Int.J.Curr.Microbiol.App.Sci (2018) *7*(5): 551-559

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 7 Number 05 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.705.069

Genetic Variability Estimates for Yield and Yield Components Traits and Quality Traits in Rice (*Oryza sativa* L.)

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Keywords

Variability, Heritability, Genetic advance, Rice

Article Info

Accepted:
07 April 2018
Available Online:
10 May 2018

A B S T R A C T

An experiment with a total of 36 rice entries consisted of 28 cross and eight parental lines were evaluated to estimate the variability parameters for 10 yield attributing character, 6 physical quality traits; 8 cooking and chemical quality traits of rice cultures. Analysis of variance revealed the existence of significant differences among cultures for all traits studied. High PCV coupled with GCV was recorded for gel consistency and alkali spreading value revealed wider variability for these traits. Moderate PCV and GCV was observed for total number of tillers per plant, number of grains per panicle, LAI at maximum tillering stage, volume expansion ratio, water uptake, amylose content and grain yield per plant indicating the moderate variability. High heritability coupled with high genetic advance as per cent of means for total number of tillers per plant, number of grains per panicle, leaf area index at maximum tillering stage, water uptake, gel consistency, alkali spreading value, amylose content and grain yield per plant, revealed the role of additive gene effect and simple selection procedures may be effective for improving these traits. High heritability coupled with moderate genetic advance as per cent of mean was observed for days to 50% flowering, days to maturity, plant height, test weight, kernel breadth after cooking and volume expansion ratio, revealed that role of both additive and non-additive gene effects in the inheritance of these traits.

Introduction

Rice (*Oryza sativa* L., 2n=24) is the most important food crop in the world (Asia, Latin America, parts of Africa and the Middle East), which accounts for more than 21% of the calorific needs of the world's population and up to 76% of the calorific intake of the population of South East Asia (Melissa *et al.*, 2009). About 90% of the world's rice is grown and consumed in Asia. According to the projections made by the Population Foundation of India, the country's population will be 1546 million by the end of 2030 and

1824 million by the end of 2050. It is estimated that the demand for rice will be 121.2 million tonnes by the year 2030 and 137.3 million tonnes by the year 2050 (CRRI - VISION 2050).

Due to various socio-economic constraints, a chance of bringing more area under rice cultivation is very remote. Hence to achieve the target of increased rice production, it requires raising the production per unit area. Emphasis is being diverted towards the maximum utilization of land by producing more rice yield per unit area per unit time for which there is a need to improve different traits related to grain yield.

Yield is the resultant product of various morphological, physiological and biological components. Yield can be enhanced using the various cultivars with wider genetic variability in hybridization programme. The presence of adequate genetic variability is regarded as the fundamental pre-requisite to launch any crop improvement programme and the success depends on its magnitude in a given species. The genotypic coefficient of variation measures the magnitude of genetic variability. Since, it reflects the heritable portion of variability.

Information on heritability along with genetic advance will be helpful in prediction of genetic gain possible in improvement of a character by selection. Heritability and genetic advance are regarded as important selection parameters. Burton (1952) suggested that genetic variation along with heritability estimates would give a better idea about the efficiency of selection. Hence, wider range of genetic variability helps in selecting desired genotypes. In addition to the genetic variability, knowledge on heritability and genetic advance helps the breeder to employ the suitable breeding strategy. Therefore, it is necessary to have knowledge of genetic variability, heritability and genetic advance present in the available genetic material.

Materials and Methods

Twenty eight F_1s along with eight parents were sown in *rabi*, 2016-15 at Andhra Pradesh Rice Research Institute (APRRI) and Regional Agricultural Research Station (RARS), Maruteru, West Godavari, Andhra Pradesh in a Randomized Complete Block Design with three replications. Observations were recorded on ten randomly chosen plants for twenty four various yield attributing traits and quality characters, i.e.10 yield attributing characters *viz.*, days to 50% flowering, days to maturity, plant height (cm), number of tillers per plant, number of ear bearing tillers per plant, panicle length (cm), number of grains per panicle, test weight (g), leaf area index at maximum tillering stage and grain yield per plant (g); 6 physical quality traits such as hulling recovery per cent, milling recovery per cent, head rice recovery, kernel length (mm), kernel breadth (mm), kernel L/B ratio; 8 cooking and chemical quality traits such as kernel length after cooking (mm), kernel breadth after cooking (mm), kernel elongation ratio, volume expansion ratio, water uptake value (ml), gel consistency (mm), alkali digestion value and amylose content (%). The data were subjected to statistical analysis and various genetic parameters such as PCV, GCV, heritability and genetic advance were worked out as per Johnson *et al.*, (1955) and Hanson (1963).

Results and Discussion

The mean sum of squares due to genotypes was highly significant at 1% level of significance for all the characters studied in the present investigation. This indicated the existence of considerable variability for all characters studied among the genotypes. Hence, it offers a better scope for further improvement of breeding material by the

selection of promising genotypes in rice breeding programme. The mean sum of squares of various characters was presented in Table 2.

The parameters of genetic variability such as mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance as percentage of mean (GA) were estimated for all the quantitative characters are presented in Table 1 and 3.

The variation for yield attributing traits viz., days to 50% flowering ranged from 68.67 (BPT 3291 × MCM 100) to 108.00 (MTU 1064 × MTU 7029) with a mean of 94.34, days to maturity from 97.67 days (BPT 3291 × MCM 100) to 138.00 days (MTU 1064 × MTU 7029) with a mean of 123.69 days, plant height ranged from 92.90 cm (BPT 3291 × MTU 7029) to 130.18 cm (MCM 100 × MTU 7029) with a mean of 114.90 cm, total number of tillers per plant varied from 10.33 (MTU 1121) to 17.67 (MTU 1001 × MTU 1140) with a mean of 14.87.

The variation for number of ear bearing tillers per plant ranged from 8.67 (MCM 100 × MTU 7029) to 14.00 (BPT 3291) with a mean of 11.85. Panicle length per plant in the material studied varied from 24.47 (BPT 3291) to 31.20 (MTU 1140 × MTU 1064) with a mean of 28.73. Number of grains per panicle was from 141.23 (BPT 3291) to 270.89 (MTU 1140 × MTU 1064) with a mean of 213.78.

The range for test weight was from 18.20 (MTU 7029) to 24.33 (MTU 1001 × MCM 100) with a mean of 21.15. Leaf area index at maximum tillering stage was from 2.09 (BPT 3291 × MTU 1121) to 3.72 (MTU 1001 × MTU 1140) with a mean of 2.70. Grain yield per plant ranged from 20.21 g (MTU 1001 × MTU 1061) to 38.03 g (BPT-329) with a mean of 28.75 g.

The physical quality traits *viz.*, hulling recovery per cent was ranged from 77.82% (MTU 1061 × MTU 7029) to 82.24% (BPT 3291 × MTU 1064) with a mean of 79.85%. Head rice recovery per cent ranged from 62.67% (MTU 7029) to 74.98% (MTU 1001 × MTU 1140) with a mean of 62.09%. Kernel length (mm) ranged from 5.31 mm (MTU 7029) to 6.06 mm (BPT 3291 × MTU 1140) with a mean of 5.67 mm.

Kernel breadth (mm) varied from 1.93 mm (MTU 1001 × MTU 1064) to 2.46 mm (MTU 1001 × MTU 7029) with a mean of 2.23 mm. Kernel length/breadth ratio noted for this trait varied from 2.37 (MTU 1001 × MTU 7029) to 2.90 (MTU 1001 × MTU 1064) with a mean of 2.54.

The variation for cooking and cooking quality characters such as kernel length after cooking (mm) ranged from 8.73 (MTU 7029) to 10.09 (MTU 1061) with a mean of 9.53. Kernel breadth after cooking varied from 2.56 (MTU 1001 × MTU 1064) to 3.25 (MTU 1001 × MTU 1140) with a mean of 2.89. Kernel elongation ratio ranged from 1.55 (MCM 100 × MTU 7029) to 1.77 (MTU 1001 × MTU 1121) with a mean of 1.68. Volume expansion ratio ranged from 3.79 (BPT 3291 × MTU 1140) to 5.82 (MTU 1001 × MTU 7029) with a mean of 4.73.

Water uptake (ml) varied from 121.67 (BPT 3291 × MTU-100) to 256.67 (MTU 1001) with a mean of 183.29. Gel consistency ranged from 41.66 (MTU 1064 × MTU 1061) to 98.27 (MTU 1140 × MTU 1061) with a mean of 67.69. The range of variation noted for alkali spreading value varied from 2.50 (MCM 100 × MTU 1121) to 6.17 (MTU 1061) with a mean of 4.30. Amylose content possessed significant variation which was ranged from 18.86 (MCM 100 × MTU 1061) to 32.53 (MTU 1121 × MTU 7029) with a mean of 23.70.

Table.1 Mean performance of 8 parents and 28 F_1s in rice (*Oryza sativa* L.)

S. No.	Parents and F_1s	DFF	DM	PH	TNTP	TEBTP	PL	NGPP	TW	LAI	GYPP	HP
1	MTU 1001	89.33	119.67	113.05	11.33	9.33	26.51	160.56	23.42	2.43	23.04	78.35
2	BPT 3291	95.33	125.33	106.44	10.67	8.67	24.47	141.23	19.43	2.17	20.21	79.08
3	MCM 100	100.33	129.67	105.02	12.00	10.33	26.63	195.13	18.43	2.49	20.39	80.38
4	MTU 1121	92.00	122.00	106.39	10.33	9.67	26.57	181.76	19.70	3.23	22.27	78.69
5	MTU 1140	105.67	134.67	115.67	12.33	10.33	26.41	225.50	21.03	3.28	22.98	80.14
6	MTU 1064	104.67	132.67	113.06	12.00	10.67	26.64	232.50	19.56	2.35	23.32	79.97
7	MTU 1061	107.00	136.67	114.84	12.33	11.00	26.97	214.77	19.85	3.02	23.02	79.02
8	MTU 7029	105.67	135.00	109.84	13.00	10.67	25.03	171.96	18.20	2.43	23.12	78.79
9	MTU 1001 × BPT 3291	83.67	114.00	109.66	14.67	12.00	29.20	211.09	23.42	3.47	24.79	81.26
10	MTU 1001 × MCM 100	95.67	126.67	117.43	15.67	11.67	29.71	213.49	24.33	2.86	35.20	80.20
11	MTU 1001 × MTU 1121	83.00	113.00	113.11	14.33	12.33	29.01	193.77	23.06	2.47	34.72	79.47
12	MTU 1001 × MTU 1140	90.67	121.00	125.40	17.67	12.67	29.27	214.69	22.46	3.72	36.55	80.67
13	MTU 1001 × MTU 1064	92.67	122.67	116.23	15.33	12.67	28.87	208.05	21.44	2.78	36.14	79.72
14	MTU 1001 × MTU 1061	82.33	111.33	118.46	16.67	13.33	28.58	222.60	21.87	2.50	38.03	79.60
15	MTU 1001 × MTU 7029	96.67	124.33	96.00	14.00	12.00	29.54	191.86	20.52	2.13	25.98	79.11
16	BPT 3291 × MCM 100	68.67	97.67	113.10	16.00	13.00	30.59	225.98	23.19	2.54	26.27	80.45
17	BPT 3291 × MTU 1121	95.67	123.33	108.53	16.00	13.33	29.52	211.90	19.78	2.09	26.92	78.98
18	BPT 3291 × MTU 1140	96.67	125.00	129.83	16.00	13.33	31.11	230.48	23.36	3.52	34.30	81.67
19	BPT 3291 × MTU 1064	86.00	117.00	103.90	16.00	12.67	29.59	216.85	19.85	2.45	29.11	82.24
20	BPT 3291 × MTU 1061	92.67	120.67	112.53	17.33	12.00	29.33	228.24	20.92	2.79	33.59	79.40
21	BPT 3291 × MTU 7029	92.67	120.00	92.90	15.00	10.67	28.97	212.60	19.35	2.17	26.71	79.36
22	MCM 100 × MTU 1121	87.67	118.00	116.98	16.67	12.00	30.36	205.97	21.62	2.36	25.47	78.67
23	MCM 100 × MTU 1140	98.67	128.33	123.12	17.33	13.00	28.28	257.28	21.73	3.62	35.31	79.73
24	MCM 100 × MTU 1064	82.67	111.00	122.29	16.00	12.33	28.94	215.40	20.06	2.56	35.93	81.12
25	MCM 100 × MTU 1061	92.00	122.00	115.11	16.00	10.67	30.65	248.88	19.98	2.45	32.76	79.52
26	MCM 100 × MTU 7029	91.33	118.33	130.18	17.33	14.00	29.61	225.94	21.37	2.11	29.29	80.68
27	MTU 1121 × MTU 1140	91.33	120.67	123.36	14.67	12.00	29.14	227.67	21.96	3.07	36.18	80.67
28	MTU 1121 × MTU 1064	96.67	128.00	107.31	14.33	12.33	29.06	186.82	22.64	2.57	24.40	78.97
29	MTU 1121 × MTU 1061	90.67	120.33	113.61	16.00	12.33	29.47	185.59	22.14	2.63	25.78	80.22
30	MTU 1121 × MTU 7029	98.33	127.33	112.09	14.67	13.00	28.65	190.59	20.00	2.16	23.75	80.98
31	MTU 1140 × MTU 1064	96.00	126.33	123.02	15.67	13.67	31.20	270.89	22.85	3.17	26.55	79.19
32	MTU 1140 × MTU 1061	99.33	128.33	129.10	15.67	12.67	29.58	249.50	23.33	3.04	27.85	79.65
33	MTU 1140 × MTU 7029	102.00	129.00	121.27	16.00	12.00	27.97	214.84	20.14	3.12	32.34	79.54
34	MTU 1064 × MTU 1061	100.33	129.33	121.44	17.33	12.00	29.09	236.17	19.88	2.49	35.68	80.15
35	MTU 1064 × MTU 7029	108.00	138.00	116.70	14.67	11.33	29.66	205.34	19.76	2.34	28.24	81.14
36	MTU 1061 × MTU 7029	104.67	135.67	119.28	14.33	11.00	30.20	270.11	20.71	2.49	28.91	77.82
	Overall Mean	94.35	123.69	114.90	14.87	11.85	28.73	213.78	21.15	2.70	79.85	72.65
	C.V.	2.04	1.84	1.77	6.49	8.64	4.41	5.28	2.05	4.68	1.43	1.66
	S.Em	1.11	1.32	1.17	0.56	0.59	0.73	6.51	0.25	0.07	0.66	0.70
	C.D. 5%	3.14	3.71	3.31	1.57	1.67	2.06	18.37	0.71	0.21	1.86	1.96

DFF: Days to 50% Flowering; DM: Days to Maturity; PH: Plant Height; TNTP: Total Number of Tillers per Plant; TEBTP: Total number of Ear Bearing Tillers per Plant; PL: Panicle Length per plant; NGPP: Number of Grains per Panicle; TW: Test Weight; LAI: Leaf Area Index at maximum tillering stage.

Table.1 Mean performance of 8 parents and 28 F_1s in rice (*Oryza sativa* L.)

S. No.	Parents and F_1s	MP	HRR	KL	KB	L/B	KLAC	KBAC	KLER	VER	WU	GC	ASV	AC
1	MTU 1001	67.87	63.91	5.93	2.31	2.57	10.05	2.81	1.69	4.91	256.67	52.27	5.50	25.45
2	BPT 3291	69.50	64.12	5.43	2.03	2.67	9.28	2.59	1.71	5.15	165.00	53.34	3.67	24.53
3	MCM 100	71.56	66.55	5.56	2.22	2.50	9.06	2.71	1.63	5.11	150.00	57.95	3.39	20.23
4	MTU 1121	69.50	64.52	5.78	2.09	2.76	9.40	2.58	1.63	4.80	171.67	57.27	2.94	22.21
5	MTU 1140	70.52	66.00	5.69	2.24	2.54	10.03	2.66	1.76	4.67	225.00	49.04	4.06	25.08
6	MTU 1064	72.36	65.80	5.66	2.11	2.69	9.98	2.61	1.76	4.47	156.67	62.88	6.11	24.22
7	MTU 1061	71.55	66.98	5.78	2.04	2.83	10.09	2.77	1.75	4.66	208.33	62.86	6.17	21.05
8	MTU 7029	67.20	62.67	5.31	2.13	2.49	8.73	3.07	1.64	3.92	185.00	46.12	3.11	22.48
9	MTU 1001 × BPT 3291	74.19	69.82	5.85	2.31	2.54	9.56	2.83	1.64	4.41	151.67	45.97	5.17	21.68
10	MTU 1001 × MCM 100	73.98	69.18	5.53	2.18	2.53	9.55	2.80	1.73	4.24	153.33	69.23	5.17	22.78
11	MTU 1001 × MTU 1121	73.13	70.23	5.65	2.23	2.54	10.00	2.72	1.77	4.05	165.00	86.70	4.28	23.89
12	MTU 1001 × MTU 1140	77.92	74.98	5.61	2.32	2.42	9.78	2.99	1.74	4.21	190.00	94.08	5.06	26.51
13	MTU 1001 × MTU 1064	73.99	67.73	5.60	1.93	2.90	9.77	2.56	1.75	4.44	255.00	76.36	4.94	22.70
14	MTU 1001 × MTU 1061	74.89	66.04	5.84	2.36	2.47	9.85	2.84	1.69	5.80	211.67	87.36	5.72	21.56
15	MTU 1001 × MTU 7029	72.83	65.42	5.84	2.46	2.37	9.81	3.08	1.68	5.82	170.00	50.75	4.28	20.86
16	BPT 3291 × MCM 100	74.10	70.46	5.57	2.27	2.46	9.38	3.10	1.68	4.62	121.67	91.37	2.56	28.73
17	BPT 3291 × MTU 1121	71.45	64.96	5.77	2.34	2.47	9.97	3.09	1.73	4.09	185.00	44.47	3.33	23.50
18	BPT 3291 × MTU 1140	76.51	70.54	6.06	2.25	2.69	9.55	3.20	1.58	3.79	166.67	94.10	2.78	23.61
19	BPT 3291 × MTU 1064	76.24	68.97	5.71	2.34	2.44	9.88	3.06	1.73	4.74	165.00	78.37	5.17	19.84
20	BPT 3291 × MTU 1061	70.69	63.60	5.51	2.16	2.55	9.05	3.23	1.64	4.71	185.00	43.04	4.67	31.04
21	BPT 3291 × MTU 7029	74.05	64.63	5.64	2.23	2.53	9.56	3.11	1.70	4.78	185.00	97.96	5.89	22.64
22	MCM 100 × MTU 1121	70.88	64.13	5.74	2.23	2.58	9.15	2.99	1.59	4.78	190.00	70.41	2.50	30.80
23	MCM 100 × MTU 1140	73.79	70.69	5.36	2.15	2.49	9.06	3.25	1.69	4.53	193.33	56.57	2.61	20.16
24	MCM 100 × MTU 1064	72.51	68.60	5.76	2.26	2.55	9.50	3.05	1.65	5.44	193.33	42.03	5.22	22.40
25	MCM 100 × MTU 1061	73.58	67.61	5.65	2.26	2.50	9.87	3.22	1.75	4.76	163.33	97.92	3.44	18.86
26	MCM 100 × MTU 7029	73.87	69.45	5.88	2.38	2.47	9.08	2.86	1.55	5.05	190.00	92.18	2.61	21.75
27	MTU 1121 × MTU 1140	73.39	71.51	5.49	2.15	2.55	9.54	2.79	1.74	4.40	163.33	87.11	3.56	21.94
28	MTU 1121 × MTU 1064	70.14	65.07	5.57	2.25	2.48	9.43	2.77	1.69	5.41	190.00	45.14	5.28	25.39
29	MTU 1121 × MTU 1061	73.00	67.33	5.61	2.27	2.47	9.09	2.56	1.62	4.70	200.00	55.87	4.78	22.67
30	MTU 1121 × MTU 7029	72.97	63.22	5.71	2.25	2.54	9.34	3.03	1.63	5.48	181.67	88.72	5.00	32.53
31	MTU 1140 × MTU 1064	71.96	68.54	5.73	2.27	2.53	9.62	2.76	1.68	4.91	163.33	55.14	2.56	21.17
32	MTU 1140 × MTU 1061	75.37	70.60	5.60	2.30	2.43	9.43	2.56	1.69	4.69	171.67	98.27	4.56	25.36
33	MTU 1140 × MTU 7029	70.44	67.38	5.67	2.27	2.50	9.17	2.75	1.62	4.06	163.33	87.85	4.44	23.26
34	MTU 1064 × MTU 1061	73.56	65.11	5.75	2.25	2.55	9.87	2.73	1.72	4.81	223.33	41.66	2.61	20.99
35	MTU 1064 × MTU 7029	74.62	65.32	5.55	2.22	2.51	9.47	3.10	1.71	4.79	205.00	48.03	5.67	29.36
36	MTU 1061 × MTU 7029	71.28	63.48	5.73	2.30	2.50	9.11	3.08	1.59	5.10	183.33	68.56	5.94	21.95
	Overall Mean	67.09	5.67	2.23	2.54	9.53	2.89	1.68	4.73	183.29	67.69	4.30	23.70	28.75
	C.V.	2.01	1.46	1.59	1.69	1.74	3.80	2.27	3.27	3.78	4.18	4.11	2.92	5.55
	S.Em	0.78	0.05	0.02	0.02	0.10	0.06	0.02	0.09	4.00	1.63	0.10	0.40	0.92
	C.D. 5%	2.20	0.13	0.06	0.07	0.27	0.18	0.06	0.25	11.29	4.60	0.29	1.13	2.60

HP%: Hulling percentage; MP%: Milling percentage; HRR%: Head Rice Recovery; KL: Kernel Length; KB: Kernel Breadth ;L/B: Kernel L/B ratio; KLAC: Kernel Length After Cooking; KBAC: Kernel Breadth After Cooking; KLER: Kernel Linear Elongation Ratio; VER: Volume Expansion Ratio; WU: Water Uptake; GC: Gel Consistency; ASV: Alkali Spreading Value; AC: Amylose Content.

Table.2 Analysis of variance for grain yield, yield component characters and quality trait of 28 F_1s and 8 parents in rice (*Oryza sativa* L.)

Source of variations	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Total number of tillers per plant	Number of ear tillers per plant	Panicle length per plant (cm)	Number of grains per panicle	Test weight (gm)	Leaf area index at maximum tillering stage	Hulling percentage	Milling percentage	Head rice recovery
Mean sum of squares													
Replications	2	1.037	1.750	0.073	0.065	0.009	0.124	4.896	0.039	0.006	0.045	0.053	0.001
Treatments	35	207.085**	207.036**	218.032**	11.681**	4.751**	7.762**	2333.950**	7.616**	0.636**	16.181**	24.776**	0.072**
Error	70	3.723	5.188	4.127	0.931	1.047	1.605	127.268	0.188	0.016	1.451	1.824	0.007
Total	107	211.844	213.974	222.231	12.678	5.808	9.491	2466.114	7.843	0.657	17.677	26.653	0.080

Table.2 Analysis of variance for grain yield, yield component characters and quality trait of 28 F_1s and 8 parents in rice (*Oryza sativa* L.)

Source of variations	d.f.	Kernel length (mm)	Kernel breadth (mm)	Kernel L/B ratio	Kernel length after cooking (mm)	Kernel breadth after cooking (mm)	Kernel elongation ratio	Volume expansion ratio	Water uptake (ml)	Gel consistency (mm)	Alkali spreading value (mm)	Amylose content (%)	Grain yield per plant (gm)
Mean sum of squares													
Replications	2	0.000	0.001	0.005	0.004	0.000	0.005	0.926	1.688	0.001	0.064	0.152	1.088
Treatments	35	0.033**	0.038**	0.381**	0.142**	0.010**	0.711**	2338.327**	1162.144**	4.306**	32.493**	86.673**	2.883**
Error	70	0.001	0.002	0.027	0.012	0.001	0.024	48.069	7.994	0.031	0.480	2.543	1.299
Total	107	0.035	0.040	0.413	0.158	0.012	0.740	2387.321	1171.825	4.338	33.036	89.367	5.269

**** Significant at 1% level**

Table.3 Estimates of variability, heritability and genetic advance as per cent of mean for grain yield, yield component characters and quality trait of 28 F_1s and 8 parents in rice (*Oryza sativa* L.)

S. No.	Characters	Mean	Range		Coefficient of variation		Heritability (broad sense)	Genetic Advancement	Genetic advance as per cent of mean
			Min.	Max.	PCV (%)	GCV (%)			
1	Days to 50% flowering	94.35	68.67	108.00	8.96	8.73	94.80	16.51	17.50
2	Days to maturity	123.69	97.67	138.00	6.88	6.63	92.80	16.28	13.16
3	Plant height (cm)	114.90	92.90	130.18	7.56	7.35	94.50	16.91	14.72
4	Total number of tillers plant^{-1}	14.87	10.33	17.67	14.29	12.73	79.40	3.47	23.36
5	Number of ear bearing tillers plant^{-1}	11.85	8.67	14.00	12.75	9.38	54.10	1.68	14.21
6	Panicle length per plant (cm)	28.73	24.47	31.20	6.66	4.99	56.10	2.21	7.69
7	Number of grains per panicle	213.78	141.23	270.89	13.74	12.69	85.20	51.59	24.13
8	Test weight (g)	21.15	18.20	24.33	7.72	7.44	92.90	3.13	14.77
9	LAI at max tillering stage	2.70	2.09	3.72	17.49	16.85	92.80	0.90	33.45
10	Grain yield plant $^{-1}$ (g)	28.75	20.21	38.03	19.24	18.42	91.70	10.45	36.33
11	Hulling (%)	79.85	77.82	82.24	1.69	0.91	28.90	0.81	1.01
12	Milling (%)	72.65	67.20	77.92	3.47	3.05	77.20	4.01	5.52
13	Head rice recovery (%)	67.09	62.67	74.98	4.59	4.12	80.70	5.12	7.63
14	Kernel length (mm)	5.67	5.31	6.06	2.99	2.61	76.20	0.27	4.69
15	Kernel breadth (mm)	2.23	1.93	2.46	4.89	4.62	89.40	0.20	9.01
16	Length/Breadth Ratio	2.54	2.37	2.90	4.62	4.30	86.60	0.21	8.24
17	Kernel length after cooking (mm)	9.53	8.73	10.09	4.00	3.60	81.10	0.64	6.68
18	Kernel breadth after cooking (mm)	2.89	2.56	3.25	8.14	7.20	78.20	0.38	13.12
19	Kernel Elongation Ratio	1.68	1.55	1.77	3.92	3.19	66.40	0.09	5.35
20	Volume expansion ratio	4.73	3.79	5.82	10.63	10.12	90.60	0.94	19.83
21	Water uptake (ml)	183.29	121.67	256.67	15.54	15.08	94.10	55.21	30.12
22	Gel consistency (mm)	67.69	41.66	98.27	29.28	28.98	98.00	39.99	59.08
23	Alkali spreading value (mm)	4.30	2.50	6.17	28.08	27.77	97.90	2.43	56.60
24	Amylose content (%)	23.70	18.86	32.53	14.09	13.78	95.70	6.58	27.78

PCV = Phenotypic coefficient of variation **GCV = Genotypic coefficient of variation**

The phenotypic coefficient of variance (PCV) was slightly higher in magnitude than genotypic coefficient of variance (GCV) for all the characters studied indicating the influence of environment on expression of these traits. Gel consistency and alkali spreading value showed high PCV and GCV. While, moderate PCV and moderate GCV was observed for total number of tillers per plant, number of grains per panicle, leaf area index at maximum tillering stage, volume expansion ratio, water upatake, amylase content and grain yield per plant, whereas number of ear bearing tillers per plant exhibited moderate PCV and low GCV. Plant height recorded moderate PCV and low GCV. However, low PCV, GCV were recorded for days to 50% flowering, days to maturity, plant height, panicle length, test weight, hulling per cent, milling per cent, head rice recovery, kernel length, kernel breadth, L/B ratio, kernel length after cooking, kernel breadth after cooking and kernel elongation ratio (Table 3). Similar results were reported by Allam *et al.,* (2015), Navin Kumar *et al.,* (2015), Sameera *et al.,* (2015), Shajedur Hossain *et al.,* (2015), Vijay Kumar *et al.,* (2015), Arpita *et al.,* (2014) and Gokulakrishnan *et al.,* (2014).

High heritability coupled with high genetic advance as per cent of mean was observed for the characters viz., total number of tillers per plant, panicle length, number of grains per panicle, leaf area index at maximum tillering stage, water uptake, gel consistency, alkali spreading value, amylase content and grain yield per plant, indicating that the heritability was due to additive gene effects, which may be exploited through breeding methods involving simple selection like pedigree method, mass selection, ear-to-row method etc. are to be followed to improve these traits. Whereas high heritability and moderate genetic advance as per cent of mean was recorded for days to 50% flowering, days to maturity, plant height, test weight, kernel breadth after cooking and volume expansion ratio. While, number of ear bearing tillers per plant exhibited moderate heritability, genetic advance as per cent of mean, reveals that heritability was due to additive gene effects and selection may be effective. Milling per cent, hulling per cent, kernel length, kernel breadth, L/B ratio, kernel length after cooking and kernel elongation ratio showed high heritability coupled with low genetic advance as per cent of mean, indicative of non-additive gene action and heritability was being exhibited due to favorable influence of environmental conditions rather than genotype and selection for this trait may not be rewarded. Whereas moderate heritability coupled with low genetic advance as per cent of mean was noticed for panicle length and low heritability coupled with low genetic advance as per cent of mean for hulling per cent. These findings are corroborated by Keya *et al.,* (2015), Sameera *et al.,* (2015), Arpita *et al.,* (2014), Gokulakrishnan *et al.,* (2014) and Swati Sharma *et al.,* (2014).

High to moderate variability was observed for total number of tillers per plant, number of grains per panicle, LAI at maximum tillering stage, volume expansion ratio, water uptake, amylose content and grain yield per plant. High heritability coupled with high genetic advance as per cent of means were observed for total number of tillers per plant, number of grains per panicle, leaf area index at maximum tillering stage, water uptake, gel consistency, alkali spreading value, amylose content and grain yield per plant, revealed the role of additive gene action. This in turn suggests the feasibility of simple selection procedures for improving these traits.

Acknowledgement

I humbly thank the authorities of Acharya N.G. Ranga Agricultural University-Guntur, Andhra Pradesh and University Grants Commission – New Delhi for providing financial assistance in the form of fellowship during my course of study.

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How to cite this article:

Hari Ram Kumar Bandi, P.V. Satyanarayana, D. Ratna Babu, N. Chamundeswari, V. Srinivasa Rao and Krishnam Raju, S. 2018. Genetic Variability Estimates for Yield and Yield Components Traits and Quality Traits in Rice (*Oryza sativa* L.). *Int.J.Curr.Microbiol.App.Sci.* 7(05): 551-559. doi: https://doi.org/10.20546/ijcmas.2018.705.069