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Genetic variability studies for yield and its Components and quality traits with high iron and zinc content in segregating population of rice (*Oryza sativa* L.)

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Abstract
The present investigation was carried out for yield and yield related traits in the F_2, F_3 and Biparental populations of four rice cross combinations *viz*., Rajamudi x ASD 16, Rajamudi x CO 47, Mohini samba x ASD 16 and Mohini samba x CO 47. The genotypic and phenotypic coefficient of variability were low in four crosses for most of the traits *viz*., days to 50% flowering, plant height, panicle length, number of grains per panicle and spikelet fertility in F_2, F_3 and BIPs generation. High heritability coupled with high genetic advance as mean observed for number of productive tillers in F_2, F_3, BIPs population of Mohini samba x ASD 16 and Rajamudi x ASD 16 and Rajamudi x CO 47 in F_2 and BIPs generation. This indicates scope of selection in the population, since there is a wide range of variation and additive gene action. The Rajamudi x ASD 16 and Mohini samba x CO 47 crosses were selected with high zinc and iron content for grain quality analysis in F_3 and biparental population. Based on mean, GCV, PCV, heritability and genetic advance, it was understood that the progenies of Mohini samba x CO 47 would be more useful for improving grain iron content with the desirable quality traits *viz*., kernel length, kernel length after cooking, kernel breadth after cooking, linear elongation ratio and breadth wise expansion ratio. Similarly Rajamudi x ASD 16 segregants could be used for improving the kernel length, kernel breadth, and kernel L/B ratio, kernel length after cooking, kernel breadth after cooking, breadth wise expansion ratio and grain zinc content.

Keywords: Rice, genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), Genetic Advance (GA), yield related traits, iron & zinc content, quality

Introduction
Rice is the life and the Prince among cereals as this unique grain helps to sustain two thirds of the world's population. It is considered as the main staple food for more than 50 per cent of the world's population. Landraces provide a vast genetic variability for the present day rice improvement programme. Landraces possess several undesirable agronomic traits including tall plant stature, long crop duration, sensitivity to photoperiod, and poor response to fertilizer application resulting in too low yield. Though domesticated, un-adapted landraces are phenotypically less desirable. Diverse plant types is immediately valuable for shaping new varieties and this forms the basic wealth on which plant breeders can operate for reconstructing the existing genotypes. Rice is most widely consumed in one or other form by poorest to richest person. However, rice is a poor source of essential micronutrients such as iron (Fe) and zinc (Zn) (Bouis and Welch, 2010) [4]. Because of the importance of rice, FAO named the year 2004 'International Year of Rice' and the theme of that year was 'Rice is life'.
Segregating populations are more important for improving plant types by operating further selection improvement. The F_2 or F_3 derived lines are far from being homozygous and early generation selection relies on the assumption that the performance of a line at an early generation of selfing is predicative of its performance at homozygosity.
In order to improve the yield and quality through selection, it is essential to have a thorough knowledge on genetic variability available in the segregating population and the extent to which the desirable traits are heritable, which requires a letter insight of the ancillary characters for better selection. Therefore, the present study was aimed at finding out nature and magnitude of genetic variability in F_2, F_3 and Biparental population of rice for yield and other yield component traits, grain quality and micronutrient traits to select the transgressive segregants for further breeding programme.

Materials and Methods

The F_2 of four cross combinations, namely, Rajamudi x ASD 16, Rajamudi x CO 47, Mohini samba x ASD 16 and Mohini samba x CO 47 along with four parents were raised during *kharif* 2017 at Department of Rice, Tamil Nadu Agricultural University, Coimbatore, which formed the materials for the present study. The experiment was conducted at the Department of rice, Centre for Plant Breeding and Genetics, Tamil Nadu Agriculture University, Coimbatore. The F_2, F_3 and Biprental population was raised during December 2017 to April 2018. Segregating populations of F_2 in four crosses were raised in non replicated plots. The F_3 and Biparental population of each cross were planted in a randomized block design with two replications. The number of seedlings raised were 40 for parents, 20 for F_1, 120 for F_2 and 32 for F_3 families per replication. The row spacing was 20 cm and plant spacing was 20 cm. Normal recommended cultural practices were adopted for growing the material. The observations were recorded for yield and yield attributing characters *viz.*, days to 50% flowering, plant height (cm.), number of productive tillers per plant, panicle length (cm.), number of grains per panicle, spikelet fertility (%), hundred grain weight (g.) and grain yield per plant (g.) in all the tagged plants in F_1, 100 randomly tagged plants in $F_{2,}$ 20 randomly tagged plants in $F_{3.}$ and 20 randomly tagged plants in BIPs and parents per replication. Among the four crosses, Rajamudi x ASD 16 and Mohini samba x CO 47 were selected with high zinc and iron content for grain quality analysis for kernel length, kernel breadth, kernel length/breadth ratio, kernel length after cooking, kernel breadth after cooking, linear elongation ratio, breath wise expansion ratio, volume expansion ratio, alkali spreading value, amylose content, gel consistency, grain Iron and Zinc content. The Iron and zinc content were determined by using Atomic absorption spectrophotometer (AAS) as suggested by Jackson (1973).

Result and Discussion

The potentiality of a cross is measured not only by mean performance but also on the extent of variability. Knowledge on nature and magnitude of genotypic and phenotypic variability present in any crop species plays an important role in formulating successful breeding programmes. The estimates of genotypic and phenotypic coefficient of variation for different quantitative characters for four crosses in F_2, F_3 and BIPs generations are presented in Table 1 to 4. The estimates revealed that PCV for all the characters were slightly more than that of GCV indicating the less influence of environment. Thus selection based on phenotypic performance of these traits would be effective to bring about considerable improvement of these traits. Similar results were found by Patel *et al*., (2014) [10], Subbaiah *et al*., (2011) [16] and Shobha Rani *et al*., (2001) [15].

The genotypic and phenotypic coefficient of variability were low in four crosses for most of the traits *viz*., days to 50% flowering, plant height, panicle length, number of grains and spikelet fertility in F_2, F_3 and BIPs generation and number of productive tillers showed low GCV, PCV in F_3 generation of Mohini samba x CO47, Rajamudi x ASD 16 and Rajamudi x CO 47 crosses. Hundred grain weight and seed yield per plant were also exhibited low GCV and PCV in Mohini samba x CO47 and Rajamudi x CO 47 in F_3 and BIPs generation. These results were in accordance with Mahalingam (2008) [8] who studied low genotypic and phenotypic coefficient of variation for the traits *viz*., days to 50% flowering, plant height, panicle length, number of productive tillers and seed yield per plant in F_2, F_3 and BIPs progenies of the cross WGL 14 × Rasi and the report of Ravikumar *et al*., (2014) in rice of F_3 progenies showed low genotypic and phenotypic coefficient of variation for days to 50% flowering, plant height and panicle length.

The moderate GCV and PCV was obtained for number of productive tillers for Mohini samba x ASD 16 in F_2, F_3 and BIPs generation and Mohini samba x CO 47, Rajamudi x ASD 16, Rajamudi x CO 47 in F_2 and BIPs generation. For the trait hundred grain weight showed moderate genotypic and phenotypic coefficient of variation for Rajamudi x ASD 16 in F_2, F_3 and BIPs generation and Mohini samba x CO 47 in F_2 generation where as Mohini samba x ASD 16 cross showed moderate GCV and PCV in F_3 and BIPs generation. Similar result finding was in accordance with Savitha and Ushakumari (2015) [13] in the cross IR 72 x Veeradangan and ADT 39 x Kavuni of F_2 and F_3 generations.

Rajamudi x ASD 16 showed moderate genotypic and phenotypic coefficient of variation and Mohini samba x ASD 16 in all three generations of F_2, F_3 and BIPs and Mohini samba x CO 47, Rajamudi x CO 47 in F_2 generation for seed yield per plant where as Rajamudi x ASD 16 showed moderate variability present in F_2, F_3 and BIPs generation. These results was accordance with Mahalingam (2008) [8] who studied moderate variability in F_2 and BIPs generation of the cross WGL 14 × Rasi for seed yield and the result of Savitha *et al*., (2015) [13] in the cross of IR 72 x Veeradangan and ADT 39 x Kavuni of F_2 and F_3 generation. The phenotypic and genotypic coefficient of variability were high for hundred grain weight in F_2 generation of Mohini samba x ASD 16 cross. For the trait seed yield per plant showed moderate genotypic and phenotypic coefficient of variation in F_2, F_3 and BIPs generation of Rajamudi x ASD 16 cross. Similar result finding with Savitha and Ushakumari (2015) [13] in the cross IR 72 x Veeradangan and ADT 39 x Kavuni of F_2 and F_3 generation and the report of Hariramakrishnan (2008) [6] in BPT 5204 x IR 20 cross of $F_{2,}$ F_3 and BIPs generation.

Estimated heritability value alone is less reliable because as these values are prone to alter with change in the environment and experimental material (Swarup and Changale, 1962) [17]. Hence, heritability values coupled with genetic advance would be more reliable than heritability alone. In the present investigation, high heritability coupled with high genetic advance as mean observed for number of productive tillers in F_2, F_3 and BIPs generation of Mohini samba x ASD 16, Rajamudi x ASD 16 and Rajamudi x CO 47 for F_2 and BIPs progenies. But in case of Mohini samba x CO 47 showed high heritability with high genetic advance as per cent of mean in BIPs generation. Similar result finding with Hefena *et al.*, (2016) [7] for number of productive tillers per plant.

For the trait hundred grain weight showed high heritability with high genetic advance as mean in the cross of Mohini samba x ASD 16 in F_2, F_3 and BIPs generation and Mohini samba x CO 47 in F_2 generation. Rajamudi x ASD 16 also exhibited high heritability with high genetic advance as mean in BIPs generation. Thus, these traits are most probably controlled by additive gene action and hence these traits can be fixed by selection. These results are in accordance with the findings of Savitha and Ushakumari (2015) [13] who studied F_2 and F_3 generation of ASD 16 x Navara and TPS 4 x Kathanellu crosses.

High heritability coupled with moderate to high genetic advance as percent of mean was recorded for plant height for Rajamudi x CO 47 and Rajamudi x ASD 16 and Mohini samba x CO 47 for F_2 and BIPs progenies. It can be contributed to favourable influence of environment rather than genotype and selection may not be rewarding. This observation is in agreement with the earlier findings of F_2 and F_3 generation (Sanjeev Kumar *et al*., 2005, Anilkumar, 2008) [2]. Seed yield per plant exhibited high heritability with moderate to high genetic advance as percent of mean was recorded for Rajamudi x CO 47 in F_2, F_3 and BIPs generations and Mohini samba x ASD 16 and Mohini samba x CO 47 in F_2 and BIPs generations.

Grain quality traits with Iron and Zinc content

The estimates of genotypic and phenotypic coefficient of variation for grain quality traits with Iron and Zinc content of selected Rajamudi x ASD 16 and Mohini samba x CO 47 crosses of F_3 and BIPs generation are presented in Table 5 and 6. The genotypic and phenotypic coefficient of variability were low in both the crosses for the most of the traits *viz.*, Kernel length, Kernel breadth, Kernel L/B ratio, Kernel length after cooking, Kernel breadth after cooking, Linear elongation ratio Breadth wise expansion ratio, Amylose content and Volume expansion ratio in F_3 and BIPs progenies (table 1). It indicated that all the crosses might have attained homozygosity in F_3 itself for these traits. These results were in accordance with Hari ramakrishnan (2008) [6] who studied F_3 and BIPs progenies which was derived from the cross BPT 5204 x Tadukan and the report of Sala and Ananda Kumar (2012) [12] in rice F_4 and F_5 generation recorded low genotypic and phenotypic coefficient of variability in both the generations of the ADT 37 x IR68144-3B-2-2-3 and TRY (R) 2 x Mapillaisamba crosses.

The genotypic and phenotypic coefficient of variability was high in Alkali spreading value in Mohini samba x CO 47 in both generations and moderate GCV and high PCV were recorded in Rajamudi x ASD 16 of F_3 generation and moderate GCV and PCV exhibited in Rajamudi x ASD 16 cross of BIPs generation.

For the trait gel consistency, moderate genotypic and phenotypic coefficient of variability showed in F_3 (12.91/13.03) followed by BIPs generation (10.23/10.27) in the cross of Rajamudi x ASD 16 and Low PCV and GCV was recorded (8.86/8.90) in BIPs followed by F_3 generation (8.27/8.22) of Mohini samba x CO 47 cross. Similar results were reported by Hariramakrishnan (2008) [6] who studied moderate genotypic and phenotypic coefficient of variability in F_3 and BIPs progenies.

Iron and zinc content in present study indicated low, moderate PCV and GCV was observed in F_3 and BIPs generation for both the crosses. Hence, these traits need one or more generations in order to attain homozygosity. These results were in parallel with the findings of Kalaimaghal (2011) [5] who observed moderate GCV and PCV for iron content in the in F_2 and F_3 in the cross ADT37 x IR68144-3B-2-2-3 and Sala and Ananda Kumar (2012) [12] who studied ADT 37 x IR68144-3B-2-2-3 and TRY (R) 2 x Mapillaisamba crosses in F_4 and F_5 generation.

High heritability coupled with high genetic advance as percentage of mean was observed for Alkali spreading value and Iron content in Rajamudi x ASD 16 and Mohini samba x CO 47 crosses and Mohini samba x CO 47 cross for zinc content. Hence, these traits were least influenced by environment and mostly governed by additive gene action. Therefore, there is scope for improvement of iron and zinc content by exercising selection pressure on these two characters. These results were in agreement with Shanmuga sundara pandian (2007) [14], Purusothaman (2010) [11] and Aswini Shamak *et al*. (2011) [3] in F_4 and F_5 generation.

High heritability with moderate genetic advance as percentage of mean was observed in Kernel breadth and Kernel L/B ratio, Volume expansion ration, Amylose content, Gel consistency in F_3 and BIPs generation and Kernel breadth after cooking in F_3 generation of Mohini samba x CO 47 cross and Linear elongation ratio, Breadth wise expansion ratio, Volume expansion ratio, Amylose content and zinc content in F_3 and BIPs generation of Rajamudi x ASD 16 cross.

Table 1: Mean, range and genetic parameters for yield and yield related traits in F_2, F_3 and Biparental progenies of Rajamudi x ASD 16 in rice

Characters	Generation	Mean	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance as % mean
Days to 50% flowering	F_2	79.50	66.00 – 85.00	5.90	6.34	86.43	11.89
	F_3	76.14	70.00 – 83.00	3.70	4.38	71.16	6.43
	BIPs	76.77	71.50 – 83.50	4.71	4.79	96.82	9.55
Plant height	F_2	107.51	95.00 – 124.15	7.65	7.69	98.87	16.50
	F_3	103.39	94.00 – 115.00	5.01	5.62	79.22	9.18
	BIPs	102.48	90.00 – 112.00	5.01	5.27	93.58	10.16
Number of productive tillers	F_2	14.38	10.00 – 19.00	17.00	18.76	82.19	33.45
	F_3	14.82	13.00 – 17.00	5.66	7.81	52.40	8.43
	BIPs	15.43	12.00 – 19.30	12.89	13.22	95.11	25.89
Panicle length	F_2	23.10	20.00 – 26.50	5.01	6.07	68.22	8.98
	F_3	22.80	20.00 – 27.00	5.56	7.72	51.80	8.24
	BIPs	24.15	21.28 – 26.00	3.84	4.58	70.55	6.65
Number of grains	F_2	129.88	117.00 – 144.00	4.75	5.83	66.38	8.39
	F_3	127.47	119.00 – 136.00	3.32	3.56	87.20	6.40
	BIPs	130.58	121.00 – 142.00	3.56	3.72	91.57	7.02
Spikelet fertility	F_2	79.67	70.00 – 91.00	5.63	7.32	59.19	9.40
	F_3	79.70	74.50 – 87.73	4.61	4.78	93.10	9.17
	BIPs	81.09	75.88 – 89.30	4.63	4.67	98.40	9.46
Hundred grain weight	F_2	1.77	1.30 – 2.39	15.39	16.52	86.81	31.12
	F_3	1.88	1.50 – 2.28	10.40	11.61	80.26	19.20
	BIPs	1.95	1.55 – 2.32	10.01	10.33	93.90	19.99
Seed yield per plant	F_2	28.15	24.20 – 38.50	10.33	12.28	70.78	18.87
	F_3	28.69	23.15 – 36.00	10.69	12.16	77.30	19.36
	BIPs	31.03	25.86 – 39.00	10.64	11.01	90.47	20.50

Table 2: Mean, range and genetic parameters for yield and yield related traits in F_2, F_3 and Biparental progenies of Rajamudi x CO 47 in rice

Characters	Generation	Mean	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance as % mean
Days to 50% flowering	F_2	76.50	67.00 – 82.00	6.75	7.33	84.78	13.48
	F_3	77.28	70.00 – 86.00	4.69	4.91	91.31	9.24
	BIPs	78.02	72.00 – 84.00	3.80	4.10	85.93	7.25
Plant height	F_2	101.68	86.50 – 117.60	8.64	8.68	99.07	18.65
	F_3	102.09	88.00 – 117.20	6.65	6.79	96.14	13.44
	BIPs	102.53	90.27 – 116.00	6.57	6.68	96.55	13.29
Number of productive tillers	F_2	14.71	9.00 – 20.00	19.78	22.05	80.50	38.51
	F_3	13.94	11.00 – 17.00	6.16	9.77	39.78	8.01
	BIPs	14.99	12.00 – 21.00	11.54	12.84	80.71	21.35
Panicle length	F_2	21.53	18.50 – 24.80	7.62	8.41	82.10	14.99
	F_3	22.75	21.00 – 25.00	3.85	5.50	48.92	5.54
	BIPs	22.02	20.00 – 24.00	3.79	4.02	89.12	7.38
Number of grains	F_2	125.53	117.00 – 136.00	3.94	4.34	82.45	7.76
	F_3	122.07	115.00 – 130.00	2.96	3.19	86.44	5.67
	BIPs	124.21	117.50 – 132.00	3.19	3.34	91.38	6.28
Spikelet fertility	F_2	87.12	84.00 – 91.00	2.38	2.74	75.68	4.49
	F_3	86.90	85.00 – 88.55	0.68	0.88	60.60	1.10
	BIPs	87.37	86.00 – 90.50	1.31	1.34	91.65	2.58
Hundred grain weight	F_2	1.60	1.37 – 1.80	8.09	8.45	91.65	16.80
	F_3	1.64	1.55 – 1.77	3.27	3.70	78.17	5.96
	BIPs	1.69	1.52 – 1.80	3.79	4.16	83.00	7.12
Seed yield per plant	F_2	28.00	23.00 – 40.00	10.80	13.82	61.14	18.33
	F_3	29.81	24.25 – 36.00	6.98	8.31	70.44	12.07
	BIPs	31.63	27.00 – 39.00	7.73	8.46	83.53	14.56

Table 3: Mean, range and genetic parameters for yield and yield related traits in F_2, F_3 and Biparental progenies of Mohini samba x ASD 16 in rice

Characters	Generation	Mean	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance as % mean
Days to 50% flowering	F_2	83.13	70.00 - 92.00	8.86	8.91	98.78	19.10
	F_3	81.49	70.00 - 96.00	8.22	8.65	90.20	16.07
	BIPs	81.86	72.00 - 93.00	7.05	7.13	97.86	14.38
Plant height	F_2	98.30	93.70 - 102.10	2.61	2.79	87.81	5.31
	F_3	99.01	94.57 - 104.56	1.85	2.14	74.72	3.29
	BIPs	97.65	91.56 - 101.12	2.74	3.06	79.93	5.04
Number of productive tillers	F_2	13.58	10.00 - 18.00	17.28	19.41	79.23	33.38
	F_3	12.69	10.20 - 15.00	10.12	10.38	95.12	20.34
	BIPs	14.01	11.20 - 19.00	13.85	14.05	97.12	28.12
Panicle length	F_2	23.35	19.80 - 27.00	7.30	8.42	75.05	13.72
	F_3	21.80	20.00 - 24.00	3.66	5.34	47.11	5.18
	BIPs	21.59	19.00 - 23.47	5.28	5.73	84.80	10.02
Number of grains	F_2	130.28	120.00 - 144.00	7.30	8.42	82.81	9.50
	F_3	123.94	116.00 - 135.00	3.38	3.73	81.78	6.29
	BIPs	126.70	118.40 - 138.50	4.30	4.51	90.63	8.43
Spikelet fertility	F_2	80.87	74.50 - 86.70	4.01	4.70	72.67	7.41
	F_3	81.50	80.00 - 83.50	1.05	1.24	72.21	1.84
	BIPs	83.00	80.45 - 86.00	1.65	1.85	79.36	3.03
Hundred grain weight	F_2	1.73	1.24 - 2.50	20.01	20.28	97.37	42.84
	F_3	1.87	1.42 - 2.32	11.68	12.54	86.68	22.40
	BIPs	1.94	1.35 - 2.35	11.33	11.78	92.62	22.47
Seed yield per plant	F_2	26.23	23.00 - 33.56	8.63	10.59	66.48	15.28
	F_3	31.18	28.00 - 35.13	4.58	5.88	60.69	7.35
	BIPs	32.67	27.88 - 38.00	7.25	7.45	94.61	14.53

Table 4: Mean, range and genetic parameters for yield and yield related traits in F_2, F_3 and Biparental progenies of Mohini samba x CO 47 in rice

Characters	Generation	Mean	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance as % mean
Days to 50% flowering	F_2	85.17	71.00 – 97.00	9.26	9.53	94.95	19.65
	F_3	79.43	66.50 – 93.00	9.33	9.52	96.00	18.82
	BIPs	79.36	70.00 – 94.00	8.03	8.11	98.10	16.39
Plant height	F_2	99.22	87.50 – 107.00	5.69	5.78	96.91	12.16
	F_3	93.27	88.00 – 97.80	2.63	2.82	86.90	5.05
	BIPs	94.65	85.70 – 103.52	5.75	5.81	97.87	11.71
Number of productive tillers	F_2	14.38	12.00 – 17.00	10.67	12.53	72.59	19.73
	F_3	12.54	10.10 – 14.20	8.24	9.25	79.39	15.12
	BIPs	14.12	11.00 – 19.80	14.28	14.64	95.18	28.70

Panicle length	F_2	21.48	18.00 – 24.50	8.17	9.07	81.09	15.97
	F_3	20.78	17.00 – 23.00	6.92	8.05	74.01	12.27
	BIPs	21.82	19.50 – 23.40	4.67	4.50	94.14	8.73
Number of grains	F_2	127.09	119.00 – 137.00	4.24	4.57	86.18	8.54
	F_3	124.12	119.00 – 132.00	2.64	2.80	88.97	5.13
	BIPs	126.47	120.00 – 131.00	2.36	2.38	98.39	4.82
Spikelet fertility	F_2	84.93	80.20 – 90.00	3.27	3.65	80.44	6.37
	F_3	83.13	80.00 – 86.00	2.11	2.31	83.35	3.96
	BIPs	84.13	82.00 – 88.00	1.51	1.65	83.93	2.85
Hundred grain weight	F_2	1.57	1.21 – 1.84	11.07	11.23	97.20	23.69
	F_3	1.55	1.35 – 1.75	7.10	7.63	86.67	13.62
	BIPs	1.59	1.35 – 1.76	6.78	6.99	94.15	13.55
Seed yield per plant	F_2	27.49	24.00 – 35.78	10.59	12.49	71.94	19.50
	F_3	31.30	27.00 – 35.70	4.95	6.60	56.30	7.66
	BIPs	33.63	29.00 – 38.45	6.49	6.65	95.18	13.04

Table 5: Mean, range and genetic parameters for quality and micronutrient traits in F_3 and Biparental progenies of Rajamudi x ASD 16 in rice

Characters	Generation	Mean	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance as % mean
Kernel length	F_3	5.71	5.30 - 6.12	4.06	4.27	90.22	7.94
	BIPs	5.78	5.40 - 6.25	4.42	4.51	95.95	8.92
Kernel breadth	F_3	2.54	2.40- 2.72	2.65	3.40	60.82	4.26
	BIPs	2.59	2.33 – 2.85	3.23	3.60	80.90	5.99
Kernel L/B ratio	F_3	2.25	2.11 - 2.42	3.29	3.64	81.88	6.14
	BIPs	2.24	2.04 - 2.46	4.02	4.44	82.03	7.50
Kernel length after cooking	F_3	7.75	7.50 - 8.15	1.87	2.03	85.34	3.57
	BIPs	7.72	7.41 - 8.16	1.85	1.96	89.57	3.62
Kernel breadth after cooking	F_3	3.44	2.78 - 3.97	8.29	8.51	94.86	16.63
	BIPs	3.60	3.07 - 3.96	5.30	5.49	93.02	10.52
Linear elongation ratio	F_3	1.36	1.27 - 1.42	2.63	2.89	82.80	4.92
	BIPs	1.34	1.22 - 1.45	4.08	4.23	92.92	8.10
Breadth wise elongation ratio	F_3	1.35	1.14 - 1.52	7.86	8.06	94.98	15.78
	BIPs	1.39	1.17 - 1.52	4.45	4.86	83.66	8.38
Volume expansion ratio	F_3	3.98	3.62 - 4.51	5.68	5.81	95.45	11.43
	BIPs	4.14	3.65 - 4.61	5.32	5.46	94.92	10.68
Alkali spreading value	F_3	4.51	2.70 – 6.20	18.48	20.10	91.14	37.75
	BIPs	4.82	3.00 – 6.50	17.72	18.48	92.01	35.02
Amylose content	F_3	19.77	16.10 - 23.00	9.52	9.98	90.93	18.70
	BIPs	21.15	17.70 - 24.00	7.47	8.09	85.35	14.22
Gel consistency	F_3	86.12	64.60 – 102.80	12.91	13.03	98.10	26.34
	BIPs	90.57	72.60 – 117.20	10.23	10.27	99.20	20.98
Iron content	F_3	12.74	9.00 - 15.10	10.32	10.67	93.56	20.56
	BIPs	14.07	11.00 - 17.00	10.19	10.24	98.91	20.87
Zinc content	F_3	22.77	15.10 – 25.30	9.23	9.38	96.70	18.69
	BIPs	24.08	17.10 - 29.70	9.62	9.71	98.09	19.63

Table 6: Mean, range and genetic parameters for quality and micronutrient traits in F_3 and Biparental progenies of Mohini samba x CO 47 in rice

Characters	Generation	Mean	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance as % mean
Kernel length	F_3	5.63	5.43 – 5.94	2.59	2.69	92.40	5.13
	BIPs	5.76	5.51 – 6.10	2.29	2.43	89.25	4.46
Kernel breadth	F_3	2.37	1.97 – 2.63	6.61	6.85	93.26	13.16
	BIPs	2.45	2.08 – 2.75	6.47	6.67	93.87	12.90
Kernel L/B ratio	F_3	2.39	2.20 – 2.82	5.60	5.74	95.17	11.26
	BIPs	2.36	2.09 – 2.74	6.07	6.19	96.28	12.27
Kernel length after cooking	F_3	7.60	7.35 - 7.82	1.46	1.59	84.76	2.77
	BIPs	7.70	7.27 – 7.90	1.76	1.89	87.47	3.40
Kernel breadth after cooking	F_3	3.27	2.79 – 3.57	5.19	5.37	93.28	10.32
	BIPs	3.28	2.85 – 3.55	4.25	4.62	84.73	8.07
Linear elongation ratio	F_3	1.35	1.31 – 1.40	1.54	1.71	81.52	2.87
	BIPs	1.34	1.27 – 1.39	1.90	2.02	88.77	3.69
Breadth wise elongation ratio	F_3	1.38	1.30 – 1.48	6.12	3.34	89.93	6.18
	BIPs	1.34	1.25 – 1.45	7.02	3.62	94.21	7.02
Volume expansion ratio	F_3	4.04	3.55 – 4.38	5.65	5.94	90.39	11.06
	BIPs	4.20	3.73 – 4.49	5.17	5.29	95.65	10.43
Alkali spreading value	F_3	4.14	2.30 – 6.20	25.36	26.31	92.84	50.33
	BIPs	4.48	2.60 – 6.50	24.64	25.23	95.38	49.57
Amylose content	F_3	20.53	18.00 -25.20	7.39	8.02	84.94	14.03
	BIPs	21.42	19.30 – 26.00	6.61	7.16	85.00	12.55

Gel consistency	F_3	88.61	80.20 - 106.00	8.22	8.27	98.77	16.82
	BIPs	94.12	74.60 - 119.70	8.86	8.90	99.03	18.15
Iron content	F_3	12.60	8.15 -15.00	12.32	12.40	98.80	25.23
	BIPs	13.79	10.00 - 16.80	11.94	12.05	98.28	24.39
Zinc content	F_3	21.37	12.00 - 24.25	11.41	11.56	97.35	23.19
	BIPs	22.04	14.70 - 27.50	14.10	14.18	98.96	28.90

Conclusion
High GCV and PCV value indicating greater scope for improvement of traits through selection on these characters in desirable direction. Low to moderate GCV and PCV values of the limited scope for improvement of the character by selection. On the whole, co-efficient considerable amount of variability was observed for number of productive tillers, hundred grain weight and seed yield per plant for the most of the crosses. The close correspondence between the estimates of GCV and PCV for most of the traits indicated lesser environmental influence on the expression of these traits, which is also reflected by their high heritability values.
Heritability and genetic advance were determined to study the scope of improvement in various characters through selection. Heritability and genetic advance are important selection parameters. In the present investigation, high heritability along with low genetic advance as percentage of mean was recorded for the most of the traits of all crosses in F_2, F_3 and BIPs generation, indicating non additive gene action.
High heritability coupled with high genetic advance as per cent of mean for some of the characters indicating the presence of considerable genetic variation and additive gene effects. Hence, improvement of these characters could be effective through phenotypic selection.
Based on mean, GCV, PCV, heritability and genetic advance, it was understood that the progenies of Mohini samba x CO 47 would be more useful for improving grain iron content with the desirable quality traits *viz*., kernel length, kernel length after cooking, kernel breadth after cooking, linear elongation ratio and breadth wise expansion ratio. Similarly Rajamudi x ASD 16 segregants could be used for improving the kernel length, kernel breadth, kernel L/B ratio, kernel length after cooking, kernel breadth after cooking, breadth wise expansion ratio and grain zinc content.

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