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Study of Genetic Variance in Yield Contributing Traits of Rice (*Oryza sativa* L.)

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ABSTRACT: Rice (*Oryza sativa* L.) is one of the major food crops, feeding more than half of the world's population. It needs to enhance the rice production by 35% to meet the food demand of growing population. Grain yield in rice can be induced by utilizing the genetically diverse lines/parent having higher yield potential, resistant against different biotic and abiotic stresses in the crossing programme. The study was conducted in Kharif 2016 and Rabi 2016-17 at the Research and Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh and Kharif 2017 at Research Farm of National Rice Research Institute (NRRI), Cuttack, Odisha (India) to identify the genetic diverse lines. 10 rice parental genotypes, Chandrahasini, Samleshwari, Durgeshwari, IC-134022, IC-388728, IC-389860, IC-390376, IC-548384, Indira Barani Dhan1, IRHTN-105 and seven F_3-F_4 populations were taken for the study of genetic diversity e.g., spikelet fertility, test weight, Grain shape, L/B ratio and grain yield per plant in rice. It was reported that out of 306 genotypes, 5 genotypes having more than 92% spikelet fertility. 9 genotypes having 35.0g test weight, 9 genotypes having 37.18g/plant grain yield. 24 genotypes were having grain length 10.72 mm whereas 28 genotypes having grain length/breadth ratio (2.59). Hence, based on the results obtained in the present study the maximizing genetic gain in breeding population can be inferred to be playing important role in further enhancement in farm productivity of rice.

Keywords: Genetic Diversity, Genotype, Grain Shape, Test weight, Spikelet fertility, L/B ratio.

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple and primary source of food for most of the world's population (Manjunatha *et al.*, 2018). Alarming population increase demands a higher production of rice. Therefore, rice breeding aims towards a higher grain yield. Grain yield is complex traits affected by both genetically as well as environmental factors (Zhang L. *et al.*, 2017). Higher grain yield depends on longer flowering duration, optimum plant height, larger flag leaf for higher photosynthesis, large panicle size, higher spikelet fertility, more test weight, larger grain shape, higher per plant yield grain-weight (Huang *et al.*, 2013).

Mainly number of fertile panicles is the one of most crucial traits associated with rice yield. Not only the spikelet fertility but also the traits e.g., number of spikelets/panicle; percent filled grains/panicle, secondary and tertiary branching in panicle play significant role to enhance rice grain yield. (Ratna *et al.*, 2015). Apart from these traits panicle density is helpful to increase the grain yield. Another trait directly related to panicle is panicle density which chiefly affects the yield potential. Increase number of spikelets per panicle is required to enhance the grain yield in rice (Kato *et al.*, 2007). Diverse yield contributing traits e.g., plant height; number of tillers, number of productive tillers per plant, number of grains per panicle, and grain weight are useful to enhance the grain yield in rice (Russinga *et al.*, 2020). However, traits like number of panicles, grains per panicle and grain weight are paramount to enhance the grain yield (Anh *et al.*, 2015).

Grain appearance and grain quality in rice mainly depends on grain length (GL), grain width (GW), grain thickness (GT) and grain length to width ratio (GL/GW). GL/GW is the major determinant of grain appearance quality and grain weight which contributes towards grain yield (Xing and Zhang, 2010). Rice grain yield directly depends on panicle number per unit area, filled grain number per panicle, and 1000-grain-weight) and indirectly growth period, plant height, panicle length, grains per panicle (Sakamoto and Matsuoka, 2008).

It is crucial for breeder to well-known with genetic diversity of various genotypes discussed above to select parents for initiating parental crosses (Belaj *et al.*, 2002) which will contributes towards the rice grain yield.

MATERIAL AND METHODS

The experimental materials comprised altogether 10 rice parental genotypes, Chandrahasini, Samleshwari, Durgeshwari, IC-134022, IC-388728, IC-389860, IC-390376, IC-548384, Indira Barani Dhan1, IRHTN-105 and seven F3-F4 populations. The experimental material was acquired from the Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur. In F2, individual plant harvested separately and sown following panicle progeny manner on raised nursery. Twenty one days old seedlings were transplanted in well puddled field at NRRI, Cuttack under standard agronomic practices and recommendations.

The five plants were randomly chosen from each entry or generation and data were used for the statistical analysis. The plants were selected from the middle rows to minimize error due to the border effect. The details 5 quantitative observations taken from are given below.

1. Spikelet fertility per cent (%): Spikelet fertility was obtained by counting of fertile spikelets in proportion to total number of spikelets.

2. 1000-grain weight (g): Thousand well-developed grains of each accession were taken randomly after sun drying up to 13% moisture content and weighed in gram on a precision balance. Thousand grain weight was grouped into very low (30 g) classes.

3. Grain length (mm): Ten paddy seed were selected randomly from each replication and dehusked by hand and kernel length were taken by using dial micrometer. Grain breadth (mm): Ten paddy seed were selected randomly from each replication and dehusked by hand and kernel breath were taken by using dial micrometer.

4. Grain L/B ratio: Average of length of ten kernels and breadth of ten kernels were taken in millimeters and length /breadth ratio was calculated.

5. Grain yield/plant (g): The panicle from ten plants were harvested separately, dried and threshed separately and paddy grain weight of each plant was recorded and expressed it in gram (g).

Data Analysis. The data recorded in respect of 7 quantitative characters on 306 breeding lines.

Mean: The mean value of each trait was determined by summing up all the observations and dividing them by corresponding number of observations.

Range: The lowest and highest value for each trait was taken as the range.

Analysis of Variance: The characters studied were analysed using analysis of variance techniques suggested by Federer (1956).

RESULT AND DISCUSSION

Analysis of variance (ANOVA) for 7 quantitative Characters: The analysis of variance for augmented design in respect of all the 6 quantitative characters is presented in Table 1. The variation due to blocks was significant for number of fertile grains. The differences among the checks were found to be highly significant number of fertile grains. Hence, genotypes involved in the study are useful to be utilized as parents in maximization of genetic gain for respective traits and grain yield directly.

Mean performance of the genotypes presented in the table 2: The grain fertility is very crucial yield deciding trait in rice affected by several genic as well as surrounding factors. Utilization of potential source for diversification as well as for trait development of rice has immense role to play in maximizing rice farm productivity. The overall mean value recorded in the study for this trait was 134.13 with a range of 63.0 cm in (IC-390376 × Chandrahasini) 30 to 186.0 cm in (IC-390376 × Chandrahasini) 25. The genotypes found in non-significant group of less fertile grain number were (IC-134022 × Durgeshwari) 50. Whereas, only one (IC390376 × Chandrahasini) 1 was found statistically at par with genotype possessing highest per panicle fertile grain number.

On the other hand, overall mean value for spikelets fertility percent was recorded to be 84.55% with a range of 52.07% in genotype (IC-390376 × Chandrahasini) 30 and 93.8% in (IC-548384 × Chandrahasini) 4. Three out of total 306 genotypes were found in non-significant group and being statistically at par with genotype possessing lowest spikelets fertility. However, 6 genotypes were found statistically at par with genotype having highest spikelets fertility. The genotypes having lowest spikelet fertility % were (IC-548384 × Chandrahasini) 39, (IC-390376 × Chandrahasini) 9 and (IC-134022 × Durgeshwari) 50, and highest spikelets fertility percent were (IC-548384 × Chandrahasini) 4, (IC-548384 × Chandrahasini) 9, (IC548384 × Chandrahasini) 33, (IC-390376 × Chandrahasini) 25, (IC-390376 × Samleshwari) 35 and Samleshwari. The results indicates the potential and extent of variability for these two trait in the parentage utilized and in the breeding population derived has immense value to utilize in betterment of rice breeding and per se rice crop (Qi B and Wu C. 2022).

Test-weight is major predictor of milling yield in rice. In this study the overall mean value for this trait was recorded to be 23.08g with a range of 15.1g in line (IC 388728 × Chandrahasini) 18 to 35.2g in the line (Indira Barani Dhan 1 × IRHTN-105) 1708. Eleven out of 306 genotypes were found in non-significant group of low test weight being statistically at par with the genotype having lowest test-weight. The genotypes possessed lowest test weights were (IC-548384 × Chandrahasini) 42, (IC548384 X Chandrahasini) 43, (IC-390376 × Chandrahasini) 7, (IC-390376 × Chandrahasini) 47, (IC-390376 × Samleshwari) 2, (IC-390376 × Samleshwari) 5, (IC-390376 × SamleshwarI) 6, IC-390376 × Samleshwari) 9, (IC-390376 × Samleshwari) 10, (IC-390376 × Samleshwari) 15, (IC-388728 × Chandrahasini) 7 and (IC-388728 × Chandrahasini) 10. The genotype with highest test-weight were found to having at value with the genotype recorded highest test-weight are (Indira Barani Dhan 1 × IRHTN-105) 1705, (Indira Barani Dhan 1 × IRHTN-105) 1706, (Indira Barani Dhan 1 × IRHTN-105)1707, (Indira Barani Dhan 1 × IRHTN-105) 1708, (Indira Barani Dhan 1 × IRHTN-105) 1709, (Indira Barani Dhan 1 × IRHTN-105) 1710, (Indira Barani Dhan 1 × IRHTN-105) 1711, (Indira Barani Dhan 1 × IRHTN105) 1714 and (Indira Barani Dhan 1 × IRHTN-105) 1715. The results indicate that there is substantial variability existing among parents as well as in derivatives which is good sign for designing breeding programme (Wang *et al.*, 2022; Xu *et al.*, 2015).

Yield is a crucial quantitative trait which is very prone to external environment. Exploring and exploiting higher yield potential is an exhaustive research activity but ultimate target for any breeding programme. To be realized needs thorough screening of different level of genetic pools. The overall mean value of grain yield per plant was ranged from 17.08 g/plant in (IC-388728 × Chandrahasini) 18 to 37.18 g/plant in (Indira Barani Dhan 1 × IRHTN-105) 1708 with an overall mean value of 25.08 g/plant. Among the genotypes, 38 were found in non-significant group for low grain yield /plant being statistically at par with the genotype recorded lowest grain yield. The genotypes recorded lowest grain yield were (IC-548384 × Chandrahasini) 1, (IC-548384 × Chandrahasini) 28, (IC-548384 × Chandrahasini) 31, (IC-548384 × Chandrahasini) 33, (IC-548384 × Chandrahasini) 34, (IC- 548384 × Chandrahasini) 42, (IC-548384 × Chandrahasini) 43, (IC- 548384 × Chandrahasini) 48, (IC-390376 × Chandrahasini) 6, (IC-390376 × Chandrahasini) 7, (IC-390376 × Chandrahasini) 8, (IC-390376 × Chandrahasini) 47, (IC-390376 × Samleshwari) 2, (IC-390376 × Samleshwari) 3, (IC-390376 × Samleshwari) 5,(IC-390376 × Samleshwari) 6, (IC390376 × Samleshwari) 7, (IC-390376 × Samleshwari) 9,(IC-390376 × Samleshwari) 10, (IC-390376 × Samleshwari) 16, (IC-390376 × Samleshwari) 17, (IC-390376 × Samleshwari) 24, (IC-390376 × Samleshwari) 26, (IC-390376 × Samleshwari) 33, (IC-390376 × Samleshwari) 34, (IC-390376 × Samleshwari) 37, (IC-134022 × Durgeshwari) 10, (IC-134022 × Durgeshwari) 23, (IC-388728 × Chandrahasini) 7, (IC-388728 × Chandrahasini) 8, (IC-388728 × Chandrahasini) 9, (IC-388728 × Chandrahasini) 10, (IC-388728 × Chandrahasini) 18, (IC-388728 × Chandrahasini) 42, (IC-389860 × Samleshwari) 4, (IC-389860× Samleshwari) 23, (IC-389860 × Samleshwari) 28, (Indira Barani Dhan 1 × IRHTN-105) 1712 and Samleshwari. Whereas, 9 genotypes were found to be in group of highest grain yield per plant were statistically at par with the genotype recorded highest yield value. The results indicates that trend for grain yield per plant among parents and breeding population shows vast scope and beauty of this trait to be further utilized/improved (Mao *et al.*, 2010).

Grain size in particular, India has great diversity of preference varying for many reasons throughout the country. Rice improvement for yield along with quality aspects is prime objective of Indian rice breeding programme. In this study, quality parameters in terms of grain size were analysed, the overall mean value for this trait (paddy grain length) was recorded to be 8.71 mm with a range of 8.71 mm in (IC-388728 × Chandrahasini) 6 to 10.72 mm in the genotype (IC-390376 × Chandrahasini) 42. Amongst, 2 out of 306 genotypes were found in non-significant group of small grain length being statistically at par with smallest grain length bearing genotype. The genotypes possessed smaller grain length were (IC-388728 × Chandrahasini) 9, (IC134022 × Durgeshwari) 1. The genotype in large grain size group, 24 were found to having at par grain size with largest grain length bearing genotype (IC -390376 × Chandrahasini) 42. The genotypes possessed larger grain length were IC- 548384 × Chandrahasini (5), (IC -390376 × Chandrahasini) 1, (IC -390376 × Chandrahasini) 4, (IC-390376 × Chandrahasini) 14, (IC-390376 × Chandrahasini) 22, (IC-390376 × Chandrahasini) 41, (IC-390376 × Chandrahasini) 42, (IC-390376 × Samleshwari) 12, (IC-390376 × Samleshwari) 13, (IC-390376 × Samleshwari) 16, (IC-390376 × Samleshwari) 38, (IC-134022 × Durgeshwari) 3, (IC-134022 × Durgeshwari) 10, (IC134022 × Durgeshwari) 18, (IC-134022 × Durgeshwari) 19, (IC-388728 × Chandrahasini) 12, (IC-388728 × Chandrahasini) 18, (IC-388728 × Chandrahasini) 19, (Indira Barani Dhan 1 × IRHTN-105) 1706, (Indira Barani DHAN 1 × IRHTN105) 1707, (Indira Barani Dhan 1 × IRHTN-105) 1708, (Indira Barani Dhan 1 × IRHTN-105) 1709, (Indira Barani Dhan 1 × IRHTN-105) 1710 and (Indira Barani Dhan 1 × IRHTN-105) 1714. Besides, the mean value for grain breadth (paddy grain breadth) was recorded to be 2.43 mm with a range of 1.64 mm in (IC-388728 × Chandrahasini) 3 to 3.29 mm in the genotype (IC -390376 × Chandrahasini) 44. Five out of 306 genotypes were found in non-significant group of narrow grain breadth being statistically at par with the genotype having narrowest grain breadth. The genotypes possessed narrow grain breadth were (IC-390376 × Chandrahasini) 4, (IC390376 × Samleshwari) 10, (IC-134022 × Durgeshwari) 2, (IC-388728 × Chandrahasini) 1 and (IC-388728 × Chandrahasini) 9. However, 12 genotypes in wider grain breadth group were found to be at par with widest grain bearing genotype (IC-390376 × Chandrahasini) 44. The genotypes possessed wider grain size were (IC390376 × Chandrahasini) 24, (IC-390376 × Chandrahasini) 32, (IC-390376 × Chandrahasini) 44, (IC-388728 × Chandrahasini) 20, (IC-388728 × Chandrahasini) 31, (IC-389860 × Samleshwari) 14, (IC-389860 × Samleshwari) 34, (IC-389860 × Samleshwari) 37, (IC-389860 × Samleshwari) 42, (IC-389860 × Samleshwari) 45, (Indira Barani Dhan 1 × IRHTN-105) 171 1 and IC-134022.

The mean value for grain length/breadth ratio (paddy grain) was recorded to be 3.48 with a range of 2.59 in (IC -390376 × Chandrahasini) 44 to 4.98 in the genotype (IC-390376 × Chandrahasini) 6. Twenty eight out of 306 genotypes were found in non-significant group of high L/B ratio being statistically at par with the genotype having highest L/B ratio. The genotypes possessed lowest L/B ratio were (IC- 548384 × Chandrahasini) 33, (IC-548384 × Chandrahasini) 37, (IC-548384 × Chandrahasini) 47, (IC-390376 × Chandrahasini) 35, (IC -390376 × Chandrahasini) 44, (IC-390376 × Samleshwari) 7, (IC-390376 × Samleshwari) 8, (IC-390376 × Samleshwari) 28, (IC134022 × Durgeshwari) 1, (IC-134022 × Durgeshwari) 28, (IC-388728 × Chandrahasini) 7, (IC-388728 × Chandrahasini) 20, (IC-388728 × Chandrahasini) 21, (IC-388728 × Chandrahasini) 29, (IC-388728 × Chandrahasini) 31, (IC-388728 × Chandrahasini) 43, (IC-388728 × Chandrahasini) 46, (IC-389860 × Samleshwari) 9, (IC-389860 × Samleshwari) 15, (IC-389860 × Samleshwari) 22, (IC-389860 × Samleshwari) 28, (IC-389860 × Samleshwari) 35. (IC-389860 × Samleshwari) 37, (IC-389860 × Samleshwari) 41, (IC-389860 × Samleshwari) 42, (IC-389860 × Samleshwari) 48, IC-

389660 and IC-134022. However, 6 genotypes were found at par with highest L/B ratio group bearing genotype. The genotypes possessed higher L/B ratios were (IC-390376 × Chandrahasini) 6, (IC-390376 × Chandrahasini) 22, (IC390376 × Samleshwari) 13, (IC-390376 × Samleshwari) 16, (IC-388728 × Chandrahasini) 3 and Chandrahasini. The results for grain size (grain length, grain breadth and grain L/B ratio) indicates presence of vast variability among parents as well as among derivatives breeding population shows close association with previous results (Hu *et al.*, 2021; Li *et al.*, 2013).

Table 1: Analysis of variance of augmented design for 12 quantitative characters of rice genotypes.

Sr. No.	Characters	Blocks	Checks	Error
d.f.		17	2	34
1	No of fertile grain	11.56*	11.008*	4.78
2	Spikelets fertility %	3.54	2.41	3.26
3	1000-grain weight (g)	6.55	1.012	1.40
4	Grain Yield/plant (g)	3.10	4.60	4.01
5	Length (mm)	0.067	0.0068	0.099
6	Breadth (mm)	0.824	1.92	2.48
7	Grain L/B ratio	1.420	0.008	0.010

*, ** significant at 5% and 1% probability levels, respectively

Table 2: Mean value of parents and F_4 derivatives.

Crosses	No of fertile grain	SF (%)	1000-grain weight (g)	Grain Yield/plant (g)	Length (mm)	Breadth (mm)	L/B ratio
C1-1	106.23	85.74	19.20	21.18	8.36	2.60	3.35
C1-2	100.76	86.39	26.30	28.28	8.47	2.65	3.18
C1-3	92.31	88.93	25.10	27.08	8.95	2.59	3.70
C1-4	145.00	93.08	23.10	25.08	8.97	2.56	3.55
C1-5	102.52	87.13	28.40	30.38	10.10	2.73	3.76
C1-6	105.46	85.21	21.20	23.18	8.72	2.50	3.68
C1-7	99.92	86.48	23.10	25.08	9.33	2.81	3.36
C1-8	98.86	87.11	26.30	28.28	9.24	2.75	3.42
C1-9	137.00	90.25	25.40	27.38	9.47	2.75	3.42
C1-10	103.70	86.23	24.30	26.28	8.35	2.61	3.30
C1-11	107.94	83.65	28.00	29.98	8.90	2.76	3.25
C1-12	105.86	85.25	22.00	23.98	8.05	2.46	3.28
C1-13	103.91	85.59	21.20	23.18	9.73	2.31	4.42
C1-14	109.39	85.37	29.10	31.08	9.10	2.27	4.06
C1-15	105.90	86.17	23.40	25.38	8.42	2.13	3.97
C1-16	107.36	84.65	27.20	29.18	8.19	2.40	3.43
C1-17	105.48	85.97	26.90	28.88	8.38	2.35	3.92
C1-18	105.74	86.03	23.50	25.48	8.14	2.66	3.07
C1-19	105.22	85.94	22.60	24.58	8.72	2.35	3.88
C1-20	103.10	86.54	25.20	27.18	9.89	2.51	4.18
C1-21	104.58	85.70	22.60	24.58	7.64	2.89	2.64
C1-22	105.67	84.68	23.50	25.48	8.42	2.81	3.03
C1-23	96.17	87.41	21.20	23.18	8.27	2.74	3.05
C1-24	110.30	70.57	23.60	25.58	8.35	2.60	3.17
C1-25	108.28	84.90	23.90	25.88	8.10	2.60	3.17
C1-26	109.87	83.95	25.10	27.08	8.12	2.67	3.08
C1-27	104.06	85.06	20.90	22.88	8.26	2.50	3.41
C1-28	109.22	85.01	19.50	21.48	8.39	2.66	3.23

C1-29	106.28	84.79	25.20	27.18	8.33	2.72	3.14
C1-30	107.33	84.59	23.40	25.38	9.53	2.90	3.37
C1-31	103.50	86.35	20.20	22.18	9.08	2.62	3.49
C1-32	103.10	85.50	20.30	22.28	8.76	2.53	3.51
C1-33	161.00	91.92	19.80	21.78	8.45	2.91	2.93
C1-34	97.84	88.26	20.10	22.08	9.30	2.83	3.31
C1-35	100.72	86.90	21.30	23.28	8.27	2.39	3.46
C1-36	103.12	85.72	21.10	23.08	8.23	2.71	3.07
C1-37	108.72	84.27	25.20	27.18	7.84	2.64	2.99
C1-38	98.72	87.35	20.40	22.38	8.49	2.53	3.50
C1-39	107.78	60.97	26.10	28.08	8.37	2.40	3.51
C1-40	106.84	86.43	29.20	31.18	8.21	2.56	3.24
C1-41	105.00	83.97	21.30	23.28	8.95	2.59	3.47
C1-42	105.05	84.59	18.50	20.48	9.21	2.75	3.36
C1-43	95.96	88.01	17.40	19.38	8.29	2.23	3.74
C1-44	105.32	83.81	22.30	24.28	7.57	2.10	3.66
C1-45	105.10	84.50	20.30	22.28	7.65	2.37	3.47
C1-46	105.78	84.11	23.10	25.08	8.46	2.53	3.39
C1-47	108.48	82.44	26.20	28.18	6.98	2.41	2.82
C1-48	104.76	84.68	23.10	25.08	8.53	2.43	3.47
C1-49	107.96	82.85	18.60	20.58	7.70	2.18	3.55
C2-1	178.00	88.05	22.30	24.28	10.50	2.66	4.27
C2-2	105.04	85.64	20.80	22.78	8.69	2.20	4.10
C2-3	105.32	85.36	21.40	23.38	9.71	2.45	3.99
C2-4	103.58	86.40	20.50	22.48	10.08	1.70	3.75
C2-5	108.68	85.83	23.20	25.18	8.13	2.17	4.08
C2-6	105.62	86.07	19.30	21.28	9.24	2.11	4.98
C2-7	104.56	86.36	16.90	18.88	9.15	2.41	3.80
C2-8	103.46	86.27	18.80	20.78	8.91	2.41	4.00
C2-9	115.92	64.43	23.20	25.18	8.88	2.22	4.21
C2-10	116.32	83.36	26.10	28.08	9.49	2.25	4.28
C2-11	114.32	84.49	24.30	26.28	9.57	2.68	3.62
C2-12	109.90	85.69	26.20	28.18	8.64	2.24	4.12
C2-13	109.62	84.77	24.20	26.18	9.58	2.83	3.43
C2-14	114.72	84.02	25.90	27.88	10.43	2.65	4.06
C2-15	109.88	84.82	22.50	24.48	9.77	2.55	3.89
C2-16	109.28	84.49	22.40	24.38	9.48	2.38	4.18
C2-17	110.72	84.84	22.60	24.58	8.37	2.37	3.71
C2-18	106.26	85.91	22.40	24.38	8.12	2.36	3.52
C2-19	108.80	86.13	21.30	23.28	8.49	2.18	3.85
C2-20	115.66	84.02	22.60	24.58	9.15	2.60	3.55
C2-21	116.92	83.67	21.50	23.48	7.71	2.39	3.26
C2-22	118.04	82.89	28.10	30.08	10.70	2.33	4.77
C2-23	117.62	83.56	24.40	26.38	9.05	2.60	3.55

C2-24	99.58	87.32	25.20	27.18	9.53	3.07	3.12
C2-25	186.00	89.42	21.60	23.58	8.79	2.72	3.24
C2-26	112.98	83.71	23.40	25.38	9.43	2.78	3.43
C2-27	108.94	85.28	22.50	24.48	9.61	2.86	3.02
C2-28	118.44	83.19	25.20	27.18	9.46	2.66	3.59
C2-29	113.98	83.86	26.80	28.78	9.07	2.87	3.23
C2-30	63.00	52.07	23.20	25.18	9.62	2.77	3.49
C2-31	116.14	84.02	23.40	25.38	8.67	2.42	3.90
C2-32	113.56	85.01	25.10	27.08	9.64	3.01	3.24
C2-33	111.96	85.08	21.30	23.28	9.64	2.91	3.33
C2-34	112.76	84.31	26.10	28.08	9.54	2.80	3.44
C2-35	114.84	83.94	22.50	24.48	7.94	2.90	2.74
C2-36	105.08	85.64	21.30	23.28	9.30	2.61	3.60
C2-37	111.04	85.33	24.90	26.88	7.76	2.34	3.52
C2-38	105.36	86.09	26.80	28.78	9.85	2.87	3.47
C2-39	104.52	86.59	24.20	26.18	8.84	2.74	3.17
C2-40	111.20	84.94	25.30	27.28	9.35	2.48	3.79
C2-41	113.16	84.00	23.50	25.48	10.16	2.73	3.70
C2-42	114.66	84.45	20.80	22.78	10.72	2.48	4.58
C2-43	115.60	83.02	21.60	23.58	7.70	2.15	3.78
C2-44	113.78	84.33	20.40	22.38	8.50	3.29	2.59
C2-45	113.74	84.11	21.20	23.18	9.12	2.84	3.24
C2-46	113.26	83.52	21.40	23.38	8.94	2.60	3.52
C2-47	107.66	85.93	17.30	19.28	9.10	2.63	3.45
C2-48	106.40	84.47	20.90	22.88	6.84	2.02	3.42
C2-49	110.82	84.67	25.20	27.18	9.72	3.08	3.18
C2-50	107.64	85.83	23.30	25.28	8.13	2.46	3.34
C3-1	114.84	83.44	22.40	24.38	6.34	1.93	3.56
C3-2	119.06	81.23	18.50	20.48	6.47	1.90	3.74
C3-3	111.24	84.70	19.20	21.18	9.12	2.74	3.36
C3-4	115.18	82.37	24.20	26.18	8.13	2.34	3.95
C3-5	105.20	86.88	17.20	19.18	8.91	2.40	3.73
C3-6	114.04	83.53	18.20	20.18	8.91	2.40	3.81
C3-7	109.86	85.08	19.30	21.28	5.86	2.16	2.61
C3-8	107.54	86.18	20.90	22.88	7.58	2.66	2.86
C3-9	106.12	86.32	16.30	18.28	6.75	2.04	3.55
C3-10	103.22	84.66	18.10	20.08	7.25	1.68	4.12
C3-11	112.14	83.54	23.50	25.48	8.46	2.22	4.01
C3-12	107.57	85.23	20.40	22.38	10.11	2.86	3.60
C3-13	114.44	83.14	21.20	23.18	10.67	2.30	4.84
C3-14	111.74	83.14	20.50	22.48	8.42	2.72	3.14
C3-15	105.36	86.11	18.50	20.48	8.35	2.72	3.14
C3-16	107.10	84.72	17.20	19.18	10.53	2.21	4.82
C3-17	108.53	83.77	20.10	22.08	8.66	2.78	3.13

C3-18	109.96	84.16	23.20	25.18	8.17	2.31	3.75
C3-19	112.15	83.88	24.50	26.48	8.37	2.31	3.86
C3-20	109.82	84.06	22.30	24.28	8.25	2.78	3.01
C3-21	106.53	84.96	24.40	26.38	8.12	2.25	3.69
C3-22	110.52	84.59	24.20	26.18	8.23	2.83	2.96
C3-23	110.43	83.47	22.30	24.28	9.35	2.66	3.68
C3-24	104.28	83.57	18.50	20.48	8.57	2.31	3.84
C3-25	105.81	85.18	21.30	23.28	9.04	2.29	4.05
C3-26	108.64	84.47	19.40	21.38	8.78	2.55	3.53
C3-27	106.93	84.64	23.20	25.18	9.11	2.33	3.97
C3-28	109.28	84.41	21.10	23.08	7.85	2.65	2.86
C3-29	111.17	84.06	21.30	23.28	9.61	2.40	4.05
C3-30	112.01	84.31	22.10	24.08	9.02	2.35	3.96
C3-31	106.68	85.42	24.20	26.18	9.04	2.46	3.79
C3-32	111.90	82.86	25.10	27.08	8.53	2.31	3.73
C3-33	102.30	85.65	18.60	20.58	9.18	2.39	4.33
C3-34	109.92	85.38	19.30	21.28	8.98	2.94	3.11
C3-35	92.10	90.16	28.10	30.08	8.73	2.58	3.41
C3-36	109.40	85.48	22.40	24.38	10.51	2.80	3.72
C3-37	111.24	83.71	19.30	21.28	9.04	2.58	3.53
C3-38	115.74	83.44	24.20	26.18	10.49	2.61	4.08
C3-39	108.46	83.83	23.30	25.28	7.64	2.66	2.93
C3-40	108.44	85.08	23.20	25.18	9.78	2.72	3.63
C3-41	115.60	83.85	20.40	22.38	8.14	2.64	3.14
C4-1	108.83	84.98	26.10	28.08	5.50	2.08	2.62
C4-2	111.48	84.44	25.30	27.28	7.37	1.72	4.20
C4-3	110.06	85.07	23.20	25.18	10.25	2.09	5.19
C4-4	116.02	82.90	24.10	26.08	8.89	2.20	4.35
C4-5	114.25	84.09	25.30	27.28	9.66	2.52	3.84
C4-6	110.08	85.24	22.40	24.38	9.13	2.12	4.45
C4-7	110.64	84.61	23.30	25.28	9.75	2.56	3.90
C4-8	112.59	83.61	22.30	24.28	9.51	2.54	3.86
C4-9	111.40	84.21	23.20	25.18	9.82	2.62	3.87
C4-10	108.50	84.15	19.50	21.48	10.69	2.54	4.28
C4-11	107.82	85.07	25.10	27.08	8.80	2.59	3.44
C4-12	114.37	83.71	27.20	29.18	9.20	2.56	3.64
C4-13	111.48	84.58	24.40	26.38	8.51	2.65	3.22
C4-14	108.64	84.21	25.20	27.18	9.85	2.85	3.46
C4-15	105.48	86.37	22.30	24.28	8.96	2.36	3.85
C4-16	109.47	84.68	23.20	25.18	9.06	2.26	4.22
C4-17	98.01	87.28	21.40	23.38	8.93	2.98	3.02
C4-18	113.18	83.82	28.10	30.08	10.71	2.53	4.43
C4-19	107.32	86.37	27.20	29.18	10.04	2.66	3.83
C4-20	105.16	86.03	24.10	26.08	9.72	2.71	3.78
C4-21	108.68	85.16	23.20	25.18	9.37	2.36	4.01
C4-22	101.57	86.92	22.10	24.08	8.57	2.75	3.12
C4-23	108.47	85.04	19.20	21.18	8.62	2.85	3.04
C4-24	108.42	85.48	24.40	26.38	8.63	2.61	3.40
C4-25	103.97	87.00	21.30	23.28	8.59	2.49	3.64
C4-26	115.49	83.66	27.90	29.88	8.76	2.59	3.40
C4-27	106.94	86.01	26.20	28.18	7.50	2.33	3.29

C4-28	108.92	86.42	22.30	24.28	8.12	2.85	2.88
C4-29	113.93	83.90	25.20	27.18	8.19	2.82	2.95
C4-30	110.59	84.93	20.40	22.38	8.78	2.49	3.82
C4-31	111.27	85.36	21.20	23.18	8.36	2.65	3.20
C4-32	112.45	84.57	23.40	25.38	8.44	2.68	3.18
C4-33	107.94	84.98	25.20	27.18	8.67	2.70	3.39
C4-34	109.29	85.05	23.30	25.28	9.11	2.63	3.63
C4-35	110.83	84.89	21.20	23.18	7.27	2.37	3.11
C4-36	111.42	84.74	24.10	26.08	8.28	2.51	3.44
C4-37	112.24	84.82	20.90	22.88	7.89	2.51	3.22
C4-38	108.15	85.37	23.90	25.88	8.25	2.70	3.09
C4-39	104.32	86.17	22.40	24.38	8.55	2.60	3.32
C4-40	107.53	85.77	23.10	25.08	8.22	2.50	3.32
C4-41	106.56	85.53	23.30	25.28	8.24	2.72	3.00
C4-42	111.49	84.03	24.40	26.38	8.44	2.82	3.07
C4-43	107.06	85.48	22.90	24.88	8.44	2.28	3.81
C4-44	110.35	84.71	22.30	24.28	8.75	2.38	3.73
C4-45	108.48	84.95	24.20	26.18	9.31	2.22	4.36
C4-46	111.22	84.48	21.40	23.38	9.82	2.66	3.76
C4-47	111.85	84.60	20.50	22.48	6.95	2.28	3.21
C4-48	114.24	83.66	22.10	24.08	8.73	2.62	3.60
C4-49	110.83	85.10	22.90	24.88	8.43	2.61	3.27
C4-50	71.00	54.35	21.30	23.28	8.85	2.13	4.18
C5-1	107.06	85.85	19.30	21.28	6.11	1.72	3.42
C5-2	108.27	85.20	20.90	22.88	8.06	2.50	3.21
C5-3	110.37	84.59	20.30	22.28	7.06	1.64	4.62
C5-4	112.23	83.97	21.80	23.78	8.88	2.20	4.39
C5-5	111.48	84.74	21.20	23.18	9.32	2.39	4.26
C5-6	113.82	83.57	22.30	24.28	7.00	2.10	3.45
C5-7	103.58	86.26	17.20	19.18	4.22	2.07	2.89
C5-8	107.90	85.66	18.90	20.88	9.22	2.42	4.01
C5-9	106.34	85.27	18.30	20.28	5.42	1.70	3.33
C5-10	100.62	87.28	16.80	18.78	9.12	2.83	3.24
C5-11	114.69	83.61	28.70	30.68	9.41	2.29	4.28
C5-12	116.32	83.82	27.30	29.28	10.04	2.79	3.64
C5-13	115.86	83.65	23.90	25.88	8.70	2.53	3.43
C5-14	109.76	85.78	23.20	25.18	9.77	2.35	4.16
C5-15	120.06	82.74	26.10	28.08	9.74	2.69	3.69
C5-16	105.60	85.77	23.40	25.38	9.01	2.16	4.18
C5-17	112.82	84.19	23.90	25.88	8.68	2.73	3.22
C5-18	108.41	84.74	15.10	17.08	10.21	2.58	4.01
C5-19	111.98	85.22	24.70	26.68	10.09	2.51	4.04
C5-20	111.58	83.84	21.50	23.48	8.54	3.03	2.86
C5-21	117.80	82.83	24.30	26.28	7.56	2.65	2.88

C5-22	108.56	85.59	24.10	26.08	8.50	2.80	3.06
C5-23	111.09	83.90	22.90	24.88	8.63	2.82	3.09
C5-24	116.44	82.51	28.80	30.78	8.52	2.90	2.95
C5-25	114.26	83.38	23.30	25.28	9.23	2.74	3.20
C5-26	115.52	83.22	28.20	30.18	8.40	2.89	2.94
C5-27	111.81	85.16	21.20	23.18	9.16	2.96	3.08
C5-28	119.36	82.48	23.50	25.48	8.33	2.82	2.99
C5-29	117.78	83.30	25.30	27.28	8.17	2.82	2.86
C5-30	111.67	85.26	23.10	25.08	9.19	2.81	3.33
C5-31	108.78	85.16	24.20	26.18	8.28	3.01	2.79
C5-32	118.49	82.92	26.10	28.08	8.82	2.67	3.38
C5-33	109.27	85.69	26.30	28.28	8.38	2.63	3.23
C5-34	106.30	86.10	20.30	22.28	8.03	2.71	2.98
C5-35	104.64	84.85	26.10	28.08	8.47	2.43	3.52
C5-36	113.21	84.01	25.20	27.18	8.46	2.33	3.66
C5-37	115.95	83.15	23.40	25.38	8.73	2.31	3.80
C5-38	107.77	85.64	25.30	27.28	9.52	2.55	3.83
C5-39	106.56	85.49	21.80	23.78	8.62	2.87	3.05
C5-40	107.14	85.42	24.30	26.28	8.94	2.52	3.55
C5-41	108.33	85.00	23.10	25.08	7.96	2.27	3.41
C5-42	116.01	82.89	23.20	25.18	7.14	2.35	3.02
C5-43	103.32	86.63	19.80	21.78	7.97	2.74	2.90
C5-44	111.80	83.68	21.20	23.18	8.11	2.41	3.43
C5-45	108.94	85.41	21.90	23.88	9.02	2.83	3.18
C5-46	108.99	84.86	22.30	24.28	6.77	2.50	2.65
C5-47	114.38	83.60	25.70	27.68	6.56	2.15	2.94
C5-48	101.53	87.62	22.90	24.88	8.17	2.48	3.43
C5-49	106.87	85.18	20.20	22.18	8.35	2.63	3.21
C5-50	103.70	86.73	21.10	23.08	9.45	2.74	3.49
C6-1	99.29	88.04	25.30	27.28	8.62	2.85	3.05
C6-2	99.35	88.12	20.90	22.88	8.59	2.71	3.20
C6-3	107.97	83.92	22.50	24.48	9.21	2.78	3.40
C6-4	103.48	86.57	19.30	21.28	8.63	2.72	3.21
C6-5	109.93	85.12	21.70	23.68	8.16	2.91	2.82
C6-6	106.84	85.55	21.40	23.38	8.71	2.86	3.08
C6-7	103.05	85.82	25.10	27.08	9.29	2.65	3.63
C6-8	108.05	85.19	22.10	24.08	9.32	2.84	3.41
C6-9	112.29	83.77	20.90	22.88	8.15	2.89	2.85
C6-10	106.46	85.62	23.80	25.78	8.45	2.68	3.17
C6-11	115.32	83.31	24.20	26.18	8.18	2.60	3.27
C6-12	111.05	84.16	23.50	25.48	9.28	2.75	3.41
C6-13	114.66	83.35	22.10	24.08	8.54	2.70	3.26
C6-14	114.12	83.52	28.70	30.68	9.33	3.00	3.14
C6-15	106.43	85.16	22.30	24.28	8.18	2.83	2.91

C6-16	113.08	84.21	24.20	26.18	7.54	2.11	3.75
C6-17	110.79	84.33	23.40	25.38	7.15	2.28	3.11
C6-18	113.43	84.15	21.90	23.88	9.19	2.77	3.49
C6-19	111.01	83.65	25.10	27.08	8.34	2.43	3.56
C6-20	112.69	84.45	23.30	25.28	8.38	2.69	3.12
C6-21	110.27	84.28	23.50	25.48	8.57	2.80	3.11
C6-22	110.50	83.66	20.40	22.38	8.11	2.98	2.77
C6-23	105.86	85.47	18.40	20.38	8.21	2.50	3.31
C6-24	108.77	84.44	22.10	24.08	8.64	2.71	3.24
C6-25	114.91	83.10	26.30	28.28	8.27	2.63	3.64
C6-26	112.97	82.87	22.40	24.38	8.19	2.78	2.92
C6-27	115.12	82.89	24.30	26.28	8.39	2.98	2.82
C6-28	108.54	85.05	20.10	22.08	8.01	2.65	3.14
C6-29	115.15	82.19	25.40	27.38	8.30	2.61	3.18
C6-30	106.01	87.63	21.20	23.18	8.42	2.58	3.58
C6-31	109.44	84.69	22.10	24.08	8.28	2.82	3.11
C6-32	109.72	84.60	21.30	23.28	9.02	2.45	3.58
C6-33	106.75	85.90	20.50	22.48	8.46	2.76	3.09
C6-34	110.19	85.02	25.10	27.08	8.86	3.19	2.80
C6-35	109.76	84.86	23.90	25.88	7.69	2.81	2.76
C6-36	111.83	84.46	22.80	24.78	7.87	2.74	2.86
C6-37	115.03	82.96	28.10	30.08	8.85	3.11	2.86
C6-38	111.27	84.89	22.50	24.48	8.62	2.71	3.19
C6-39	112.91	84.67	24.20	26.18	8.91	2.95	3.08
C6-40	111.07	84.95	23.10	25.08	8.47	2.87	2.98
C6-41	106.16	86.34	26.20	28.18	8.43	2.97	2.88
C6-42	115.14	82.94	22.60	24.58	8.19	3.11	2.66
C6-43	112.46	83.92	26.30	28.28	8.99	3.03	2.98
C6-44	114.78	83.81	21.40	23.38	8.76	2.70	3.36
C6-45	108.62	84.97	23.10	25.08	9.22	3.10	2.99
C6-46	114.45	83.18	22.90	24.88	8.80	2.90	3.06
C6-47	112.32	82.95	22.10	24.08	8.43	2.83	3.02
C6-48	111.35	83.79	20.40	22.38	8.14	2.86	2.81
C6-49	116.19	82.76	22.30	24.28	8.44	2.64	3.33
C6-50	105.46	85.23	22.30	24.28	7.55	2.46	3.06
C7-1705	110.63	82.86	33.10	35.08	9.30	2.41	4.17
C7-1706	110.28	83.26	31.10	33.08	10.66	3.00	3.61
C7-1707	105.34	84.15	31.40	33.38	10.35	2.73	3.86
C7-1708	108.31	83.86	35.20	37.18	10.70	3.00	3.58
C7-1709	107.31	84.26	32.30	34.28	10.02	2.80	3.67
C7-1710	107.48	84.01	31.20	33.18	10.42	2.91	3.61
C7-1711	108.89	83.35	32.50	34.48	8.94	2.67	3.23
C7-1712	107.87	84.06	19.10	21.08	10.13	3.11	3.27
C7-1713	108.44	83.38	29.30	31.28	9.75	2.93	3.28
C7-1714	108.88	83.41	30.20	32.18	10.70	2.95	3.65
C7-1715	108.33	83.31	34.30	36.28	9.73	2.62	3.67
IC-388728	102.00	89.47	21.40	23.38	7.60	2.65	3.06
IC-390376	92.00	85.19	24.20	26.18	8.53	2.73	3.15

IC-389660	116.00	81.69	24.30	26.28	8.38	3.04	2.81
IC-548384	98.00	83.76	24.70	26.68	7.86	1.96	4.13
IC-134022	123.00	84.25	29.10	31.08	8.93	3.17	2.84
Ind. Barani Dhan1	101.00	86.32	20.20	22.18	9.26	2.43	3.84
IRHTN105	124.00	86.71	23.40	25.38	8.80	2.68	3.30
1-Durgeshwari	102.00	89.47	23.90	25.88	9.09	2.44	3.74
2-Samleshwari	127.00	89.44	19.10	21.08	8.64	2.55	3.41
3-Chandrahasini	101.00	88.60	21.10	23.08	9.45	1.97	4.92
Mean	134.13	84.55	23.08	25.08	8.71	2.43	3.48
Maximum value	186	93.8	35.2	37.18	10.72	3.29	4.98
Minimum value	63	52.07	15.1	17.08	4.22	1.64	2.59

Note:
C1- IC- 548384 x Chandrahasini
C2- IC -390376 x Chandrahasini
C3- IC-390376 x Samleshwari
C4- IC-134022 x Durgeshwari
C5- IC-388728 x Chandrahasini
C6- IC-389860 x Samleshwari
C7- Indira Barani Dhan 1 x IRHTN-105

CONCLUSIONS

In breeding population (306 genotypes), vast genetic diversity for all the studied traits was reported. Several derivatives were reported to have more than 90% spikelets fertility amongst genotypes (IC-548384 × Chandrahasini) 4, (IC-548384 × Chandrahasini) 9, (IC-548384 × Chandrahasini) 33, (IC390376 × Chandrahasini) 25, (IC-390376 × Samleshwari) 35 and Samleshwari were found with more than 92% fertility percentage. Test-weight is major predictor of milling yield in rice recorded vast genetic diversity amongst breeding lines, genotype (Indira Barani Dhan 1 × IRHTN-105) 1705, (Indira Barani Dhan 1 × IRHTN-105) 1706, (Indira Barani Dhan 1 × IRHTN-105) 1707, (Indira Barani Dhan 1 × IRHTN-105) 1708, (Indira Barani Dhan 1 × IRHTN-105) 1709, (Indira Barani Dhan 1 × IRHTN-105) 1710, (Indira Barani Dhan 1 × IRHTN-105) 1711, (Indira Barani Dhan 1 × IRHTN-105) 1714 and (Indira Barani Dhan 1 × IRHTN-105) 1715 were recorded 35.0g test weight. Amongst breeding lines, 9 were found to have maximized genetic gain able to produce 37.18g/plant yield.

Breeding population also have great genetic diversity for grain size, 24 genotypes (IC-548384 × Chandrahasini) 5, (IC-390376 × Chandrahasini) 1, (IC390376 × Chandrahasini) 4, (IC-390376 × Chandrahasini) 14, (IC-390376 × Chandrahasini) 22, (IC-390376 × Chandrahasini) 41, (IC-390376 × Chandrahasini) 42, (IC-390376 × Samleshwari) 12, (IC-390376 × Samleshwari) 13, (IC-390376 × Samleshwari) 16, (IC-390376 × Samleshwari) 38, (IC-134022 × Durgeshwari) 3, (IC134022 × Durgeshwari) 10, (IC-134022 × Durgeshwari) 8, (IC-134022 × Durgeshwari) 19, (IC-388728 × Chandrahasini) 12, (IC-388728 × Chandrahasini) 18, (IC-388728 × Chandrahasini) 19, (Indira Barani Dhan 1 × IRHTN-105) 1706, (Indira Barani Dhan 1 × IRHTN-105) 1707, (Indira Barani Dhan 1 × IRHTN-105) 1708, (Indira Barani Dhan 1 × IRHTN-105) 1709, (Indira Barani Dhan 1 × IRHTN-105) 1710 and (Indira Barani Dhan 1 × IRHTN-105) 1714 has recorded grain length of 10.72 mm whereas, however, breeding lines reported to have 28 genotypes had grain length/breadth ratio (2.59) more accepted in the country.

FUTURE SCOPE

There was vast genetic diversity found for all the studied traits which can be utilized in the breeding programme to enhance the grain yield in rice. Also different gene interaction, their mode of inheritance and stability to different environment can be studied.

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