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Research Note

Characterization and assessment of variability in upland rice collections

Abhishek Singh, A. K. Singh, Shama Parveen and P. K. Singh*
Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, India.
*Email: pksbhu@gmail.com

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Abstract
The upland rice accessions are natural reservoir of genetic variability for various biotic and abiotic stresses. Forty eight upland rice germplasm accessions were evaluated and characterized for fourteen quantitative and fifteen qualitative traits. Analysis of variance revealed that existence of significant variation among accessions for all the quantitative traits. High genotypic and phenotypic coefficient of variation, heritability and genetic advance as per cent of mean was recorded for total number of grains per panicle, fertile spikelet per panicle, number of effective tillers per plant, leaf width and grain yield per plant. Among the qualitative traits variation was found to be high for leaf blade colour, leaf blade pubescence, ligule shape, panicle shattering, leaf senescence and sterile lemma colour. The accessions PKSLGR-16, PKSLGR-23, PKSLGR-43 and PKSLGR-45 are found to be most promising for yield and two to four of its component traits.

Keywords:
Rice, Genetic variability, heritability, qualitative traits and quantitative traits

Rice is the world's second most important cereal crop belonging to the family Poaceae grown under diverse eco-geographical conditions in various tropical and subtropical countries. India is a primary centre of origin of rice and has many local landraces. Most of the land races are not in cultivation while many are lost and few are still cultivated by resource-poor traditional farmers in areas practising subsistence farming. They constitute an excellent reservoir of variability for several traits, resistance to biotic and abiotic stresses, quality and yield traits (Tanksley and Mc-couch, 1997). The upland rice harbors a great genetic potential for rice improvement as subjected to subtle selection over a long period of time. However, the switch over to high yielding varieties with the spread of modern agriculture, posed a great threat to the securities of the age-old practice of growing traditional varieties and land races which may have immense potential for different important traits (Sharma *et al.*, 1987 and Patra, 2000). The exact genetic potential, differences from commercial varieties, and the magnitude of diversity present in landraces are not well catalogued. In order to prevent further gene erosion, collection, characterization and conservation of such precious genetic recourses of upland rice is essential; therefore become useful in developing rice cultivars tolerant to biotic and abiotic stresses. Keeping these points in view, field survey was conducted to collect large number of upland rice germplasm from natural habitats of major rice growing areas of Eastern India. These accessions were characterized further for quantitative and qualitative traits.

Plant material and experimental design: Panicles of forty eight upland rice germplasm accessions were collected from natural habitat of Eastern India during *Kharif* 2009 and 2010 and their seeds were multiplied in next wet season 2010 and 2011, respectively. The details of the source of upland rice accessions are presented in Table-1. These accessions were evaluated in randomized block design with three replications during *Kharif* 2012 and 2013. Twenty five days old single seedlings were transplanted in small separate plot 20 cm apart between row and 15 cm within row. The recommended packages of practices were followed to raise a healthy crop.

Data collections: The data on fourteen quantitative traits were recorded from ten randomly selected plants of each accession in each replication *viz*., days to 50% flowering, days to maturity, leaf length, leaf width, plant height, panicle length, number of effective tillers per plant, number of fertile spikelets per panicle, total number of grains per panicle, spikelet fertility, test weight, kernel length, kernel breadth and grain yield per plant and fifteen qualitative traits *viz*., coleoptile colour, auricle colour, basal leaf sheath colour, leaf blade colour, leaf blade pubescence, ligule shape, flag leaf angle, stigma colour, awning, apiculus colour, panicle exsertion, panicle shattering, leaf senescence, sterile lemma colour and threshability as per IRRI-IBPGR descriptors based on 50% population. The panicles of accessions showing shattering characteristics were observed every day and fertile spikelet were plucked one by one 1-2 days before shattering and stored. Threshability was determined by grasping the panicle with the hand, applying a slight rolling pressure with the palm and fingers, and assessing the percentage of grains that are removed by the action. Shattering was observed day to day as the extent to which grains have shattered from the panicle.

Statistical analysis: The mean value of both year data were pooled over and used for statistical analysis. The data were analyzed for variability as per procedure given by Panse and Sukhatme (1985), genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) by Burton and De-Vane (1953), and heritability and genetic advance by Johnson *et al*. (1955).

Variation and genetic parameters among accessions for quantitative traits: The analysis of variance revealed highly significant difference among the accessions for all the traits indicating the presence of large amount of variability among the accessions for the traits studied. The range, mean value, standard error and genetic components of different quantitative traits are presented in table 2. The magnitude of phenotypic coefficient of variation was higher for yield and yield attributing traits but the difference is very less indicates the presence of environmental influence to some degree in the phenotypic expression of the traits. These findings were in confirmation with earlier findings (Bhadru *et al.*, 2012 and Singh *et al.*, 2014). The magnitude of PCV was higher than the GCV for all the traits which may be due to higher degree of interaction of genotypes with the environment. The highest estimate of PCV and GCV were observed for fertile spikelet per panicle, total grains per panicle, number of effective tillers per plant and grain yield per plant, while lowest in spikelet fertility percentage followed by days to maturity. These finding are similar to those of Fiyaz *et al.* (2011) for high PCV and GCV in spikelet per panicle, total biomass, yield per plant and test weight and Gangashetty *et al.* (2013) for plant height, number of tillers per plant, number of productive tillers per plant, panicle weight, grain length, test weight and grain yield per plant; Singh *et al.* (2014) for low PCV and GCV in days to maturity, panicle length, spikelet fertility percentage and kernel breadth. Higher estimates of PCV and GCV indicated the presence of high amount of variance and the role of the environment on the expression of these traits. These values alone are not helpful in determining the heritable portion of variation. The proportion of genetic variability which is transmitted from parents to offspring is reflected by heritability. In the present study, all the quantitative traits showed high heritability, but it does not always indicate high genetic gain. The estimate of heritability were high for days to maturity (97.20%), plant height (97.10%), days to 50% flowering (96.80%) and kernel breadth (96.00%) due to genetic causes rather only by environmental effects. Genetic advance measures the difference between the mean genotypic values of selected population and the original population from which they were selected. The heritability coupled with high genetic advance as per cent of mean under the control of additive gene action would be effective for selecting superior varieties. High heritability coupled with high genetic advance as per cent of mean were recorded for total number of grains per panicle, fertile spikelet per panicle, number of effective tillers per plant, leaf width and grain yield per plant. The traits days to maturity, days to 50 per cent flowering and panicle length exhibited high heritability coupled with low genetic advance, suggesting preponderance of non-additive gene action in the inheritance of these traits; hence, in this case selection may not be effective. These results are conformity with the earlier reports of Ghosh and Sharma (2012) for high heritability coupled with high genetic advance in grain yield per plant, pollen fertility, sterile spikelet per panicle, fertile spikelet per panicle, spikelet fertility and test weight; Rahaman *et al.* (2012) for high heritability coupled with low genetic advance in days to 50 per cent flowering, panicle exertion rate and harvest index. The promising rice accessions for different yield characteristics are given in Table 3. The accessions PKSLGR-16, PKSLGR-23, PKSLGR-43 and PKSLGR-45 are found to be most promising for yield and two to four of its component traits.

Variation among accessions for qualitative traits**:** Qualitative characters are considered as marker characters in the identification of landraces of rice, which are less influenced by environmental fluctuations. The frequency distributions of qualitative traits are presented in Table 4, and variability in grain colour, size and shape are shown in Figure 1. Coleoptiles colour and auricle colour showed moderate variability. The 70.83% accessions had green coleoptiles and yellowish auricle colour. Colour of outer surface of leaf sheath had moderate variability while high variability was found in leaf blade colour. Most of the accessions had green basal leaf sheath colour. The 50.00 % accessions had medium green followed by dark green (29.17 %) and light green (12.50 %) coloured leaf blade. Frequency of glabrous type leaf blade pubescence was 04.17 %, intermediate (54.17 %) and pubescent (41.67 %) in the accessions collected. Rice plant with pubescence leaf blade irritates workers skin during harvesting and threshing, thus glabrousness is fairly desirable. Regarding leaf ligules shape, 04.17 per cent accessions were distinct for having truncate ligules shape, while 45.83 per cent having acute to acuminate and 50.00 per cent split shaped ligules. Flag leaf angle is very important for photosynthesis; most of the accessions had erect (77.08 %), intermediate (20.83 %) and horizontal (02.08 %) flag leaf angle. Low variability was found stigma colour with maximum accessions had white (85.42 %), light purple (12.50 %) and yellow (02.08 %) coloured. Awn is a filiform exertion of the keel of the lemma. Farmers prefer awnless grain because awns are objectionable in threshing and milling. In the collected accessions, 91.67 % was awnless, while 04.17 % had short and 04.17 % long awned, which is fairly desirable. Similar results were also reported by Rana *et al.* (2009) for awning in rice germplasms of Western Himalayan region of India. Low variability was found in apiculus colour with a maximum of straw (87.50 %) followed by red (06.25 %) and 02.08 % accessions had white, brown and purple coloured each. Low variability was also found in panicle exertion. Most of the accessions had well exerted (81.25 %), moderately well exerted (08.33 %), just-exserted (06.25 %) and partly-exserted (04.17 %) panicle. Panicle shattering showed high variability in the collected accessions. The 29.16 % accessions showed high panicle shattering characteristics followed by 60.42 % moderate and 10.41 % with low panicle shattering. High variability was found in leaf senescence with 18.75 % accessions showed early, 66.67 % intermediate and 14.58 % late leaf senescence. Sterile lemma colour showed high variability with 62.50 % accessions having straw, 18.75 % purple, 12.50 % red and 06.25 % gold coloured. Threshability had moderate variability with maximum accessions (83.33 %) having easy threshability followed by intermediate type (12.50 %) and difficult (04.17 %). Most of the above results of present investigation are conformity with the findings Subudhi *et al.* (2012).

The main purpose of the present investigation was to collect, evaluate, characterize and conserve the upland rice germplasm accessions of Estern India. The rice accessions in the present set of study have diverse eco-geographical origin. The considerable amount of morphological and agronomical variability was exhibited among the accessions of local collection. It would be quite useful to aid in improvement of *indica* rice through introgression of desirable genes from the suitable donors. Therefore, these accessions should be conserved and could be exploited in future rice breeding programmes.

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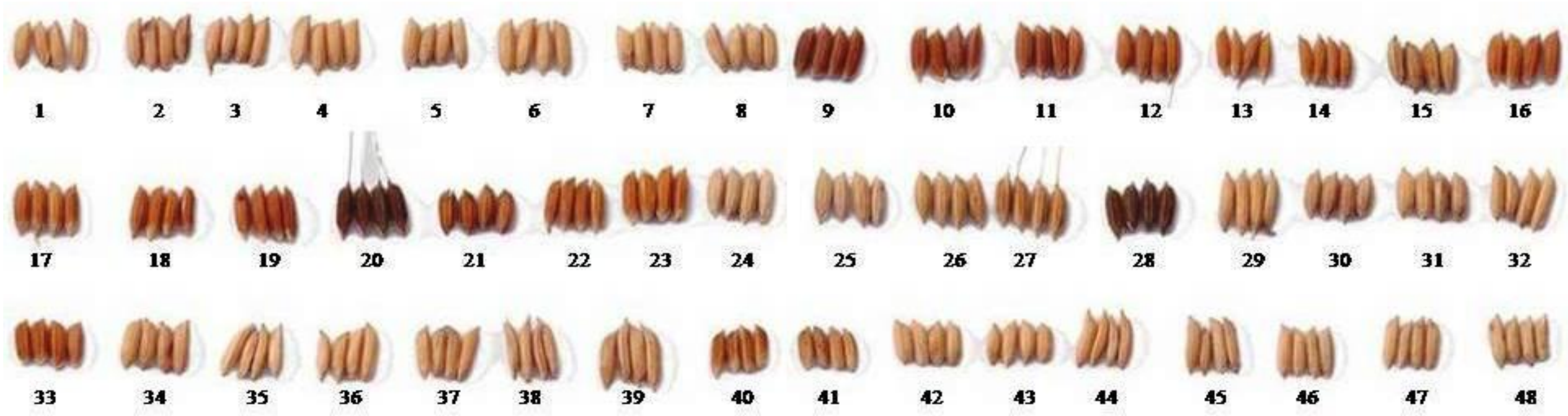

Fig. 1. Variability in grain colour, size and shape of forty eight upland rice germplasm accessions, the serial number represents upland rice germplasm accessions as described in Table 1.

Table 1. List of forty eight upland rice germplasm accessions and their collection site

S.N.	Accession Number	Collection site (Village, Block, District, Country)
1	PKSLGR-1	Hingutarghar, Dhanapur, Chandauli, India
2	PKSLGR-2	Nakenampur, Dhanapur, Chandauli, India
3	PKSLGR-3	Bhaluadai, Shahabganj, Chandauli, India
4	PKSLGR-4	Bishunpura, Chakiya, Chandauli, India
5	PKSLGR-5	Mamarakpur, Shahabganj, Chandauli, India
6	PKSLGR-6	Ramghar, Chakiya, Chandauli, India
7	PKSLGR-7	Muzafferpur, Chakiya, Chandauli, India
8	PKSLGR-8	Diberiya, Chakiya, Chandauli, India
9	PKSLGR-9	Nawajganj, Chakiya, Chandauli, India
10	PKSLGR-10	Ghorawal, Newarpura, Sonbhadra, India
11	PKSLGR-11	Dumahar, Babhani , Sonbhadra, India
12	PKSLGR-12	Dadvahani, Babhani, Sonbhadra, India
13	PKSLGR-13	Satvahani, Babhani, Sonbhadra, India
14	PKSLGR-14	Chhiyari, Babhani, Sonbhadra, India
15	PKSLGR-15	Mahuariya, Babhani, Sonbhadra, India
16	PKSLGR-16	Nibi, Vijaypur, Mirzapur, India
17	PKSLGR-17	Tilai, Vijaypur, Mirzapur, India
18	PKSLGR-18	Joya, Vijaypur, Mirzapur, India
19	PKSLGR-19	Tamua, Madiyan, Mirzapur, India
20	PKSLGR-20	Katariya, Madiyan, Mirzapur, India
21	PKSLGR-21	Barakachha, Madiyan, Mirzapur, India
22	PKSLGR-22	Gulalpur, Madiyan, Mirzapur, India
23	PKSLGR-23	Dhanawal, Madiyan, Mirzapur, India
24	PKSLGR-24	Ninwar, Lalganj, Mirzapur, India
25	PKSLGR-25	Sikhar, Sikhar, Mirzapur, India
26	PKSLGR-26	Baburi, Vijaypur, Mirzapur, India
27	PKSLGR-27	Shisotar, Nawanagar, Ballia, India
28	PKSLGR-28	Maturi, FatehpurManda, Ballia, India
29	PKSLGR-29	Deorara, Bansdih, Ballia, India
30	PKSLGR-30	Mehnagar, Meghnaghar, Azamghar, India
31	PKSLGR-31	Naretha, Jahanaganj, Azamgarh, India
32	PKSLGR-32	Shahpur, Jahanaganj, Azamgarh, India
33	PKSLGR-33	Kotila, Rani kiSarai, Azamgarh, India
34	PKSLGR-34	Mehnagar, Meghnaghar, Azamghar, India
35	PKSLGR-35	Naretha, Jahanaganj, Azamgarh, India
36	PKSLGR-36	Shahpur, Jahanaganj, Azamgarh, India
37	PKSLGR-37	Kotila, Rani kiSarai, Azamgarh, India
38	PKSLGR-38	Ganjari Dheeh, Gangapur, Varanasi, India
39	PKSLGR-39	Raghunathpur, Sewapuri, Varanasi, India
40	PKSLGR-40	Bhainsa, Sewapuri, Varanasi, India
41	PKSLGR-41	Newada, Sewapuri, Varanasi, India
42	PKSLGR-42	Mhuar, Brahmpur, Buxar, India
43	PKSLGR-43	Balua, Buxar, Buxar, India
44	PKSLGR-44	Jalilpur, Chausha, Buxar, India
45	PKSLGR-45	Mathila, Dumraon, Buxar, India
46	PKSLGR-46	Nibi, Bhagwanpur, Kaimur, India
47	PKSLGR-47	Baspurwa, Mohania, Kaimur, India
48	PKSLGR-48	Imlia, Ramghar, Kaimur, India

Table 2. Analysis of variance and genetic components of fourteen quantitative traits in forty eight upland rice germplasm accessions

Source of variation	d.f.	Mean sum of squares													
		DF	**DM**	**LL**	**LW**	**PH**	**PL**	**ET**	**FSP**	**TGP**	**SF**	**TW**	**KL**	**KB**	**GYP**
Replecation	2	1.090	4.881	5.726	0.014	32.646	13.653	1.118	0.295	0.811	2.405	1.203	0.180	0.004	7.560
Treatment	47	183.559**	252.538**	194.043**	0.184**	1363.680**	19.886**	9.953**	4682.705**	5649.727**	128.297**	31.198**	1.403**	0.131**	64.019**
Error	94	1.998	2.420	2.870	0.007	13.653	1.121	0.646	110.218	107.157	8.413	0.718	0.023	0.001	6.371
Genetic components															
Range	Min.	74	106.33	25.88	0.72	82.47	15.53	3.89	48.47	52.60	63.71	12.07	4.67	1.71	9.31
	Max.	107	132.33	56.38	1.57	158.95	30.24	12.33	205.00	213.20	99.30	27.29	7.89	2.52	27.60
Mean		88.18	118.65	41.52	1.08	114.68	24.77	7.03	119.06	131.60	90.76	20.23	6.19	2.19	18.42
SEm (±)		0.82	0.90	0.98	0.05	2.13	0.61	0.46	6.06	5.98	1.67	0.49	0.09	0.02	1.46
Variability (%)	PCV	8.97	7.81	19.65	23.98	18.78	10.96	27.54	33.96	33.59	7.66	16.30	11.22	9.65	27.46
	GCV	8.82	7.70	19.22	22.58	18.50	10.10	25.05	32.79	32.66	6.97	15.76	10.95	9.46	23.80
Heritability (%)		96.80	97.20	95.70	88.70	97.10	84.80	82.80	93.30	94.50	82.60	93.40	95.30	96.20	75.10
Genetic advance as % of mean		17.88	15.63	38.74	43.79	37.54	19.15	46.95	65.23	65.41	13.04	31.37	22.03	19.12	42.48

** and * Significant at 1 and 5 per cent level, respectively.

DF: Days to 50 % flowering; DM: Days to maturity; LL: Leaf length; LW: Leaf width; PH: Plant height; PL: Panicle length; ET: Effective number of tillers per plant; FSP: Fertile spikelet per panicle; TGP: Total number of grains per panicle; SF: Spikelet fertility percentage; TW: Test weight; KL: Kernel length; KB: Kernel breadth; GYP: Grain yield per plant

Table 3. Promising upland rice germplasm accessions for different yield characteristics

Traits	Value	Name of accessions
Grain yield per plant (g)	> 25.00	PKSLGR-23, PKSLGR-43, PKSLGR-45
Number of fertile spikelet per panicle	> 150.00	PKSLGR-11, PKSLGR-14, PKSLGR-16, PKSLGR-22, PKSLGR-23, PKSLGR-31, PKSLGR-33, PKSLGR-40, PKSLGR-41, PKSLGR-43, PKSLGR-46
Spikelet fertility (%)	> 95.00	PKSLGR-10, PKSLGR-11, PKSLGR-12, PKSLGR-13, PKSLGR-14, PKSLGR-15, PKSLGR-16, PKSLGR-21, PKSLGR-22, PKSLGR-23, PKSLGR-24, PKSLGR-31, PKSLGR-42
Number effective of tillers per plant	> 10.00	PKSLGR-3, PKSLGR-16, PKSLGR-27, PKSLGR-28
Panicle length (cm)	> 27.00	PKSLGR-2, PKSLGR-6, PKSLGR-9, PKSLGR-10, PKSLGR-15, PKSLGR-16, PKSLGR-36, PKSLGR-39, PKSLGR-45, PKSLGR-47
Test weight (g)	> 25.0 0	PKSLGR-4, PKSLGR-6, PKSLGR-48

Table 4. Frequency distribution of fifteen qualitative traits in forty eight upland rice germplasm accessions

Characters	Stage of observation	Description	Score	No. of accession	% Frequency (n/N X100)
Coleoptiles colour	First leaf through coleoptile	Colourless	1	02	04.17
		Green	2	34	70.83
		Purple	3	12	25.00
Auricle colour	Late vegetative	Whitish	1	01	02.08
		Yellowish green	2	34	70.83
		Purple	3	08	16.67
		Light purple	4	03	06.25
		Purple lines	5	02	04.17
Basal leaf sheath colour	Late vegetative	Green	1	33	68.75
		Green with purple lines	2	03	06.25
		Light purple	3	06	12.50
		Purple	4	06	12.50
Leaf blade colour	Late vegetative	No green colour	0	04	08.33
		Light green	3	06	12.50
		Medium green	5	24	50.00
		Dark green	7	14	29.17
Leaf blade pubescence	Late vegetative	Glabrous	1	02	04.17
		Intermediate	2	26	54.17
		Pubescent	3	20	41.67
Ligule shape	Early boot stage	Acute to acuminate	1	22	45.83
		2-cleft	2	24	50.00
		Tip round or truncate	3	02	04.17
Flag leaf angle	At anthesis	Erect	1	37	77.08
		Intermediate	3	10	20.83
		Horizontal	5	01	02.08
Stigma colour	At anthesis	White	1	41	85.42
		Yellow	3	01	02.08
		Light purple	4	06	12.50
Awning	Flowering to maturity	Absent	0	44	91.67
		Short and partly awned	1	02	04.17
		Long and partly awned	7	01	02.08
		Long and fully awned	9	01	02.08
Apiculus colour	Pre-ripening stage	White	1	01	02.08
		Straw	2	42	87.50
		Brown	3	01	02.08
		Red	5	03	06.25
		Purple	7	01	02.08
Panicle exsertion	Near maturity	Well exserted	1	39	81.25
		Moderately well exserted	3	04	08.33
		Just exserted	5	03	06.25
		Partly exserted	7	02	04.17
Panicle shattering	At maturity	Very low	1	01	02.08
		Low	3	04	08.33
		Moderate	5	29	60.42
		High	7	10	20.83
		Very high	9	04	08.33
Leaf senescence	At harvest	Very early	1	02	04.17
		Early	3	07	14.58
		Intermediate	5	32	66.67
		Late	7	04	08.33
		Very late	9	03	06.25
Sterile lemma colour	After harvest	Straw	1	30	62.50
		Gold	2	03	06.25
		Red	3	06	12.50
		Purple	4	09	18.75
Threshability	After harvest	Easy	1	40	83.33
		Intermediate	2	06	12.50
		Difficult	3	02	04.17