. This set of attributes is informative as to the ancestry or breeding history of the populations. They are indicators of the recency of bottlenecks in population size, the prevalence of out-crossing, the ease with which genes are recombined, and the level of gene flow between populations (Kumar *et al*. 2010). The second set is variation in adaptation. This set comprises indicators of the degree to which populations are adapted to their environment and of their potential for continued performance or donors of characters in plant breeding. Both biotic and abiotic aspects of the environment are involved. Variations due to environmental adaptations are therefore useful to the breeders for selecting parents as donors of desired traits.

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References

Bisht IS, Mehta PS, Bhandari DC (2007). Traditional crop diversity and its conservation on-farm for sustainable agricultural production in Kumaon Himalaya of Uttaranchal state: a case study. Genetic Resources and Crop Evolution 54: 345-357

Bisht IS, Rao KS, Bhandari DC, Nautiyal S, Maikhuri RK, Dhillon BS (2006). A suitable site for *in situ* (on-farm) management of plant diversity in traditional agro-ecosystems of western Himalaya in Uttaranchal state: a case study. Genetic Resources and Crop Evolution 53: 1333–1350

Brown AHD (2000). The genetic structure of crop landraces and the challenge to conserve them in situ on farms. In: Brush, S.B. (ed.), Genes in the Fields: On-Farm Conservation of Crop Diversity, International Plant Genetic Resources Institute (IPGRI), Rome, International Development Research Centre (IDRC), Ottawa and Lewis Publishers, Boca Raton, pp. 29-48

Engels JMM (1991). A diversity study in Ethiopian barley. In: Engels, J.M.M., Hawkes, J.G. and Worede, M. (eds.) Plant Genetic Resources of Ethiopia. pp. 131-139. Cambridge University Press

Frankel OH, Brown AHD, Burdon JJ (1995). The Conservation of Plant Biodiversity. Cambridge University Press

Jarvis DI, Myer L, Klemick H, Guarino L, Smale M, Brown AHD, Sadiki M, Sthapit B, Hodgkin T (2000). A Training Guide for In situ Conservation On-farm. Version 1. Rome, Italy: International Plant Genetic Resources Institute

Negassa M (1985). Patterns of phenotypic diversity in an Ethiopian barley collection, and the Arussi-Bale Highland as a centre of origin of barley. Hereditas 102: 139-150

Kumar S, Bisht IS, Bhat KV (2010). Population structure of rice (*Oryza sativa*) landraces under farmer management. Annals of Applied Biology 156: 137–146

Pandey A, Bisht IS, Bhat KV, Mehta PS (2011). Role of informal seed system in promoting landrace diversity and their on-farm conservation: a case study of rice in Indian Himalayas. Genetic Resources and Crop Evolution 58: 1213-1224

Sneath PHA, Sokal RR (1973). Numerical Taxonomy. Freeman, Sanfrancisco, CA

Table 1: Passport data of two locally common rice landrace populations from parts of Uttarakhand

Landrace populations	**District of collection**	**Altitude (masl)**
Jaulia		
IC548373	Champawat	900
IC548382	Champawat	1100
IC548389	Bageshwar	1420
IC548353	Champawat	1180
IC548358	Champawat	1680
IC548363	Champawat	1380
Thapachini		
IC548392	Almora	1420
IC556512	Bageshwar	1300
IC548386	Almora	1350
IC548396	Bageshwar	1625
IC556509	Bageshwar	1290
IC556542	Bageshwar	1540
Controls		
VL 206		
VL 207		
VL 208		
VL 209		
Majhera 7		

Table 2 : Morphological variations among rice landrace populations of two named popular landraces, Jaulia and Thapachini in on-station trials at Bhowali

S. No.	Accession No.	DF	PHT	FLL	FLW	PLL	PLW	PL	GPP	DM	GL	GW	GWT	YPP	TPP
1.	IC548373 (Jaulia)	139.33	103.00	28.54	1.40	41.50	1.40	21.47	92.87	149.67	6.87	2.56	0.45	13.77	11.70
2.	IC548382 (Jaulia)	154.00	112.67	30.42	1.53	45.65	1.53	20.87	141.07	179.33	6.80	2.84	0.52	14.13	13.90
3.	IC548353 (Jaulia)	146.67	123.60	27.80	1.57	44.95	1.46	21.09	125.53	177.00	7.09	3.12	0.58	14.38	14.30
4.	IC548353 (Jaulia)	148.67	59.93	23.31	1.30	39.20	1.28	16.89	66.47	174.00	6.95	2.82	0.38	11.05	16.70
5.	IC548358 (Jaulia)	146.67	109.80	25.92	1.58	48.45	1.49	19.33	117.67	177.67	7.25	3.23	0.51	13.56	9.40
6.	IC548363 (Jaulia)	151.00	126.47	33.59	1.67	45.42	1.45	18.59	152.13	178.00	8.32	2.64	0.60	26.52	12.3
7.	IC548392 (Thapachini)	146.00	116.60	28.20	1.41	49.72	1.31	21.61	223.00	177.67	6.84	2.60	0.45	12.34	17.07
8.	IC556512 (Thapachini)	147.67	105.93	29.57	1.37	42.60	1.37	21.82	143.80	180.33	6.65	2.88	0.44	22.50	11.13
9.	IC548386 (Thapachini)	152.67	106.60	25.38	1.35	39.77	1.13	22.21	181.80	183.00	6.79	3.07	0.44	11.53	12.93
10.	IC548396 (Thapachini)	148.00	112.00	28.25	1.48	51.19	1.34	21.36	150.87	177.00	7.01	2.98	0.43	10.69	12.47
11.	IC556509 Thapachini)	171.00	116.13	30.75	1.51	54.33	1.31	20.35	136.73	191.33	6.14	2.41	0.32	10.48	12.93
12.	IC556542 (Thapachini)	146.67	102.27	29.03	1.51	41.42	1.52	19.71	90.07	175.00	6.58	2.71	0.44	11.57	10.80
13.	VL-206 (Control)	151.33	119.07	27.11	1.47	39.62	1.47	18.84	164.13	179.67	7.08	2.82	0.49	14.46	11.13
14.	VL-207 (Control)	155.67	103.93	33.37	1.55	50.22	1.55	21.01	152.40	181.00	7.39	3.43	0.42	11.03	9.80
15.	VL-208 (Control)	159.33	103.47	31.49	1.61	44.05	1.47	19.33	134.27	185.33	6.57	2.98	0.43	10.17	11.13
16.	VL-209 (Control)	150.33	115.67	31.13	1.60	38.25	1.51	19.73	164.87	181.00	6.98	2.54	0.47	11.99	9.00
17.	Majhera-7 (Control)	149.67	118.93	28.95	1.49	42.43	1.49	22.61	168.27	182.33	7.00	2.62	0.49	12.56	14.20
	Overall Mean	**150.86**	**109.18**	**28.99**	**1.49**	**44.63**	**1.42**	**20.40**	**141.53**	**178.20**	**6.96**	**2.84**	**0.46**	**13.69**	**12.41**
	CV%	**2.23**	**6.75**	**15.16**	**10.43**	**11.92**	**11.72**	**10.62**	**9.98**	**1.58**	**3.95**	**9.74**	**5.60**	**9.23**	**32.77**
	CD (5%)	**5.60**	**12.25**	**NS**	**NS**	**8.84**	**NS**	**NS**	**23.50**	**4.69**	**0.46**	**0.46**	**0.43**	**3.13**	**NS**

DF (Days to flowering); PHT (Plant height, cm); FLL (Flag leaf length, cm); FLW (Flag leaf width, cm); PLL (Penultimate leaf length, cm); PLW (Penultimate leaf width, cm); PL (Panicle length, cm); GPP (No. of grains / panicle); DM (Days to 80% maturity); GL (Grain length, cm); GW (Grain width, cm); GWT (100- grains weight, g); TPP (No. of tillers/plant)

Table 3: Estimates of Shannon–Weaver diversity of each character in both named landrace populations

Characters	Jaulia	Thapachini
Days to flowering	0.44	0.38
Plant height (cm)	0.58	0.58
Flag leaf length (cm)	0.78	0.58
Flag leaf width (cm)	0.44	0.58
Penultimate leaf length (cm)	0.54	0.58
Penultimate leaf width (cm)	0.68	0.38
Panicle length (cm)	0.68	0.68
No. of grains / panicle	0.68	0.68
Days to 80% maturity	0.20	0.44
Grain length (cm)	0.44	0.68
Grain width (cm)	0.68	0.78
100- grains weight (g)	0.58	0.38
Yield per plant (g)	0.20	0.38
No. of tillers/plant	0.68	0.44
Pooled SDI	**7.60**	**7.54**

Table 4: Principal component analysis of rice landrace populations for quantitative traits

Characters	PC1	PC2	PC3
Root	2.84	2.41	1.21
% Variance explained	31.63	26.73	13.50
Cumulative variance explained	31.63	58.36	71.87
	Character weightings		
Days to 50% panicle emergence	0.67	0.53	0.03
Plant height	-0.35	0.78	-0.25
Panicle length	0.31	0.54	0.28
No. of grains/panicle	-0.06	0.76	-0.18
Days to 50% maturity	0.45	0.70	0.15
Grain length	-0.79	0.18	0.31
Grain width	-0.07	0.02	0.94
100-grain weight	-0.88	0.24	0.08
Yield/plant	-0.72	0.22	-0.15

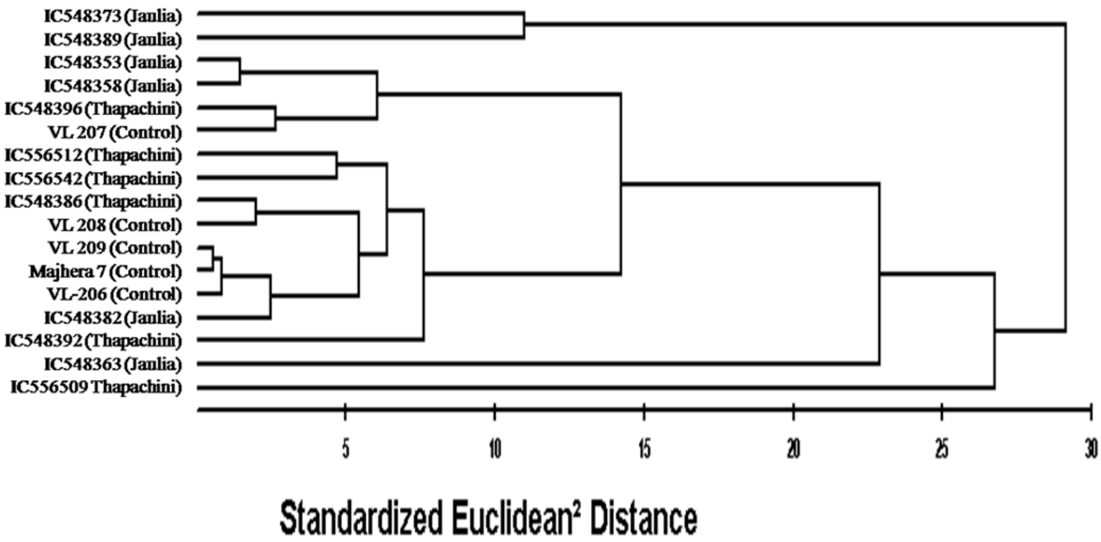

Fig 1. Ward's minimum variance dendrogram of rice landrace populations

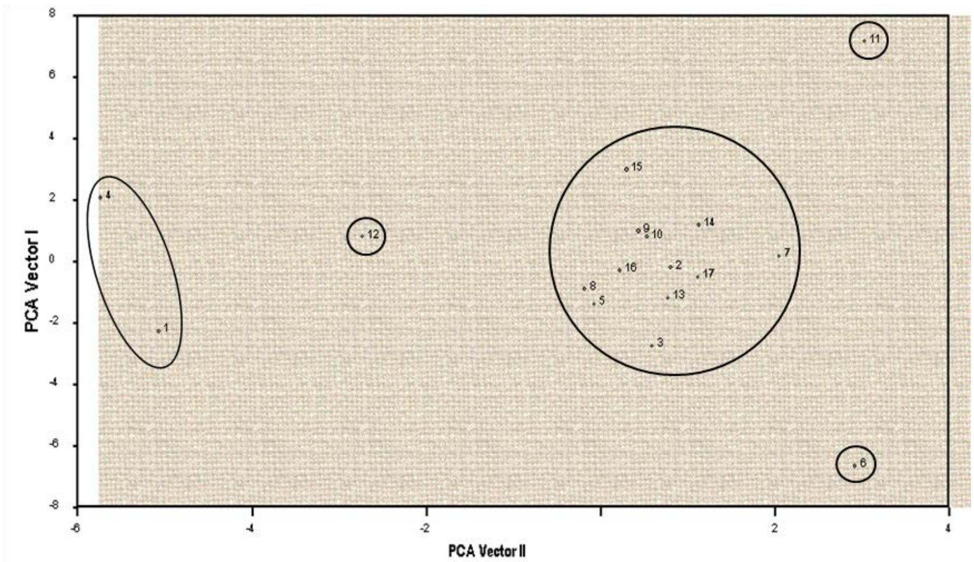

Fig 2. Principal component scatter-plot of rice landrace population