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Genetic variability studies for agro-morphological and yield related traits in locally adopted rice varieties of Bihar

Ruchika Chhaya, Nilanjaya, Sorabh Sethi, Pooja Kumari, Nitesh Kushwaha and RG Zala

Abstract
Twenty two rice varieties were transplanted in RBD with three replications during 2018-19 at Rice Research farm, RPCAU, Pusa, Samastipur, Bihar to study the genetic variability, heritability and genetic advance for yield and its components. Highly significant differences for almost the characters were observed among twenty two rice varieties under studied. Higher numerical values of phenotypic variances and co-variances with respect to its genotypic counterpart were recorded for all the traits indicating greater environmental influence on these traits for total variation. days to 50% flowering, days to maturity, length of leaf blade, 1000 grain weight, grain length, grain width, decorticated grain length, decorticated grain width and grain yield per plant showed high heritability coupled with high genetic advance as per cent of mean, indicating the preponderance of additive gene action. These characters may be subjected to any single plant selection scheme for exploiting fixable genetic variance. Hence, direct selection for these characters may be done for future improvement of genotypes.

Keywords: Agro-morphological, RBD, Bihar

1. Introduction

Rice (*Oryza sativa* L.) is one of the most important food crops in the world being staple diet of people. The needfulness for improving rice production does not only depend on rice crop and management technologies but also on the suitability of rice varieties, which must be developed by exploiting variability from already existing germplasm that has been collected and conserved by national, regional or international genetic resource centers. Rigorous evaluation, phenotyping and characterization of available rice genotypes and varieties are one of the main prerequisites in conservation and sustainable utilization of rice genetic resources. This ensures that maximum variation is captured in designing breeding strategies aimed at increasing productivity. The essence of plant breeding lies in the creation of genetic variation which is an integral part of any improvement in crop.

World population is expected to increase by about 2 billion in the next two decades and half of this increase will in Asia where rice is the staple food. The present level of rice production globally is not sufficient to feed this increasing population. Genetic variability for agronomic traits is the key component of breeding programmes for broadening the gene pool. The efficacious use of genetic resources in all plant breeding programs requires knowledge about genetic diversity. Crop improvement basically depends on the confines of variability present in the genotypes, whereas a cross involving genetically diverse parent is expected to produce high effect and also more variability in the successive segregating generations. Precise information related to the extent of genetic variability in the population is crucial in crop improvement programs. Selection of parents for any hybridisation programme based on high variability, heritability and genetic advance may prove sensible base for the successful hybridization programs. Therefore there is substantial and compelling need for improving the genetic architecture of this crop. High grain yield with better quality should be the aim of breeding program which will depend upon the extent of variability present in the germplasm and varieties being used for crop improvement.

2. Materials and Methods

The experimental material comprised of 22 selected genetically diverse true breeding varieties of rice (*Oryza sativa* L.).

The experiment was carried out at Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar. The experimental trial was laid out in randomized complete block design with three replications under normal conditions. Each plot comprised ten rows spaced 25 cm apart with plant to plant spacing. The recommended agronomical and plant protection measures were done in order to raise normal crop. Replication-wise data on the basis of five randomly taken competitive plants were recorded on days to fifty percent flowering (days), days to maturity (days), stem length excluding panicle(cm), stem thickness (mm), panicle length of main axis, panicle number per plant, length of leaf blade (cm), width of leaf blade (cm), 1000 grain weight (gm), grain length (mm), grain width (mm), decorticated grain length (mm), decorticated grain width (mm), root volume (mm^3), grain yield per plant (g). Statistical analysis for heritability (broad sense) was calculated by the formula suggested by Johnson *et al*. (1955) [9], while genetic advance was calculated by the formula given by Lush (1949) [13], Johnson *et al*. (1955) [9] and Allard (1960) [2].

Table 1: Details of the experimental materials included for the study.

Sl. No.	Name of Varieties	Sl. No.	Name of Varieties
1.	Rajendra Bhagwati	12.	Saroj
2.	Rajendra Nilam	13.	Gautam
3.	Rajendra Saraswati	14.	Sita
4.	Rajendra Kasturi	15.	Sahbhagi Dhan
5.	Rajendra Suwasini	16.	Pooja
6.	Rajendra Sweta	17.	Swarna sub-1
7.	Rajendra Mahsuri 1	18.	BPT5204
8.	Prabhat	19.	Kalanamak
9.	Richharia	20.	Dinesh
10.	Turanta	21.	Dular
11.	Dhanlaxmi	22.	Sabour Surbhit

3. Result and Discussion

The analysis of variance for the experiment involving 22 varieties of rice for fifteen characters viz., days to fifty percent flowering (days), days to maturity (days), stem length excluding panicle(cm), stem thickness (mm), panicle length of main axis, panicle number per plant, length of leaf blade (cm), width of leaf blade (cm), 1000 grain weight (gm), grain length (mm), grain width (mm), decorticated grain length (mm), decorticated grain width (mm), root volume (mm^3), grain yield per plant (g) were recorded clearly indicated that there was highly significant differences among the varieties for all the traits studied, indicating sufficient variability in the material under study. In other words, further analysis for yield will be meaningful as indicated by significant mean sum of squares. Interestingly, the magnitude of Mean Sum of Squares of many traits was more, which indicated that the amount of variation for these traits was more. More variation was expected as different genotypes responded differentially. Several workers *viz.,* Chen *et al.* (2001) [5], Pantuwan *et al.* (2002) [20], Gomez *et al.* (2003) [8], Ouk *et al.* (2006) [17], Muthuswamy and Kumar (2006) [15], Ganapathy *et al*. (2007) [6], Allah (2009) [1] and Mina *et al.* (2011) reported high variability for such traits in rice. Thus, it can be implied that there was reasonably sufficient variability in material used for the study, which provides ample scope for there by the plant breeder for further improvement by using them in hybridization programme.

The results appertain to genetic parameters viz., phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability (h^2) and genetic advance as percent of mean (GAM) for all the fifteen characters are accoutred in table 1 and Figure 1. It is presumed from the Table 1 that there is almost perfect relation between PCV and GCV of each character. This could be seen from the highest magnitude of both PCV (25.92%) for decorticated grain width and GCV (22.97%) for length of leaf blade, panicle number per plant (24.13-15.33%), width of leaf blade (22.74-14.59%), and grain width (20.88-17.74%) suggesting that these characters were under the high influence of genetic control. So the characters can be relied upon and simple selection can be practiced for further improvement. The characters like days to fifty per cent flowering (15.30-14.19%), days to maturity (13.02-12.12%), panicle length of main axis (12.94-8.23%), 1000 grain weight (19.91-17.54%), decorticated grain length (17.00-16.10%) and grain yield per plant (15.94-13.53%) showed moderate PCV (10-20%) value. However the traits which stem length (7.41-5.39%), stem thickness (9.60-8.07%) and root volume (8.13-2.03%) depicted lower magnitudes of both PCV and GCV, respectively. Similar results were obtained by Nandan, R. (2010) [16], Pal *et al*. (2016) [18], Sharma *et al*. (2000) [23] and Ganapathy *et al*. (2007) [6] for days to fifty percent flowering, days to maturity, stem length, decorticated grain length, grain length, grain yield per plant. It was interesting to note that the difference between GCV and PCV values were minimum, implying least influence of environment and preponderance of additive gene effects for these traits indicating that genotypes can be selected and improved for such characters.

The coefficient of variation indicated the extent of variability present among varieties for characters under study and does not indicate the heritable portion. This could be ascertained from the heritability estimates, which in broad sense include both additive and non-additive gene effects and narrow sense heritability include the portion of heritable variation which is due to additive component (Lush, 1949) [13]. The knowledge of heritability is helpful in assessing merits and demerits of a particular trait as it enables the plant breeder to decide the course of selection procedures to be followed under a given situation. Heritability estimates are useful in deciding the character to be considered while making selection but selection based on this factor alone may limit the progress, as it is prone to changes with environment, breeding material etc., Johanson *et al*. (1955) [9], Athwal and Gain Singh (1966) [3]. In other words, estimates of heritability have greater role to play in determining the effectiveness of selection for a character, when they are considered in conjunction with the genetic advance as per cent of mean as reported by (Panse, 1942 and Johanson *et al*. 1955) [19, 9]. In this study, heritability in broad sense for most of the characters, *namely* days to 50% flowering (86.04%), days to maturity (86.62%), stem thickness (70.15%), length of leaf blade (90.05%), 1000 grain weight (77.60%), grain length (77.33%), grain width (70.04%), decorticated grain length (89.66%), decorticated grain width (64.40%) and grain yield per plant (72.00%) were found to be high. These findings are in consonance with the findings of Manickavelu *et al*. (2006) [14], Allah (2009) [1], Lin *et al*. (2009) [12]. Lush (1949) [13] pointed out that when heritability is high, emphasis should be mainly on mass selection or as heritability become lower, more emphasis should be placed on pedigree selection method.

All the characters recorded high estimates of heritability indicating that they were least influenced by the environmental effects, however selection for improvement of such characters may not be useful, because broad sense heritability is based on total genetic variance which includes additive, dominant and epistatic variances. Thus, the heritability values along with estimates of genetic advance would be more reliable than heritability alone (Johnson *et al*., 1967) [10]. The genetic advance expressed as percent of mean values ranged from 1.05 percent (root volume) to 53.70 percent (decorticated grain width). The character, decorticated grain width (80.10%) recorded for highest magnitude of genetic advance as percent of mean followed by length of leaf blade (44.89%), 1000 grain weight (31.83%), grain length (31.61%), grain width (30.12%), decorticated grain length (31.40%) and grain yield per plant (23.65) exhibited high genetic advance as per cent of mean (>20%) while stem thickness (13.92), panicle length of main axis (10.79) and width of leaf blade (19.29) showed moderate genetic advance as per cent of mean. However, the traits like stem length (8.08) and root volume (1.05) exhibited low genetic advance as per cent of mean.

The characters, *namely* days to 50% flowering, days to maturity, length of leaf blade, 1000 grain weight, grain length, grain width, decorticated grain length, decorticated grain width and grain yield per plant showed high heritability coupled with high genetic advance as per cent of mean, indicating the preponderance of additive gene action. These characters may be subjected to any single plant selection scheme for exploiting fixable genetic variance. Hence, direct selection for these characters may be done for future improvement of genotypes. Similar results were also reported by earlier workers *viz.*, Saleem, M. Y. *et al*. (2008) [21], Chandra, B. S. *et al.* (2009), Abdul F. *et al.* (2011), Sawant, *et al*. (1995) [22]. High heritability coupled with moderate genetic advance were observed for the traits *namely* stem thickness indicating that this traits was being governed by both additive and non-additive genetic effects and therefore, selection should be practiced in later segregating generations *i.e.* in hybridization programme. Panicle number per plant showed moderate heritability coupled with high genetic advance as per cent of mean revealing that the character is governed by both additive and non-additive gene effects.

Table 2: Analysis of variance for fifteen morhological characters in rice

		Mean sum of squares		
Sl. No.	**Characters**	**Replication**	**Treatments**	**Error**
1.	Days to 50% flowering(days)	219.38	543.58**	27.9
2.	Days to maturity(days)	313.15	694.82**	34.02
3.	Stem length (cm)	46.93	135.17**	30.85
4.	Stem thickness(mm)	0.57	0.97**	0.12
5.	Panicle length of main axis(cm)	21.85	19.01**	6.25
6.	Panicle number per plant(no.)	14.23	23.68**	7.81
7.	Length of leaf blade(cm)	0.95	252.21**	8.96
8.	Width of leaf blade(cm)	0.002	0.12**	0.04
9.	1000 grain weight(gm)	1.97	76.21**	6.69
10.	Grain length(mm)	1.8	7.75**	0.69
11.	Grain width(mm)	0.11	0.64**	0.08
12.	Decorticated grain length(mm)	0.17	2.97**	0.11
13.	Decorticated grain width(mm)	0.09	0.37**	0.06
14.	Root volume(mm^3)	3923373.5	3148277.72	2622539.11
15.	Grain yield per plant (gm)	2.42	42.71**	4.9

Table 3: Mean, Range and Coefficient of variance (CV) for fifteen morphological characters in rice

SL. No.	Characters	Mean	Range (min-max)	CV
1.	Days to 50% flowering(days)	92.39 ± 3.05	66.33 - 115.33	5.72
2.	Days to maturity(days)	122.48 ± 3.37	94.67 - 145.00	4.76
3.	Stem length (cm)	109.38 ± 3.21	99.24 - 119.59	5.08
4.	Stem thickness(mm)	6.58 ± 0.20	4.91 - 7.79	5.34
5.	Panicle length of main axis(cm)	25.05± 1.44	22.25 - 33.69	9.98
6.	Panicle number per plant(no.)	15.00 ± 1.61	10.67 - 21.33	18.64
7.	Length of leaf blade(cm)	39.21 ± 1.73	23.78 - 59.64	7.63
8.	Width of leaf blade(cm)	1.15 ± 0.11	0.64 - 1.55	16.75
9.	1000 grain weight(gm)	27.45 ± 1.49	19.27 - 37.80	9.42
10.	Grain length(mm)	8.79 ± 0.48	6.24 - 12.17	9.43
11.	Grain width(mm)	2.48 ± 0.16	1.53 - 3.54	11.25
12.	Decorticated grain length(mm)	6.07 ± 0.19	4.49 - 8.55	5.44
13.	Decorticated grain width(mm)	2.03 ± 0.13	1.14 - 2.46	12.94
14.	Root volume(mm^3)	20576.29 ± 934.98	17667.34 - 22667.03	7.87
15.	Grain yield per plant (gm)	26.24 ± 1.28	21.00 - 32.57	8.44

Table 4: Mean performance of twenty two genotypes of rice for fifteen morphological characters

Sl. No.	Name of varieties/ characters	DFF	DM	SL	ST	PL	PP	LLB	WLB	TGW	GL	GW	DGL	DGW	RV	GY/P
1.	Rajendra bhagwati	88.67	116.00	99.24*	6.54	27.59	15.33	53.19*	1.09	33.37*	10.80*	2.67	7.08*	1.95	22667.03	30.63*
2.	Rajendra Nilam	85.00	117.00	102.16	6.74	24.67	15.33	43.80	1.36	29.91	8.05	2.47	5.77	2.01	20000.57	32.57*
3.	Rajendra Saraswati	84.00*	118.00	108.25	6.38	27.90	17.33	45.94*	1.31	32.84*	12.17*	2.34	8.55*	1.14*	20667.06	30.93*
4.	Rajendra Kasturi	102.00	126.67	110.53	6.68	23.28	16.33	34.24	1.02	20.12	7.96	1.75*	5.20	1.27*	21666.91	24.97
5.	Rajendra Suwashini	98.00	118.33	107.09	7.29*	24.89	15.67	35.96	1.19	25.73	9.20	2.39	7.05*	1.86	20667.14	27.20
6.	Rajendra Shweta	90.67	128.67	100.39	7.54*	25.21	14.67	28.15	1.13	22.87	7.30	1.53*	4.55	1.29*	21667.24	26.27
7.	Rajendra Mahsuri	107.00	141.00	107.42	6.49	22.88	14.67	30.11	1.23	19.27	7.90	2.56	5.58	1.44*	21333.84	31.87*
8.	Prabhat	75.67*	100.33*	106.39	6.68	23.38	20.33*	39.11	1.15	27.04	9.07	2.34	6.21	1.75	20334.06	23.23
9.	Richharia	80.33	101.00*	105.40	4.91	22.25	14.67	36.06	1.19	30.07	9.56	2.60	5.74	2.17	21000.53	23.37
10.	Turanta	66.33*	94.67*	100.28	6.54	22.77	14.67	31.09	0.64	24.20	7.24	3.28	5.60	2.46	21667.41	21.10
11.	Dhanlaxmi	79.67*	104.67*	118.45	6.24	25.30	21.33*	52.11*	1.27	29.91	10.52*	2.94	6.52	1.36*	20000.73	30.77*
12.	Saroj	81.00	126.00	102.12	6.56	27.18	12.67	34.72	0.77	23.26	9.20	2.57	6.48	1.70	20333.90	30.00*
13.	Gautam	97.67	131.67	116.45	6.51	23.06	20.33*	44.11	1.05	33.21*	7.61	2.46	5.58	1.87	19667.22	25.40
14.	Sita	103.67	133.33	109.59	7.79*	24.96	11.67	39.08	1.06	32.30*	11.60*	2.22	6.77*	2.03	20667.04	26.37
15.	Sahbhagi	91.33	117.67	108.46	6.44	23.52	14.67	44.05	1.13	29.50	9.50	2.49	6.37	2.32	21333.90	29.73
16.	Pooja	94.00	121.00	112.65	6.49	24.69	13.00	52.21*	1.05	33.06*	10.32*	2.76	7.68*	2.20	20000.77	26.93
17.	Swarna sub-1	104.67	145.00	116.05	6.30	26.77	14.67	33.12	0.99	23.20	6.62	2.31	4.49	1.70	20333.86	22.70
18.	BPT-5204	107.00	143.00	103.63	6.37	25.60	14.00	31.51	1.18	21.02	6.24	1.74*	5.09	1.62*	21333.68	21.00
19.	Kalanamak	111.00	136.33	119.59	6.27	33.69*	11.33	36.29	1.55*	24.21	6.99	2.18	5.29	1.96	20333.91	20.30
20.	Dinesh	115.33	143.33	119.45	6.49	24.73	12.67	23.78	1.14	37.80*	9.44	3.54	6.32	2.21	19667.22	24.83
21.	Dular	70.33*	101.00*	118.89	7.30*	23.45	10.67	59.64*	1.28	25.70	8.30	2.86	6.46	2.37	17667.34*	23.33
22.	Sabour Surbhi	99.33	130.00	113.95	6.21	23.32	14.00	34.32	1.44	25.23	7.87	2.49	5.12	1.91	19667.07	23.80
	Mean	92.39	122.48	109.38	6.58	25.05	15.00	39.21	1.15	27.45	8.79	2.48	6.07	2.03	20576.29	26.24
	C.V.	5.72	4.76	5.08	5.34	9.98	18.64	7.63	16.75	9.42	9.43	11.25	5.44	12.96	7.87	8.44
	S.E.	3.05	3.37	3.21	0.20	1.44	1.61	1.73	0.11	1.49	0.48	0.16	0.19	0.13	934.98	1.28
	C.D.5%	8.70	9.61	9.15	0.58	4.12	4.61	4.93	0.32	4.26	1.37	0.46	0.54	0.38	2668.41	3.65

Table 5: Genetic parameters of fifteen morphological characters in rice

Sl. No.	Characters	σ^2_g	σ^2_p	GCV	PCV	H^2(Broad sense)%	GAM
1.	Days to 50% flowering(days)	171.89	199.79	14.19	15.30	86.04	27.11
2.	Days to maturity(days)	220.26	254.28	12.12	13.02	86.62	23.23
3.	Stem length (cm)	34.77	65.62	5.39	7.41	52.99	8.08
4.	Stem thickness(mm)	0.28	0.40	8.07	9.64	70.15	13.92
5.	Panicle length of main axis(cm)	4.25	10.50	8.23	12.94	40.48	10.79
6.	Panicle number per plant(no.)	5.29	13.10	15.33	24.13	40.38	20.07
7.	Length of leaf blade(cm)	81.08	90.04	22.97	24.20	90.05	44.89
8.	Width of leaf blade(cm)	0.03	0.07	14.59	22.74	41.18	19.29
9.	1000 grain weight(gm)	23.17	29.86	17.54	19.91	77.60	31.83
10.	Grain length(mm)	2.35	3.04	17.45	19.84	77.33	31.61
11.	Grain width(mm)	0.19	0.27	17.47	20.88	70.04	30.12
12.	Decorticated grain length(mm)	0.95	1.06	16.10	17.00	89.66	31.40
13.	Decorticated grain width(mm)	0.11	0.16	14.41	25.92	64.40	53.70
14.	Root volume(mm^3)	175246.20	2797785.31	2.03	8.13	6.26	1.05
15.	Grain yield per plant (gm)	12.60	17.50	13.53	15.94	72.00	23.65

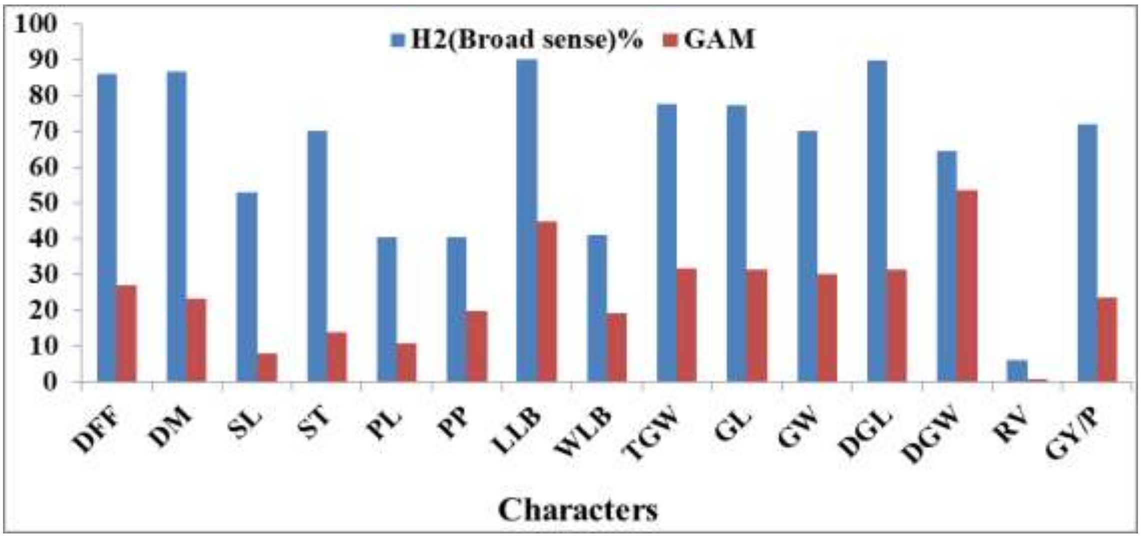

Fig 1: Histogram depicting estimates of heritability (broad sense) and genetic advance as per cent of mean for fifteen traits

The present finding is in consonance with the findings of Manickavelu *et al*. (2006) [14], Kumar *et al*., (2013), Gokulakrishnan *et al*., (2014) [7], Allah (2009) [1], Lin *et al*., (2009) [12], Subrata Chakraborty and Chaturvedi (2014), Tiwari *et al*., (2015) and Konate *et al*., (2016). High heritability with high genetic advance was recorded for days to 50% flowering, days to maturity, length of leaf blade, 1000 grain weight, grain length, grain width, decorticated grain length, decorticated grain width and grain yield per plant indicating the preponderance of additive gene action. Thus, these traits are predominantly under the control of additive gene action and hence these characters can be improved by pedigree method of breeding. Similar results were reported by Saleem, M. Y. *et al*., (2008) [21], Chandra, B. S. *et al*. (2009), Abdul F. *et al* (2011), Sawant *et al*. (1995) [22]. High heritability coupled with moderate genetic advance were observed for the traits *namely* stem thickness indicating that this trait was being governed by both additive and non additive genetic effects and therefore, selection should be practiced in later segregating generations *i.e* in hybridization programme.

4. Conclusion

In conclusion, high estimates of PCV and GCV were recorded for length of leaf blade and decorticated grain width which provides considerable variability and offers scope for genetic improvement through selection. Further high heritability coupled with high genetic advance were observed for days to 50% flowering, days to maturity, length of leaf blade, 1000 grain weight, grain length, grain width, decorticated grain length, decorticated grain width and grain yield per plant indicates the role of additive gene action in controlling the traits, hence pedigree method of breeding will be a rewarding one to improve the traits under investigation.

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