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Genetic analysis of quantitative traits for yield improvement in Rice (*Oryza sativa* L.)

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ABSTRACT

The present investigation entitled Genetic Analysis of Quantitative Traits for Yield Improvement in Rice (*Oryza sativa* L.) was conducted at research farm of Shri Durga Ji Post Graduate College, Chandeshwar, Azamgarh. Rice is a major staple crop globally, and improving its yield is a primary objective in plant breeding programs. The present study was conducted to assess genetic variability, heritability, genetic advance and genetic advance in per cent of mean among 30 rice genotypes. The experiment was laid out in a Randomized Block Design (RBD) with three replications during the kharif season. Eleven quantitative traits were analyzed. Analysis of variance revealed significant differences among genotypes for all traits, indicating the presence of substantial genetic variability. High genotypic and phenotypic coefficients of variation were observed for fertile seeds per panicle and harvest index. Moderate to high heritability coupled with genetic advance was recorded for key yield traits, suggesting the predominance of additive gene action. The study concludes that selection based on these traits can effectively enhance rice yield in breeding programs.

KEYWORDS

Rice, Genetic Variability, Heritability, Genetic Advance, Quantitative

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Rice (*Oryza sativa* L.) is one of the most important cereal crops feeding more than half of the world’s population. It belongs to the family Poaceae and serves as a staple food in Asia and many parts of the world. India is one of the largest producers of rice, yet productivity remains relatively low due to various environmental and genetic factors. Improving yield requires a deep understanding of genetic variability, heritability, and trait associations. India's rice production in 2023–2024 was estimated at a record 1364.65 lakh tonnes. As of February 3, 2024, the acreage of Rabi paddy in India had increased by 37.89% to 53.91 lakh hectares, compared to the previous year. This increase was due to higher acreage in Telangana, Tamil Nadu, Andhra Pradesh, and Assam.

India is the world's largest rice-growing country, cultivating rice over an area of about 43 million hectares. However, the yield level is still low at around 2.85 tonnes per hectare. Some factors that may contribute to low rice production in India include uncertain rainfall concentrated to four months and a lack ofassured water supply through irrigation. Rice has been grown on 216 Mha areas with a production of 510.4 MT in word (Source: USDA, 2022). Asia accounts for 90% of global rice consumption, and total rice demand there continues to rise. But outside Asia, where rice is not a staple yet, per capita consumption continues to grow. Rice is the fastest growing food staple in Africa, and also one of the fastest in Latin America.

In Asia, major rice growing countries are China, India, Indonesia, Bangladesh, Vietnam and Thailand. In 2021-22, rice has been grown on a 46 Mha area with a production of 110.15 MT (Source: Directorate of Economics & Statistics, 2021). India is one of the world's largest producers of rice, including white rice and brown rice, grown mostly in the eastern and southern parts of the country. The most important rice growing states of India include West Bengal, Uttar Pradesh, Punjab, Orissa, Madhya Pradesh, Bihar, Assam, Jharkhand, Tamil Nadu, Andhra Pradesh, Kerela, Karnataka and Maharashtra. The estimates of heritability are more advantageous when expressed in terms of genetic advance. Johnson *et al.* (1955) suggested that heritability and genetic advance when calculated together wouldprove more useful in predicting the resultant effect of selection on phenotypic expression, without genetic advance the estimates of heritability will not be of practical value and emphasized the concurrent use of genetic advance along with heritability.

High magnitude of variability in a population provides the opportunity for selection, to develop a variety having maximum desirable traits. Therefore, in addition to evaluate the mean output, the assessment of material for genetic divergence, variability, association between different yield and quality traits and direct and indirect effects contributed by each traits towards yield would be quite useful to the plant breeders. Therefore, knowledge on heritability along with genetic advance would be of considerable help to the breeder in selecting superior individuals for a desired trait and successfully using them in breeding programme. Quantitative traits such as plant height, tiller number, panicle length, and grain yield are influenced by both genetic and environmental factors. Therefore, studying variability and relationships among these traits is essential for effective selection. Despite significant progress in rice production, yield stagnation and environmental constraints continue to limit productivity. Genetic improvement through selection requires a clear understanding of variability, heritability, and trait associations. The estimation of genetic parameters such as genotypic and phenotypic coefficients of variation, heritability, and genetic advance provides insight into the nature of gene action governing traits.

Correlation and path coefficient analyses further help in identifying key traits contributing to yield. Therefore, the present study was undertaken to analyze genetic variability and interrelationships among yield and its component traits in rice.

Materials and Methods

The study was conducted during the kharif season using a Randomized Block Design (RBD) with three replications. Observations were recorded on the following 11 traits *viz*., days to 50% flowering, days to maturity, plant height (cm), number of tillers per plant, panicle length (cm), number of spikelets per panicle, fertile grains per panicle, 1000-grain weight (g), biological yield per plant (g), harvest index (%) and grain yield per plant (g). Each plot was maintained with standard agronomic practices. Analysis of variance (ANOVA) was performed to test the significance of differences among genotypes. Genotypic and phenotypic variances, coefficients of variation, heritability (broad sense), and genetic advance were calculated using standard formulas. High phenotypic and genotypic coefficients of variation were observed for traits such as grain yield, number of tillers, and spikelets per panicle, suggesting greater scope for selection. High heritability coupled with high genetic advance was observed for grain yield, number of tillers, and spikelets per panicle, indicating additive gene action and effectiveness of selection.

Results and Discussion

Genetic variability

The estimates of grand mean, standard error, ranged, genotypic coefficients of variation (GCV), phenotypic coefficients of variation (PCV), environmental coefficient of variance (ECV), heritability (h^2) in broad sense, genetic advance and genetic advance as percentage of mean for all the ten characters are presented in table 1 and fig 1. The estimates of GCV was highest for harvest index (%) (20.60) followed by fertile seed per panicle (20.47), grain yield par plant (13.60), biological yield per plant (g) (11.10), 1000-grain weight (cm) (11.09), Days to 50% flowering (9.06), spiklets per panicle (8.03), panicle length (cm) (7.04), plant height (cm) (6.84), days to 50%maturity (5.73) and tiller number per plant (5.55). The graphical representations of GCV are given in table 1 and fig 1.

Table 1. Estimates of grand mean, range, genotypic, phenotypic and environmental coefficient of variance, heritability, genetic advance and genetic advance as (% of mean) for 11 quantitative characters in rice (*Oryza sativa* L.)

S.N.	Characters	General Mean	±SEm	Range		Coefficient of Variation (C. V.)			Heritability (%)	Genetic Advance	Genetic Advanceas
		$\bar{X}$		Min.	Max.	GCV%	PCV%	ECV%			% of mean
1.	Day to 50% flowering	86.9778	2.8612	74.27	102.67	9.0688	10.7101	5.6977	71.7	13.7588	15.8188
2.	Days to 50% maturity	124.182	2.9005	112.40	138.93	5.7357	7.0188	4.0455	66.78	11.9904	9.6555
3.	Plant height (cm)	125.426	6.4557	106.20	145.17	6.8475	11.2411	8.9149	37.11	10.7771	8.5924
4.	Tiller number/ plant	11.2133	0.5508	9.80	12.87	5.5542	10.161	8.5086	59.88	0.7013	6.2542
5.	Panicle length (cm)	23.0222	0.9154	19.33	26.00	7.0473	9.8538	6.8872	51.15	2.3903	10.3826
6.	Spiklets/ panicle	13.4467	0.7435	11.27	15.67	8.0386	12.5033	9.5766	61.33	1.4316	10.6465
7.	Fertile seed/ panicle	216.947	30.4861	120.60	311.93	20.4746	31.8059	24.3393	41.44	23.9043	27.1514
8.	1000-grain weight (cm)	13.2057	0.8157	10.20	17.34	11.0947	15.4124	10.6982	51.82	2.1726	16.452
9.	Biological yield/ plant (g)	102.655	6.9955	74.87	132.27	11.1044	16.2057	11.8033	46.95	16.0904	15.6743
10.	Harvest Index (%)	31.6293	4.8806	21.02	40.03	20.6098	33.7503	26.7268	37.29	8.2002	25.9259
11.	Grain yield/ plant (g)	30.3019	3.676	17.81	40.26	13.609	25.0343	21.0121	69.55	4.618	15.24

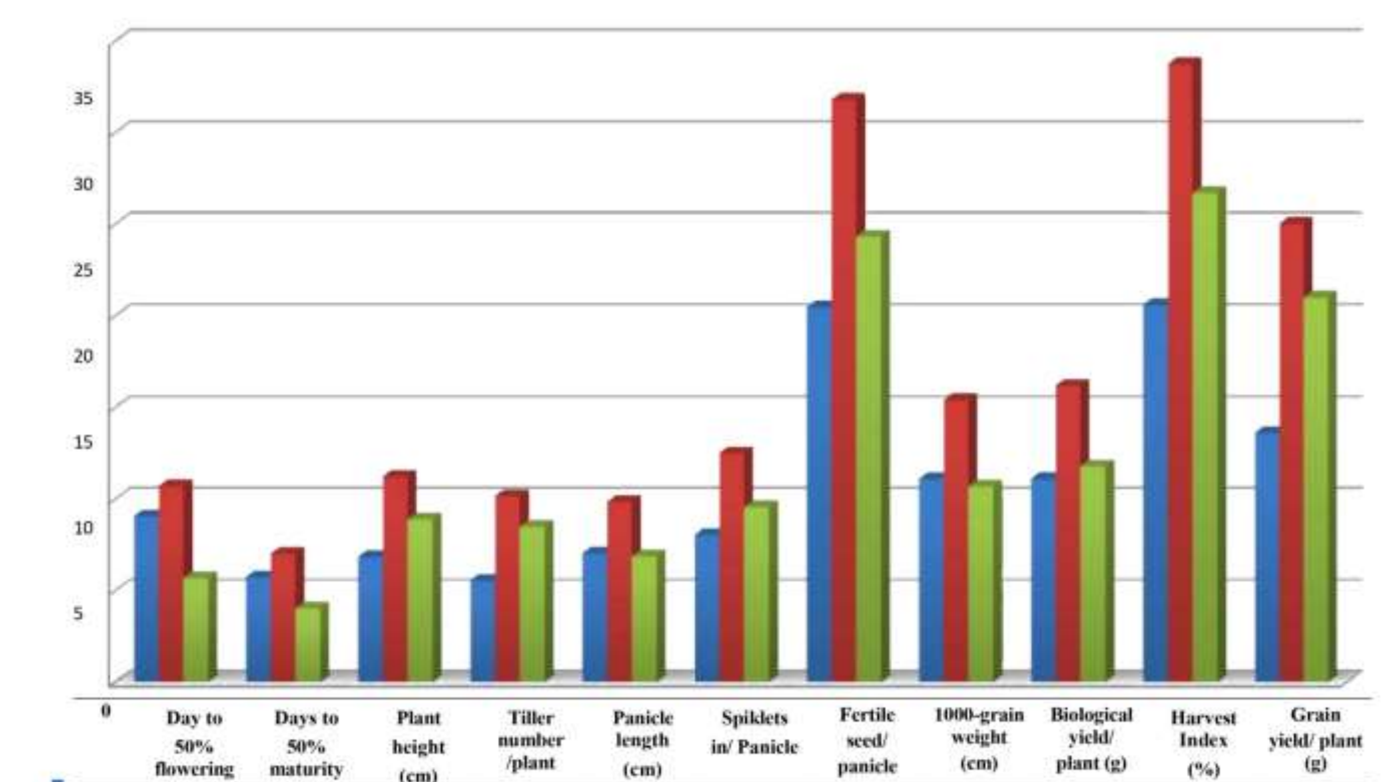
The estimates of PCV was highest for harvest index (%) (33.75) followed by fertile seed per panicle (31.80), grain yield per plant (g) (25.03), biological yield per plant (16.20), 1000-grain weight (cm) (15.41), spiklets per panicle (12.50), plant hight (cm) (11.24), day to 50% flowering (10.71), tiller number per plant (10.16), panicle length (cm) (9.85) and days to 50% maturity (7.01). The graphical representations of PCV are given in table 1 and fig 1. The estimates of ECV was highest for harvest index (%) (26.72) followed by fertile seed per panicle (24.33), grain yield per plant(g) (21.01), biological yield per plant (11.80), 1000-grain weight (cm) (10.69), spiklets per panicle (9.57), plant height (cm) (8.91), tiller number per plant (8.50), panicle lenth (cm) (6.88), days to 50% flowering (5.69) and days to 50% maturity (4.04). The graphical representations of ECV are presented table 1 and fig 1. The results are in agreement with those obtained by (Kumar *et al*., 2017, Basavaraja *et al*., 2018, Idris *et al*., 2012, Limbani *et al*., 2017 and Akshay *et al*., 2022) .

Heritability (bs)

The estimates of heritability in broad sense were recorded for the various characters which revealed that the heritability in broad sense was highest for days to 50% flowering (70.7), grain yield per plant (g) (69.55), day to 50% maturity (66.78) and spiklets per panicle (61.33). Similarly the moderate estimates of heritability were recorded for tiller number per plant (59.88), 1000-grain weight (51.82) and panicle lenth (cm) (51.15). On the other hand the lower estimates of heritability were recorded for the characters biological yield per plant (g) (46.95), fertileseed per panicle (41.44), harvest index (%) (37.29) and plant height (cm) (37.11) showed the lowest heritability in broad sense. The graphical representations of heritability are presented in table 1 and fig 2. Similar results were found by (Fahliani *et al.*, 2010, Fatema *et al.,* 2011, Idris *et al.*, 2012 and Limbani *et al.*, 2017).

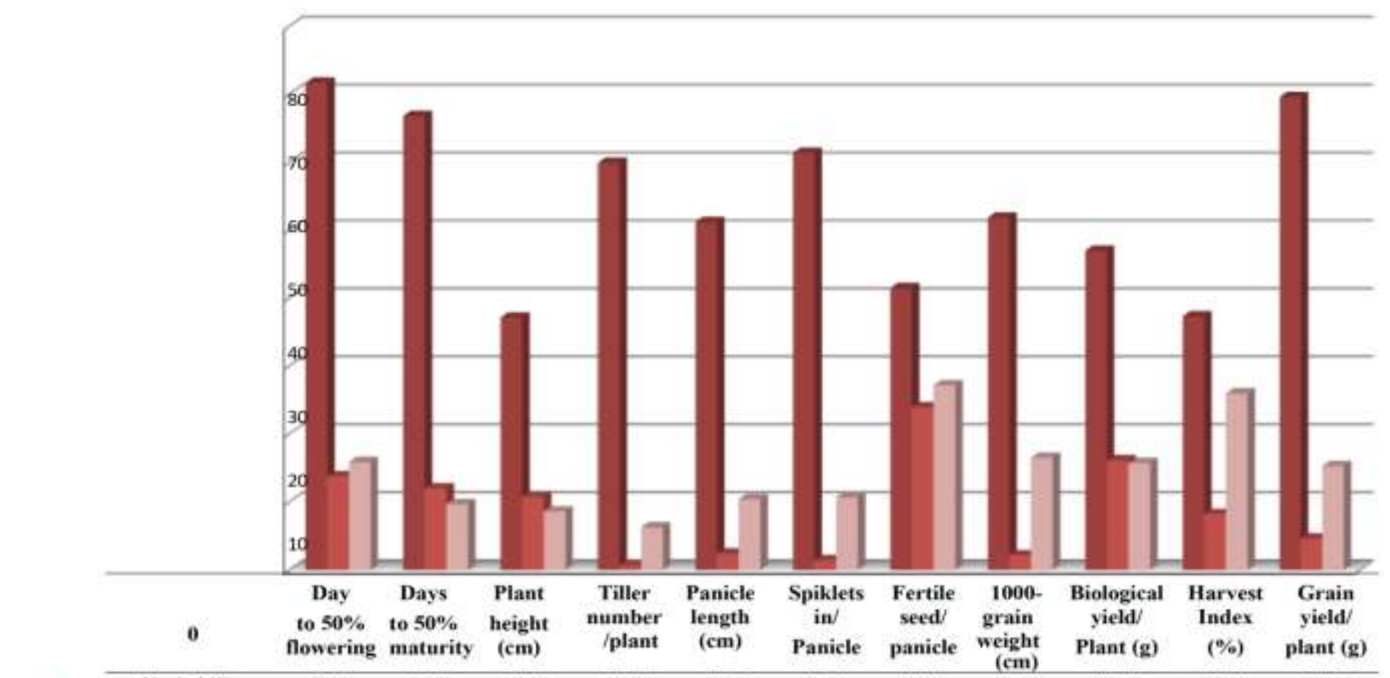
Genetic Advance

The estimates of genetic advance were recorded for fertile seed per panicle (23.90) followed by biological yield per plant (g) (16.09), day to 50% flowering (13.75), days to 50% maturity (11.99), plant height (cm) (10.77). Harvest index (%) (8.20), similarly, the lower estimates of genetic advance where recorded for grain yield per plant (g) (4.61), panicle length (cm) (2.39), 1000-grain weight (cm) (2.17), spiklete per panicle (1.43) and tiller number per plant (0.70).



	Day to 50% flowering	Days to 50% maturity	Plant height (cm)	Tiller number /plant	Panicle length (cm)	Spiklets in/ Panicle	Fertile seed/ panicle	1000-grain weight (cm)	Biological yield/ plant (g)	Harvest Index (%)	Grain yield/ plant (g)
GCV	9.0688	5.7357	6.8475	5.5542	7.0473	8.0386	20.4746	11.0947	11.1044	20.6098	13.609
PCV	10.7101	7.0188	11.2411	10.161	9.8538	12.5033	31.8059	15.4124	16.2057	33.7503	25.0343
ECV	5.6977	4.0455	8.9149	8.5086	6.8872	9.5766	24.3393	10.6982	11.8033	26.7268	21.0121

Fig 1. The comparisons of GCV, PCV & ECV variation of 11 quantitative characters in rice (*Oryza sativa* L.)



	Day to 50% flowering	Days to 50% maturity	Plant height (cm)	Tiller number /plant	Panicle length (cm)	Spiklets in/ Panicle	Fertile seed/ panicle	1000-grain weight (cm)	Biological yield/ Plant (g)	Harvest Index (%)	Grain yield/ plant (g)
Heritability (Broad Sense)	71.7	66.78	37.11	59.88	51.15	61.33	41.44	51.82	46.95	37.29	69.55
Genetic Advance	13.7588	11.9904	10.7771	0.7013	2.3903	1.4316	23.9043	2.1726	16.0904	8.2002	4.618
GA as % of mean	15.8188	9.6555	8.5924	6.2542	10.3826	10.6465	27.1514	16.452	15.6743	25.9259	15.24

Fig 2. The comparisons of heritability, genetic advance and genetic advance (% of mean) of 11 quantitative characters in rice (*Oryza sativa* L.)

The graphical representations of genetic advance are presented in table 1, and fig 2. Similar results were found by (Srujana *et al.*, 2017).

Genetic Advance as (% of Mean)

The highest estimates of genetic advance as (% of mean) were recorded for fertile seeds per panicle (27.15) followed by harvest index (%) (25.92), 1000-grain weight (cm) (16.45), day to 50% flowering (15.81), biological yield per plant (15.67) and grain yield per plant (g) (15.24), similarly, the lower estimates of genetic advance where recorded for spiklets per panicle (10.64), panicle length (cm) (10.38), day to 50% maturity (9.65), plant height (cm) (8.59) and tiller number per plant (6.25). The graphical representations of genetic advance as (% of mean) are presented in table 1 and fig 2. Similar results were found by (Kumar *et al.*, 2017, Basavaraja *et al.*, 2018, Idris *et al.*, 2012, Limbani *et al.*, 2017 and Akshay *et al.*, 2022).

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