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Phenotypic Diversity and Correlation analysis for Agro-Morphological Traits in 100 Landraces of Rice (*Oryza sativa* L.) from Chhattisgarh

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ABSTRACT

A hundred landraces of rice (Oryza sativa L.), from core group genotypes collected from different parts of Chhattisgarh, were characterized following the guidelines from the Protection of Plant Varieties and Farmers' Rights Authority, GOI. Hundred rice accessions were planted in a randomized block design (RBD). The data were recorded on 32 different agro-morphological traits (20 qualitative and 12 quantitative). The study revealed a high degree of variation in agro-morphological traits of rice accessions with a Shannon diversity Index ranging from 0 – 1.223 with a mean of 0.548. The highest diversity index of 1.223 was observed for flag leaf attitude of the blade. The coefficient of variation was more than 10 % for most of the characters; Correlation coefficients showed that all the traits were highly correlated with each other. Grain yield per plot showed a highly significant and positive correlation with biological yield per plot (r= 0.512) and days to 50% flowering (r= 0.299). Therefore, these characters emerged as the most important associates of grain yield in rice. The genetic potential of the mentioned accessions for the desired traits can be utilized in future rice breeding programs to get promising results.

Key words: *Rice, Morphological, DUS, Germplasm, Shannon Diversity Index*

INTRODUCTION

Rice is the principal food crop grown right from historic days. Today, this unique grain helps sustain two-thirds of the world's population. It is life for thousands of millions of people. It is deeply embedded in the cultural heritage of their societies. About four-fifths of the world's rice is produced by small-scale farmers and is consumed locally. Rice cultivation is the principal activity and source of income for about 100 million households in Asia and Africa. Rice has also fed more people over a longer time than has any other crop. It is spectacularly diverse, both in the way it is grown and how it is used by humans. Rice is unique because it can grow in wet environments that other crops cannot survive in. Such wet environments are abundant across Asia. The domestication of rice ranks as one of the most important developments in history.

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Rice is grown in many regions across India. For about 65% of the people living in India, rice is a staple food for them. Rice is essential to life in India. It is a part of nearly every meal, and it is grown on the majority of the rural farms. Chhattisgarh is one of the largest contributors of rice in India and is known as "Rice bowl of India". The rich biodiversity of rice in Chhattisgarh is evidence of this fact. Rice is still under cultivation as the main crop in Chhattisgarh. In the traditional rice varieties grown by the farmers have several unique features like the aroma, medicinal properties, variation in grain size, seed color etc.

To investigate germplasm resources for crop utilization and improvement programs, it is essential to describe and evaluate the morphological characteristics of existing germplasm resources to effectively identify and differentiate each cultivar[27,14,2]. As the study of genetic diversity of morphological traits can directly provide information on germplasm richness and provide important information for farmers or breeders especially when the resource population is large, using morphological traits to study genetic diversity is considered as a very simple and economical approach. Therefore, this classical method continues to be extensively employed in the evaluation of germplasm resources[16,10,31]. At present, in evaluating crop germplasm resources, qualitative traits such as morphological features could be readily distinguished and identified, and quantitative traits have large differences[11]. Furthermore, morphological traits of germplasm resources are relatively more stable under various environmental conditions. Through scientific and effective sampling, using mathematical statistical methods on morphology traits of reproductive organs, several studies have evaluated the classification, relationships, and diversity of rice landraces[14,1,29,17], which are then utilized in the protection and rational utilization of germplasm resources.

Presently the genetic base of rice is declining continuously with increasing genetic vulnerability because modern high yielding varieties takes place of the traditional genetically diverse varieties. Thus there is a direful need to collect, exploit and evaluate the unexploited diverse rice germplasm to broaden the genetic base of modern cultivars by the introgression of genes for various traits of interest[3]. The need for increasing rice cultivation depends not only on cultural/traditional practices but also, on their inbuilt genetic potential to withstand stresses. A successful breeding programme will depend on the genetic variability of a crop for achieving the goals of improving the crop and producing high yielding varieties[21]. The first step in achieving this is to evaluate and characterize available rice germplasm or genotypes at the morphological stage.

MATERIAL AND METHODS

The current research study was conducted at Research cum Instructional farm, College of Agriculture, Indira Gandhi Agricultural University, Raipur, Chhattisgarh during *Kharif*, 2017. Hundred rice accessions were characterized using 32 different agro-morphological traits (20 qualitative and 12 quantitative) based on DUS. Rice germplasm accessions used in this study are listed in the table1. Seeding was done in the well-prepared seedbeds in the last week of June 2017. The seedlings were transplanted into well-puddled field twenty-one days after seeding. Each accession was planted in two rows, with a row length of one meter and row-row distance of 25 cm using randomized block design (RBD) with two replications. Measurements of different morphological characteristics of these collected landraces at different stages of growth were recorded following the guidelines of test for Distinctness, Uniformity, and Stability of Rice (*Oryza sativa* L.)[4]. The data were collected on five randomly selected plants from each accession. Recommended cultural practices were used for growing rice crop throughout the experiment. The details of the characters and their observed genotypic descriptors are given in table 2.

Table 1. List of hundred rice genotypes for DUS based characterization

S. No.	Name	S. No.	Name	S. No.	Name	S. No.	Name
1	Bagri	26	Kanak	51	Ama jhopa	76	Ram Jira
2	Hardi chudi	27	Mehapal	52	Koudi dhull	77	Bhejari
3	Koto	28	Tebaroo Mundaria	53	Sau pankhi	78	Danwar
4	Kotte (II)	29	Padari dhan IV	54	Dokra Dokri	79	Karhani
5	Satha dhan	30	Budhiya wako	55	Parmal	80	Chiko
6	Karhani	31	BD kankari bija	56	Dokrae mechha	81	Farsa Phool
7	Kohaka	32	Bawati chudi	57	Roti	82	Baila Aankhi
8	Luchai(A)	33	Kalajira	58	Khatia pati	83	Bokra Mundi
9	Angur Guchcha	34	Sonapan	59	Hathi panjra	84	Hunuman Langur
10	Basigal(ii)	35	Bakal	60	CR-1014	85	Jal Ponga
11	Bhejari	36	Cross 116	61	Elayachi	86	Banda
12	Bhulau	37	Deshi lal dhan	62	Tulsi manjari	87	Lanji
13	Bodi	38	IR 42253	63	Shyam jira-1	88	Raja Bangla
14	Peelee Luchai	39	Lalmati	64	Lokti Machhi	89	Bhainsa Mundariya
15	Tulsi Phool	40	Laloo-14	65	Muni Bhog	90	Nariyal Chudi
16	Silipat	41	Jhitpiti	66	Jou Phool	91	Kating
17	Unknown	42	WR99	67	Bhainsa Punchhi	92	Bhamasur
18	Ama Dhul	43	E-1702	68	Bhanta Phool-1	93	Paltu
19	Baisur	44	Chapti gurmatia	69	Lahsun Bhog	94	Sindur senga
20	Bylao	45	Elayachi	70	Ichchawati	95	Swarna
21	Asam Chudi	46	Bisni-I	71	Laxmi Bhog	96	MTU-1010
22	Bhaniya	47	Moroberekan	72	Tulsi Mala	97	IR64
23	Farsa Phool	48	Nagina-22	73	Jou Phool-2	98	R-RF-75
24	Jalle	49	R-RF-75	74	Jeera Phool	99	IGKV R1
25	Kanak Jira	50	Kadam Phool	75	Tulsi Mongra	100	Danteshwari

Data Analysis

Data on quantitative traits were statistically analyzed for range and pattern of variations using INDOSTAT statistical software developed at the INDOSTAT Services, Hyderabad. Range, mean and coefficient of variation were estimated in order to assess the extent of genetic diversity among the collected germplasm (Table 2). The phenotypic frequencies of qualitative characters were also used for computing Shannon–Weaver information index[26] in order to estimate the diversity in different clusters. The index (H) was calculated as presented by Negassa[20].

$$H = -\sum_{i=1}^{n} pi \log pi$$

Where; *n* is the number of phenotypic classes for a character and pi is the portion of the total number of entries belonging to the ith class. The standardized Shannon -Weaver diversity index ranging from 0 to 1 was obtained by dividing H' by the $\log_2$ of the total number of phenotypic classes. H'l for each of the morpho-agronomic descriptors of each variety was computed using MS Excel. Correlation coefficients (r) among quantitative traits were calculated by using the STAR program.

RESULTS AND DISCUSSION

For detailed characterization or to establish distinctiveness among 100 rice landraces, 32 characters have been studied, which includes twenty qualitative characters and twelve quantitative characters. For the morphological characterization or identification of landraces of rice, qualitative characters are considered as morphological markers, because they are less influenced by environmental changes[23,13]. The rice landraces under study showed a wide range of distinctiveness for all most all the morphological traits studied and similar results have been reported by Joshi *et al.*[12], Chakrabarty *et al*.[7] Tirkey *et al*.[30]. Frequency distribution for all the characters under study was computed (Table 2).

Rice genotypes were characterized for leaf traits at late vegetative and flowering stages and variation was observed among the accessions for coleoptiles color, 30% showed purple color and rest of the 70% accessions showed a green color. Similarly for basal leaf sheath color 10% accession showed purple lines, 12% showed light purple, 6% accessions showed uniform purple, while 72% accessions were showed a green color. Character leaf intensity of green color 64% accessions had medium green color, 30% had dark green color, while 6% of the accessions showed light intensity, Leaf: Anthocyanin coloration was present in only 34 accessions, while in rest 66% does not have anthocyanin coloration in leaf.

Only 5% accessions showed the presence of anthocyanin coloration in leaf sheath, while 95% accessions do not have this character. Similarly, on Pubescence of blade surface of the leaf, only 8% had a hard surface, 54% showed strong, 3% showed weakly and 35% accessions showed medium surface of the leaf blade. Out of 100 landraces evaluated, all landraces exhibited the presence of leaf auricle, Out of which, 12% genotypes exhibited purple auricles, 9 % accessions exhibited light purple auricles. There was no variation found for the trait presence of collar in the studied rice accessions. All the accessions showed the presence of collar. Out of which, 22% accessions had the presence of anthocyanin color of the collar, while 78% of accessions does not exhibit any coloration on the collar.

For the character leaf ligule, all the landraces recorded for its presence with the split shape of ligule and having 78%, 16% and 6%, white, light purple and purple ligule respectively, Rawte *et al*.[24], in their study had also reported 95% of landraces with split shape of ligule. Culm attitude is an indicator of the growth habit of a particular species. During the current study valuable variation was observed among the accessions for culm angle. 1% accessions were found to have spreading, 90% accessions show semi-erect attitude, 8% accessions showed open culm angle, whereas 1% accessions were having erect culm angle. For the character flag leaf attitude of the blade, semi-erect type of flag leaf was observed for 41% landraces and 59% landraces are of an erect type. For the character density of pubescence of lemma 44% accessions were fallen in the medium category, 32% fall in weak, 23% were strong and only one genotype had a very strong density of pubescence of lemma. All the hundred accessions were male fertile and only 40% of accessions had awns, while rest of 60% does not have awns. For the character leaf senescence, 7% were of late, 39% were of medium and 54% were of an early type. At an early stage, the attitude of the blade of flag leaf only 1% was very short, 4% were short, 35% accessions were medium, 41% accessions were long and 11% of accessions were found to have very long flag leaf.

Table 2: Variability in qualitative traits of the germplasm with Shannon diversity index

Descriptors	Descriptors states	Frequency	Percent	Shannon diversity index
Coleoptile: Colour	Colourless	0	0	0.611
	Green	70	70	
	Purple	30	30	
Basal leaf: Sheath colour	Green	72	72	0.890
	Light purple	12	12	
	Purple lines	10	10	
	Uniform purple	6	6	
Leaf: Intensity of green colour	Light	6	6	0.816
	Medium	64	64	
	Dark	30	30	
Leaf: Anthocyanin colouration	Absent	66	66	0.641
	Present	34	34	
Leaf Sheath: anthocyanin colouration	Absent	95	95	0.199
	Present	5	5	
Leaf: Pubescence of blade surface	Absent	0	0	1.007
	Weak	3	3	
	Medium	35	35	
	Strong	54	54	
	Very strong	8	8	
Leaf: Auricles	Absent	0	0	0.000

	Present	100	100	
Leaf: Anthocyanin colouration of auricles	Colourless	79	79	0.657
	Light purple	9	9	
	Purple	12	12	
Leaf: Collar	Absent	0	0	0.000
	Present	100	100	
Leaf: Anthocyanin colouration of the collar	Absent	78	78	0.527
	Present	22	22	
Leaf: Ligule	Absent	0	0	0.000
	Present	100	100	
Leaf: Shape of ligule	Truncate	0	0	0.000
	Acute	0	0	
	Split	100	100	
Leaf: Colour of ligule	White	78	78	0.656
	Light purple	16	16	
	Purple	6	6	
Culm: attitude	Erect	1	1	0.389
	Semi-erect	90	90	
	Open	8	8	
	Spreading	1	1	
Flag leaf: Attitude of blade	Erect	59	59	0.677
	Semi-erect	41	41	
	Horizontal	0	0	
	Drooping	0	0	
Spikelet: Density of pubescence of lemma	Absent	0	0	1.110
	Weak	32	32	
	Medium	44	44	
	Strong	23	23	
	Very strong	1	1	
Male sterility	Absent	100	100	0.000
	Present	0	0	
Panicle: Awns	Absent	60	60	0.673
	Present	40	40	
Leaf: Senescence	Early	54	54	0.886
	Medium	39	39	
	Late	7	7	
flag leaf: Attitude of blade	Very short (<16 cm)	1	1	1.223
	Short (16-20 cm)	4	4	
	Medium (21-25 cm)	35	35	
	Long (26-30 cm)	41	41	
	Very long(>30 cm)	19	19	

Shannon-Weaver Diversity Indices among 100 Genotypes

Table 2 presents the Shannon-Weaver diversity indices (H’) of the 20 agro-morphological traits. The H’ ranged from 0 – 1.223 with a mean of 0.548. The highest diversity index of 1.223 was observed for flag leaf attitude of the blade, However, no significant differences were observed among leaf auricle (H’ = 0), the presence of collar (H’ = 0), ligule, male sterility etc. Overall, the 100 genotypes held in the IGKV genebank exhibited high diversity in the agro-morphological characters assessed. This, therefore, means that the collections can be an available resource for developing rice varieties.

Descriptive Statistics for 100 germplasm

Descriptive statistical measures can reveal a great deal of information about any variable of interest. Descriptive statistics, presenting the measures of central tendency and measure of variations for all the traits are given in table 3. Days to flowering ranges from 69 to 128 days with an average of 97.92 and having coefficients of variation 13.58%. For the character plant height, the range is 58.8cm to 189cm with an average of 119.85cm, the coefficients of variation for this trait was found to be 21.89%. Leaf length ranges from 34.1cm to 71.6cm with an average of 53.86cm. Leaf width ranges from 0.8cm to 1.4cm having an average of 1.10cm. A number of tillers per plant ranged from 5 to 15.5, with the mean of 8.23, and panicle length ranged from 14.5cm to 37.5cm with an average of 26.74cm. The coefficients of variation for panicle length were found to be 15.75%. Biological yield and grain yield ranges from 1460g to 6870g having an average of 3810.05g and 251.0g to 1831g, with an average of 777.47g respectively. The coefficients of variation for biological yield and grain yield were found to be 30.18% and 35.76% respectively.

Harvest index ranged from 8.6% to 56.5% with a mean of 21.93 and thousand grain weight had a mean of 22.86g and was ranged from 8.7g to 56.5g, the coefficients of variation were 37.50% for this character. For the character number of filled grains and a total number of grains, the mean was 28, 150.44 and was ranged from 3.5 to 142.5 and 46 to 308 respectively. The coefficients of variation for a number of filled grains and the total number of grains were 82.87% and 37.66% respectively.

Table 3: Descriptive Statistics for 100 germplasm

Characters	Mean	Std Dev	Sum	Range	Mean Std. error	CV(%)
DTF	97.92	13.30	9791.50	69.5-128	1.33	13.58
PH	119.85	26.24	11985.17	58.8-189	2.62	21.89
LL	53.86	5.72	5385.84	34.1-71.6	0.57	10.63
LW	1.10	0.12	109.99	0.8-1.4	0.01	11.18
NT	8.23	1.66	822.50	5-15.5	0.17	20.23
PL	26.74	4.21	2674.00	14.5-37.5	0.42	15.75
BYP	3810.05	1149.88	381005.00	1460-6870	114.99	30.18
GYP	777.47	278.05	77747.37	251.0-1831	27.80	35.76
HI	21.93	8.22	2192.76	8.6-56.5	0.82	37.50
TGW	22.86	8.26	2286.05	8.7-47.4	0.83	36.13
NFG	28.00	23.20	2800.00	3.5-142.5	2.32	82.87
TNG	150.44	56.66	15044.00	46-308	5.67	37.66

DTF- Days to 50 percent flowering, PH- Plant height, LL-Leaf length, LW-Leaf width, NT- Number of tillers, PL-Panicle length, BYP- Biological yield, GYP- Grain yield, HI- Harvest index, TGW- Thousand grain weight, NFG- Number of filled grain, TNG- Total number of grains.

Table 4: Correlation matrix of the morphological characters of germplasm

	DTF	PH	LW	NT	PL	BYP	GYP	HI	TGW	NFG	TNG	LL
DTF	1											
PH	0.577**	1										
LW	-0.308**	-0.083	1									
NT	0.164	0.05	-0.232*	1								
PL	0.46**	0.44**	-0.25*	0.005	1							
BYP	0.698**	0.586**	0	0.023	0.306**	1						
GYP	0.299**	0.172	0.172	-0.143	0.115	0.512**	1					
HI	-0.234*	-0.335**	0.177	-0.157	-0.102	-0.261**	0.598**	1				
TGW	0.034	0.226*	0.379**	-0.147	0.087	0.386**	0.397**	0.147	1			
NFG	0.058	0.031	0.02	0.052	0.087	0.11	0.115	0.042	-0.144	1		
TNG	0.221*	0.177	-0.068	-0.002	0.153	0.115	0.091	-0.051	-0.419**	0.484**	1	
LL	0.18	0.562**	0.17	-0.08	0.292**	0.388**	-0.044	-0.36**	0.265**	0.055	-0.042	1

DTF- Days to 50 percent flowering, PH- Plant height, LL-Leaf length, LW-Leaf width, NT- Number of tillers, PL-Panicle length, BYP- Biological yield, GYP- Grain yield, HI- Harvest index, TGW- Thousand grain weight, NFG- Number of filled grain, TNG- Total number of grains.
Indicate the level of significance by *
* P=0.05 and **P=0.01

Correlation among agro-morphological traits

Yield is a result of the complex traits directly or indirectly affecting each other. That is why information on the association between quantitative traits should be done. Pearson's correlation analysis was used to determine this relationship. Correlation coefficients among the traits measured are shown in Table 4.

Grain yield per plot showed a highly significant and positive correlation with biological yield per plot (r= 0.512) and days to 50% flowering (r= 0.299). Therefore, these characters emerged as the most important associates of grain yield in rice. The tendency for an increase in grain yield with an increase in biomass (r=0.512) indicated that there is a possibility to further improve rice productivity through increasing physiological efficiency by incorporating traits which have bearing on yield such as higher biomass. The strong positive association of grain yield with the characters mentioned above has also been reported in rice by earlier workers[19,15,9,32].

Plant height had a significant and positive association with days to 50 percent flowering (r=0.577) it was found that shorter varieties were early maturing while taller varieties were late maturing. The association of plant height with days to 50 percent flowering has also been reported in rice by Bhadru *et al*.[6]. Panicle length showed significant positive correlation with days to 50 percent flowering (r= 0.46) and plant height (r= 0.44).The physiological trait biological yield per plant recorded positive and significant correlation with panicle length (r= 0.306), plant height (r=0.586) and days to 50 percent flowering (r= 0.46). This indicates that vigorous plant population may enhance economic yield and a similar result was also reported by Soni *et al*.[28]. 1000 grain weight was positive and significantly correlated with leaf width (r=0.379), biological yield (r=0.386). 1000 grain weight showed a significant positive correlation with grain yield per plant (r= 0.397), it indicates that these characters can be considered for selection for higher yield. Similar results were reported by Satish Chandra *et al*.[25], Basavaraja *et al*.[5], Patel *et al*.[22], Rao *et al*.[23] for grain yield per plant.

The relationship between HI and grain yield was strong and significant. The study indicated a positive correlation of HI with grain yield (r = 0.598). It can be inferred that the increase in grain yield in the main season is accompanied by an increase in HI of the varieties. A similar result was also found by Mohamad *et al*.[18]. Flag leaf length was positive and highly significant with panicle length (r=0.292) and biological yield (r=0.388). Plants with greater leaf length had elongated panicle length, thus producing an increased number of primary and secondary rachis resulted in an increased number of grain in the panicle that ultimately improved the yield of the cultivar. Larger flag leaf increases the photosynthetic rate and provides the food material in a good amount resulting enhancement of other component traits finally seed yield. A similar result for leaf length to be correlated with panicle length and biological yield was also reported by Devi and Lal[8].

CONCLUSION

Broad variations in agronomic characters have been found in studied rice germplasm. Quantitative agro-morphological characters of 100 accessions were analyzed using descriptive statistics and correlation coefficient. The diversity of the collection was analyzed using the Shannon-Weaver diversity index. The present study gives average values for each parameter. These primary data can be utilized when traditional rice cultivars are screened for future breeding programs. There is a need for further study to confirm these findings. Additionally, extensive molecular marker analysis using more primers may need to be considered for relevant application and efficient attainment of breeding objectives in rice improvement.

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