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EXPLORING GENETIC PARAMETERS FOR YIELD TRAITS IN RICE (*Oryza sativa* L.): VARIABILITY, HERITABILITY, AND GENETIC ADVANCE

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ABSTRACT

The present investigation was conducted at Regional Agricultural Research Station (RARS), Polasa, Jagtial, Telangana during *Kharif* 2025 and *Rabi* 2025-26 to identify superior rice genotypes combining high yield potential, desirable grain quality and leaf blast resistance. The experimental material consisted of 38 genotypes, 36 F6 stable breeding lines developed from seven different crosses and two check varieties (RNR-15048 and JGL-24423). Genotypes were evaluated in randomised block design with three replications during *Kharif* 2025. The nineteen characters of yield and grain quality were recorded. Analysis of variance showed highly significant differences among genotypes for all characters studied, indicating that there is considerable genetic variability. Among the seven yield related characters for which detailed results are presented, days to 50% flowering ranged from 81.67 to 112.33 days, plant height from 85.00 to 127.17 cm, panicle length from 18.07 to 26.14 cm, effective bearing tillers from 7.00 to 10.00, grain yield per plant from 9.90 to 31.73 g, number of grains per panicle from 104.00 to 278.33 and 1000-seed weight from 11.97 to 28.70 g. Grain yield per plant had high GCV (30.27%), high heritability (94.10%) and high genetic advance as per cent of mean (60.48%). Similarly, number of grains per panicle and 1000-seed weight recorded high GCV, very high heritability and high genetic advance as per cent of mean. These results suggest a large contribution of genetic effects and a large potential for direct selection. The results indicate that grain yield per plant, number of grains per panicle and 1000-seed weight are potential selection criteria for improving yield potential in advanced rice breeding lines. The wider screening also incorporated leaf blast screening and molecular confirmation of resistance but detailed blast and marker data were not included in this present analysis.

Key words: rice, genetic variability, GCV, PCV, heritability, genetic advance, grain yield, F_6 breeding lines, leaf blast

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops in the world and serves as the staple food for more than half of the global population, rice is the staple food for billions of people worldwide and plays a crucial role in ensuring global food security Ashfaq *et al*., (2023).

It is cultivated in different agro-climatic zones and has a great impact on food security, employment generation and economic stability, particularly in developing countries. Rice is a rich source of carbohydrate and constitutes a large portion of the daily caloric intake for billions of people. Rice has become much more important as the world's population grows rapidly and as people change the way they eat. By 2050, the global population is projected to reach nearly 9.7 billion, necessitating a significant increase in food production to maintain global food security. Pradhan *et al*., (2020).

India, the world's largest producer of rice, has a significant share in the world rice production. In 2024-25 India produced about 149 million tonnes of rice and is projected to set a record production of over 154 million tonnes during 2025-26 (Ministry of Agriculture and Farmers Welfare, 2025-26). It is grown on almost 51 million hectares and is one of the most widely grown crops in the country. Rice is one of the main contributors to the agriculture economy and the staple food of a large part of the Indian population. Of the rice growing states of India, Telangana has emerged as one of the leading contributors to national rice production. Rice is grown in about 4.8 million hectares of the state yielding nearly 17 million tonnes per annum (INDIASTAT, 2025). The state has witnessed a phenomenal increase in rice production due to favourable climatic conditions, expansion of irrigation facilities and adoption of improved varieties. However, in an effort to maintain this growth, there is a need for continuous development and deployment of high-yielding cultivars with tolerance to various biotic and abiotic stresses.

Genetic improvement has played an important role in increasing rice productivity over the last few decades. According to Jeevan B. *et al*., (2023), efficient use of genetically diverse germplasm is necessary for the selection of superior cultivars with higher yield and disease resistance. Germplasm collections are rich sources of genes governing important agronomic traits such as yield potential, disease resistance, stress tolerance and adaptation. Hence, identification and evaluation of potential genotypes from diverse sources of germplasm are the basic steps in any crop improvement program. Genetic variability offers scope for selection of superior genotypes and development of better varieties with desirable traits. Grain yield is a complex quantitative trait governed by many genes and affected by the environment.

Therefore, there is a need for systematic evaluation of high-yielding genotypes under field conditions. Studies on genetic variability, heritability and genetic advance are useful in giving valuable information about the nature and magnitude of genetic variation present in breeding materials. This information enables breeders to design effective selection strategies and to identify genotypes with high performance.

Materials and Methods

Experimental site and material

The investigation was conducted during *Kharif* 2025 and *Rabi* 2025-26 at the Rice Section, Regional Agricultural Research Station (RARS), Polasa, Jagtial, Telangana. The experimental material consisted of 38 rice genotypes comprising 36 F_6 stable breeding lines derived from seven diverse crosses and two checks, RNR-15048 and JGL-24423.

The breeding lines represented diverse parental combinations involving MIL 12 × JGL 17004, (KNM 1638 × BM 71) × NLR 34449, (JGL 38206 × JGL 17004) × (RP 4516-3-6 × NLR 34449), JGL 28639 × RP 1, JGL 38957 × WGL 1145, (JGL 33124 × WGL 1293) × RNR 15048 and RNR 29325 × RNR 15048. The 36 F_6 lines were designated JGL-55530 to JGL-55590 with the specific entries corresponding to their respective crosses.

Experimental design and crop establishment

Thirty-six F_6 stable lines along with RNR-15048 and JGL-24423 were evaluated during *Kharif* 2025 in a randomized block design with three replications. Seeds were raised in a nursery and transplanted into the main field following recommended agronomic practices. Each genotype was maintained in separate plots and randomized within each replication. Uniform crop management practices were followed throughout the crop period.

Observations recorded

Observations were recorded on five randomly selected competitive plants from each genotype in each replication. Plants were selected from the middle rows to minimize border effects. The observations included days to 50% flowering, plant height, panicle length, effective bearing tillers per plant, grain yield per plant, number of grains per panicle and 1000-seed weight, in addition to other yield and grain-quality traits.

Days to 50% flowering was recorded from nursery sowing to extrusion of the panicle tip above the flag-leaf sheath in 50% of plants. Plant height was measured from ground level to the tip of the tallest panicle at maturity. Panicle length was measured from the panicle base to the tip of the terminal spikelet. Effective bearing tillers were counted as productive tillers bearing fertile panicles. Grain yield per plant was obtained from five randomly selected plants after harvesting, threshing, cleaning and drying. Number of grains per panicle was determined from five randomly selected panicles, while 1000-seed weight was determined using 1000 well-filled and properly dried grains.

Statistical analysis

Analysis of variance for the randomized block design was performed to determine the significance of differences among genotypes. Mean squares for replications, genotypes and error were estimated along with standard error, critical difference at 5% and

coefficient of variation.

Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad-sense heritability and genetic advance as per cent of mean were estimated to characterize the genetic variation and selection potential of the traits, following analytical approaches commonly used in rice genetic variability studies (Rathod *et al*., 2020; Saharia *et al*., 2024).

Results and Discussion

Analysis of variance

Analysis of variance showed highly significant differences among the 38 genotypes for all the 19 characters studied (Table 1). The large genetic variability among the breeding lines was evident from the significant treatment mean squares. Such variability is a crucial pre-requisite for effective selection and genetic improvement corroborating reports of significant variation among rice breeding materials and germplasm (Rathod *et al*., 2020; Sarika *et al*., 2025).

The mean square for genotypes for seven yield related characters for which detailed data were available were 198.87 for days to 50% flowering, 280.90 for plant height, 13.19 for panicle length, 1.61 for effective bearing tillers, 102.51 for grain yield per plant, 5128.66 for number of grains per panicle and 61.19 for 1000-seed weight. The significant differences at 5% were 1.94 days, 2.74 cm, 2.28 cm, 1.46 tillers, 2.36 g, 12.56 grains and 1.47 g respectively.

The present material showed a high level of genotypic variability which is in agreement with the recent studies on rice breeding which reported a high variability for yield and its components among advanced breeding lines and germplasm (Rathod *et al*., 2020; Naveenkumar *et al*., 2021; Sarika *et al*., 2025).

Mean performance of genotypes

The average performance of the 38 genotypes for all the nineteen characters is given in Table 2. Individual description of the per se performance of each character, its range, lowest- and highest- performing genotypes, performance of the two checks (RNR-15048 and JGL-24423) and significance of genotypic differences judged against the critical difference at 5% and coefficient of variation are described below.

Days to 50% flowering:

Days to 50% flowering ranged from 81.67 to 112.33 days with a mean of 98.21 days. The earliest flowering genotype was JGL-55421 (81.67 days) and the latest were JGL-55339 and JGL-55340 (112.33 days). RNR-15048 and JGL-24423 respectively took 104.67 and 97.33 days to flower. The first entries were JGL-55421, JGL-55416, JGL-55588, JGL-55415 and JGL-55417 and were very different from the checks. The wide range provides useful variation for flowering duration and opportunities to select genotypes for different crop-duration requirements.

Table 1: Analysis of variance (mean squares) for seven traits in 38 rice genotypes evaluated in a Randomized Block Design.

S. No.	Character	Mean sum of squares		
		R (d.f.=2)	T (d.f.=37)	E (df =74)
1	Days to 50 % floweing	0.82	198.87 **	1.42
2	Plant height (cm)	8.14	280.90**	2.83
3	Panicle lengh(cm)	7.34	13.19**	1.96
4	Effcetive bearing tillers	0.90	1.61**	0.80
5	Grain yield per plant(g)	2.84	102.51**	2.10
6	No. of grains per panicle	0.28	5128.66**	59.55
7	1000 seed weight(g)	2.09	61.19**	0.81

R: Replications; T: Treatments; E: Error; d.f: degrees of freedom; *= Significant at 5%; **= Significant at 1%

Plant height:

Average plant height was 106.15 cm (85.00-127.17 cm range). The shortest genotype was JGL-55532 and the tallest was JGL-55587. RNR-15048 and JGL-24423 gave 107.23 and 99.10 cm, respectively. Several lines (JGL-55532, JGL-55342, JGL-55416, JGL-55533, JGL-55530, JGL-55510, JGL-55419 and JGL-55420) were substantially shorter than both checks. These lines may therefore be useful in breeding programs where a shorter plant stature and improved lodging resistance are desirable.

Length of panicle:

The panicle length ranged from 18.07 to 26.14 cm with mean value of 22.33cm. JGL-55342 had the shortest panicle and RNR-15048 had the longest panicle. Among breeding lines, JGL-55585 and JGL-55590 recorded 25.90 cm and JGL-55419 recorded 24.70 cm. No test entries exceeded the checks for this character by a large margin.

Number of productive tillers/plant:

The mean number of effective bearing tillers was 8.25 and ranged from 7.00 to 10.00. The maximum value of 10.00 tillers per plant was recorded in JGL-55586. RNR-15048 and JGL-24423 recorded 9.00 and 7.67 tillers respectively. The observed variation indicates the possibility of improvement in productive tillering through selection, but the environmental effects must be considered.

Grain yield plant:

The grain yield per plant varied from 9.90 to 31.73 g

Table 2: Mean performance of 38 rice genotypes for yield and quality traits.

S. No.	Entry	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Effective bearing tillers	Grain yield per plant (g)	Number of grains per panicle	1000-seed-weight (g)
1	JGL-55530	94.33	95.27	21.20	9.00	21.50	206.33	16.54
2	JGL-55531	95.00	99.20	20.60	8.67	26.93	201.00	17.87
3	JGL-55532	104.00	85.00	18.10	7.33	18.33	223.00	18.20
4	JGL-55533	96.00	90.30	20.67	7.67	16.57	173.67	14.06
5	JGL-55534	92.00	110.57	19.40	7.67	19.13	227.67	28.70
6	JGL-55337	111.67	97.27	21.10	8.00	18.57	228.33	14.00
7	JGL-55338	109.00	107.77	21.90	7.33	15.00	175.33	19.20
8	JGL-55339	112.33	109.93	20.83	8.33	17.50	215.33	15.00
9	JGL-55340	112.33	108.13	21.50	8.00	19.63	163.33	16.73
10	JGL-55341	98.00	102.70	21.57	9.00	14.14	278.33	13.93
11	JGL-55342	98.33	85.60	18.07	7.00	13.37	271.33	15.17
12	JGL-55415	90.00	95.17	19.73	8.67	15.80	160.33	20.20
13	JGL-55416	89.33	88.03	20.47	8.33	17.50	104.00	21.03
14	JGL-55417	90.00	103.43	22.37	8.00	16.73	191.67	22.60
15	JGL-55418	111.33	110.87	23.43	7.67	10.70	148.67	23.17
16	JGL-55419	94.67	112.03	24.70	8.00	15.83	202.67	17.53
17	JGL-55420	94.33	115.60	22.73	8.00	17.60	210.33	19.07
18	JGL-55421	81.67	113.27	21.67	9.00	21.50	258.67	17.27
19	JGL-55552	103.00	106.00	22.40	8.33	14.13	150.67	24.67
20	JGL-55553	91.33	121.57	24.47	7.00	11.83	150.33	24.50
21	JGL-55554	90.67	110.27	24.57	8.33	22.50	176.67	25.47
22	JGL-55555	98.00	115.03	23.97	8.67	22.13	226.33	21.20
23	JGL-55556	93.00	110.10	22.40	8.33	22.37	220.90	22.30
24	JGL-55557	100.67	110.87	24.87	8.67	29.23	191.07	25.27
25	JGL-55585	91.00	109.07	25.90	9.00	30.23	186.33	21.11
26	JGL-55586	90.67	116.67	23.10	10.00	28.63	238.33	24.10
27	JGL-55587	90.67	127.17	21.23	9.00	22.23	253.00	25.64
28	JGL-55588	89.33	116.27	21.53	9.00	24.00	236.33	26.70
29	JGL-55589	92.00	106.93	22.83	9.00	20.13	223.33	24.77
30	JGL-55590	96.00	114.00	25.90	9.33	31.73	203.33	26.06
31	JGL-55505	110.00	112.40	18.73	7.67	12.90	205.33	16.67
32	JGL-55506	111.00	113.33	24.67	8.33	11.90	156.67	15.87
33	JGL-55507	108.33	108.10	22.17	7.67	9.90	182.00	17.37
34	JGL-55508	102.00	99.37	23.53	7.00	12.03	110.67	22.40
35	JGL-55509	104.00	96.20	23.20	7.00	12.57	132.67	27.73
36	JGL-55510	94.00	103.83	22.03	8.67	26.34	195.33	15.41
37	RNR-15048	104.67	107.23	26.14	9.00	18.13	220.33	11.97
38	JGL-24423	97.33	99.10	24.80	7.67	27.03	151.33	24.16
Mean		98.21	106.15	22.33	8.25	19.11	196.08	20.36
CV (%)		1.21	1.59	6.29	10.88	7.59	3.94	4.45
S.E.		0.69	0.97	0.81	0.52	0.84	4.46	0.52
CD (5%)		1.94	2.74	2.28	1.46	2.36	12.56	1.47
Range (Lowest)		81.67	85	18.07	7	9.9	104	11.97
Range (Highest)		112.33	127.17	26.14	10	31.73	278.33	28.7

with an average of 19.11 g. The highest grain yield was recorded by JGL-55590 (31.73 g) followed by JGL-55585 (30.23 g), JGL-55557 (29.23 g) and JGL-55586 (28.63 g). Varieties RNR-15048 and JGL-24423 recorded 18.13 and 27.03 g respectively.

JGL-55590 and JGL-55585 were significantly higher than both the checks for grain yield per plant. JGL-55557 and JGL-55586 were superior to both the checks but were at par with JGL-24423. These lines are promising for further evaluation in replicated trials and across locations. The large variation in grain yield observed here is consistent with recent rice studies which have reported substantial genetic variation for yield and related traits in advanced breeding materials (Rathod *et al*., 2020; Shanmugam *et al*., 2025). Yield has a high genetic variability, which allows for the selection of superior recombinants.

Number of Grains/panicle:

Number of grains/panicle varied from 104.00 to 278.33 with an average of 196.08. The maximum value of 278.33 grains / panicle was observed in JGL-55341 followed by JGL-55342 (271.33), JGL-55421 (258.67), JGL-55587 (253.00), JGL-55586 (238.33) and JGL-55588 (236.33). These genotypes were significantly higher than both the checks for this character.

1000 Seed weight:

The thousand seed weight ranged from 11.97 to 28.70 g with an average of 20.36 g. The highest value was recorded by JGL-55534 (28.70 g) followed by JGL-55509 (27.73 g), JGL-55588 (26.70 g), JGL-55590 (26.06 g) and JGL-55587 (25.64 g). Most of the genotypes were significantly superior to both checks with large variability for seed size and weight.

Genetic variability, heritability and genetic advance

Genetic variability forms the basis of crop improvement as the effectiveness of selection depends on the amount of variability in the breeding population. As rice genetic studies have demonstrated earlier, estimation of genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance in percentage of mean is necessary to understand the nature and extent of variability among genotypes (Rathod *et al*., 2020; Saharia *et al*., 2024). The results of the variability analysis are shown in Table 3.

Days to 50% flowering:

Days to 50% flowering recorded GCV and PCV values of 8.25 and 8.34%, respectively. The narrow difference between GCV and PCV indicated limited environmental influence. Broad-sense heritability was very high (97.9%) with moderate GAM (16.82%). The combination indicates that selection for flowering duration can be effective in the present population.

Plant height:

Plant height showed GCV and PCV values of 9.07 and 9.21%, respectively. Heritability was very high (97.0%) and GAM was 18.40%. The close correspondence between GCV and PCV indicates limited environmental influence. The high heritability coupled with moderate-to-high genetic advance suggests that selection for plant height can be effective.

Panicle length:

Panicle length recorded GCV of 8.66% and PCV of 10.70%. Heritability was moderate (65.5%) with GAM of 14.45%. The relatively wider difference between GCV and PCV indicates greater environmental influence than for flowering time and plant height. The moderate heritability and genetic advance suggest that selection may be more effective in later generations after environmental effects are reduced.

Effective bearing tillers per plant:

Effective bearing tillers showed a GCV of 6.31% and PCV of 12.57%. Heritability was comparatively low (25.2%) and GAM was only 6.52%. The large difference between GCV and PCV indicates substantial environmental influence. Therefore, early-generation phenotypic selection for productive tillers may be less effective, and replicated or later-generation selection may be preferable.

Grain yield per plant:

Grain yield per plant recorded high GCV (30.27%)

Table 3: Genetic variability parameters for seven traits in 38 rice genotypes.

Trait	Mean	Range Min	Range Max	GCV %	PCV %	h^2(bs) %	GAM %
DFF	98.21	81.67	112.33	8.25	8.34	97.90	16.82
PH	106.15	85.00	127.17	9.07	9.21	97.00	18.40
PL	22.33	18.07	26.14	8.66	10.70	65.50	14.45
EBT	8.25	7.00	10.00	6.31	12.57	25.20	6.52
GYPP	19.11	9.90	31.73	30.27	31.21	94.10	60.48
NGPP	196.08	104.00	278.33	20.96	21.33	96.60	42.45
TSW	20.36	11.97	28.70	22.04	22.48	96.10	44.50

and PCV (31.21%), indicating substantial variability. The close correspondence between GCV and PCV suggested relatively limited environmental influence. Very high heritability (94.1%) combined with high GAM (60.48%) indicates considerable scope for improvement through direct selection.

The high heritability and high genetic advance observed for grain yield per plant suggest that a substantial portion of the observed variation was genetically controlled and that selection for superior plants can be effective. Similar relationships between high genetic variability, heritability and genetic advance have been reported in rice breeding materials (Rathod *et al.*, 2020; Saharia *et al.*, 2024).

Number of grains per panicle:

Number of grains per panicle recorded high GCV (20.96%) and PCV (21.33%), with very high heritability (96.6%) and high GAM (42.45%). The close correspondence of GCV and PCV indicates that environmental influence was relatively small. The combination of high heritability and high genetic advance indicates strong potential for direct selection.

1000-seed weight:

Thousand-seed weight showed high GCV (22.04%) and PCV (22.48%), with very high heritability (96.1%) and high GAM (44.50%). The small difference between GCV and PCV indicates that environmental effects contributed relatively little to phenotypic variation. Consequently, direct selection for higher seed weight should be effective.

Implications for selection:

Among the traits studied, grain yield per plant, number of grains per panicle and 1000-seed weight were found to be important selection criteria as they exhibited high GCV along with very high heritability and high genetic advance as percentage of mean. This pattern has also been reported for important yield traits in rice (Rathod *et al.*, 2020).

High GCV for grain production per plant indicates the presence of wide range of exploitable genetic variation. Its high GAM and very high heritability also indicate that phenotypic selection can bring about important genetic improvement. Similarly number of grains per panicle and weight of 1000 seeds showed similar trend indicating that they can be used as complementary selection criteria.

In contrast, effective bearing tillers per plant showed poor genetic improvements and heritability indicating that environmental factors were somewhat important. This is consistent with the importance of evaluating yield components across environments reported in rice studies and selection for this trait should preferably be based on replicated performance and late generation testing rather than phenotypic observation on single environments (Naveenkumar *et al.*, 2021; Shanmugam *et al.*, 2025).

Conclusion

The present investigation revealed significant genetic variability among 38 rice genotypes comprising of 36 F6 stable breeding lines and two checks. There were significant genotypic differences for all 19 traits studied, which indicates sufficient variability for selection. Among the yield traits grain yield per plant exhibited high GCV (30.27%), very high heritability (94.10%) and high genetic advance as per cent of mean (60.48%). Number of grains per panicle and 1000 seed weight also exhibited high GCV, very high heritability and high GAM showing considerable possibility for direct selection. Days to 50% flowering and plant height showed very high heritability with moderate genetic advance whereas panicle length showed moderate heritability and effective bearing tillers low heritability and low genetic advance. Among JGL-55590 (31.73 g), JGL-55585 (30.23 g), JGL-55557 (29.23 g) and JGL-55586 (28.63 g), promising high yielding genotypes were found. The lines need to be further evaluated in replicated and multi-location trials and assessed for grain quality and leaf blast resistance before being considered for advanced breeding or varietal development. Overall grain yield per plant, number of grains per panicle and 1000-seed weight may be considered as important selection criteria for improving yield potential in the present breeding population.

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