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Studies on heritability and genetic advance in segregating generations of rice (*Oryza sativa* L.)

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Abstract
The present investigation was carried out during *kharif* 2017-2018, at Main Rice Research Centre farm, Navsari Agricultural University, Navsari. The experimental material for present investigation comprised of Six generations *viz.,* P_1, P_2, F_1, F_2, BC_1 and BC_2 of following four crosses were involved eight diversified cultivars of rice (*Oryza sativa* L.) were used to study the genetic analysis of quantitative and qualitative traits. High heritability coupled with high genetic advance was estimated in all the crosses for grain yield per plant except cross 4 (IET-15429 X IET-25453); plant height for cross 2 (GNR-3 X IET-25446); straw yield per plant for all crosses except cross 4 (IET-15429 X IET-25453); protein content for cross 3 and cross 4 (IET-15429 X IET-25453); Zn content for cross 1 (NAUR-1 X IET-25457) and cross 3 (GNR-5 X IET-25471) and head rice recovery (%) in cross 4 (IET-15429 X IET-25453), suggesting that these characters can be further improved by adopting selections in succeeding generations.

Keywords: Heritability, genetic advance, generation mean analysis, rice (*Oryza sativa* L.)

Introduction
Rice, being one of the most important cereal crops of India and Asia, is cultivated as pure culture mainly in *Kharif*. The crop is cultivated in large area but is characterized by very low productivity due to lack of high yielding varieties adapted to different seasons and agronomic conditions at different parts of country. As we know, yield is a complex end product of a number of components most of which are under polygenic control. So, all changes in yield must be accompanied by changes in one or more of the components as have been pointed out by Grafius (1959). The ultimate goal of any plant breeding programme is to develop improved genotypes which are better than their existing ones in one or more traits which producing the economic yield. The enhancement of mineral nutrients in rice is today's vital need to reduce malnutrition/anemic conditions in poor people of the world. Sufficient understanding of the inheritance of quantitative traits and information about heritability of grain yield, its components and quality traits are essential to develop an efficient breeding strategy.
Estimate of heritability serves as a useful guide to the plant breeder. The breeder is able to appreciate the proportion of variation that is due to genotypic (broad sense heritability) or additive (narrow sense heritability) effects, that is, the heritable portion of variation in the first case, and the portion of genetic variation that is fixable in pure lines in the later case. If heritability of a character is very high, selection for the character should be fairly easy because there would be a close correspondence between the genotype and phenotype due to relatively smaller contribution of the environment to phenotype. But for a character with low heritability, selection may be considerably difficult or virtually impractical due to the masking effect of the environment on genotypic effects. Thus, estimates of heritability are useful in predicting the transmission of characters from the parents to their offspring.

Material and methods
The material comprising of eight genetically diverse parents of rice (NAUR-1, IET-25457, GNR-3, IET-25446, GNR-5, IET-25471, IET-15429 and IET-25453) selected on the basis of their geographic origin and variation in morphological characters and based on their mineral nutrient content. four crosses (NAUR-1 X IET-25457, GNR-3 X IET-25446, GNR-5 X IET-25471 and IET-15429 X IET-25453) obtained by crossing of eight diverse parents during *kharif*-2016 at Main Rice Research Centre farm, Navsari Agricultural University, Navsari. Backcrossing was done in *summer*-2016-17 with its respective parents. Selfing of F_1s was done in the same season (*summer*- 2016-17) to get F_2s. The evaluation trial was conducted in

Kharif- 2017-18 at Main Rice Research Centre farm, Navsari Agricultural University, Navsari. The experimental material consisting of six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) of each of the four crosses were sown during *kharif*-2017-18 in compact family block design with three replications. Each replication was divided in four compact blocks. Each four crosses consisting of six generations were randomly allotted to each plot within a block. Each plot consisted of one row of parents and F_1s, two rows of the backcrosses and four rows of the F_2 generations of each cross. Inter and intra row spacing was 20 cm and 15 cm respectively. The experiment was surrounded by four guard rows to avoid damage and border effects.

Results and Discussion

Heritability is a measure of the efficiency of a selection system in separating genotypes. The quantitative traits are largely influenced by environments; therefore, those are not highly heritable. High, moderate and low heritability are not rigidly defined as it varies with character to character, but the following values are widely accepted (Robinson *et al*. 1949) [4].

1. Low heritability : 0 - 30 %
2. Moderate heritability : 30 - 60 %
3. High heritability : > 60 %

The value of expected genetic advance for various characters is demarcated into three categories *viz*., low, moderate and high, as follows (Johnson *et al.* 1955) [3].

1. Low genetic advance: 0 - 10%
2. Moderate genetic advance: 10 - 20 %
3. High genetic advance: > 20 %

Narrow sense may be more helpful in the selection of segregating populations and that is why the genetic advance was calculated on the basis of narrow sense heritability to ascertain more reliable results.

In cross 1 (NAUR-1 X IET-25457), high narrow sense heritability was recorded for grain yield per plant, straw yield per plant, protein content, amylose content, Fe content, Zn content and milling (%), whereas in cross 2 (GNR-3 X IET-25446), days to 50% flowering, plant height, grains per panicle, grain yield per plant, harvest index, protein content, amylose content, Fe content, Zn content and milling (%) exhibited high narrow sense heritability. For cross 3 (GNR-5 X IET-25471), days to maturity, plant height, grain yield per plant, straw yield per plant, harvest index, protein content, amylose content, Fe content, Zn content and head rice recovery (%) had recorded high narrow sense heritability. In case of cross 4 (IET-15429 X IET-25453), kernel L:B ratio, protein content, Fe content, Zn content and head rice recovery (%) recorded high narrow sense heritability.

In cross 1 (NAUR-1 X IET-25457), moderate narrow sense heritability was recorded for days to 50% flowering, days to maturity, grains per panicle, kernel L:B ratio, leaf area, hulling (%) and head rice recovery (%) recorded, while rest of the traits had low narrow sense heritability for this cross. In case of cross 2 (GNR-3 X IET-25446), productive tillers per plant, 100 seed weight, kernel L:B ratio, leaf area, chlorophyll content, hulling (%) and head rice recovery (%) exhibited moderate narrow sense heritability, while rest of the traits had low narrow sense heritability in this cross. moderate narrow sense heritability recorded for traits *viz*., days to 50% flowering, productive tillers per plant, grains per panicle, leaf area, hulling (%) and milling (%) in cross 3 ((GNR-5 X IET-25471), while rest of the traits had low narrow sense heritability in this cross. In case of cross 4 ((IET-15429 X IET-25453), plant height, grains per panicle, 100 seed weight, grain yield per plant, straw yield per plant, amylose content, leaf area, chlorophyll content, hulling (%) and milling (%) exhibited moderate narrow sense heritability, while rest of the traits had low narrow sense heritability in this cross.

Moderate expected genetic advance was recorded for protein content, amylose content, Fe content, leaf area and milling (%) in cross 1 (NAUR-1 X IET-25457); productive tillers per plant, grains per panicle, 100 seed weight, straw yield per plant, harvest index, protein content, amylose content, Fe content, Zn content, leaf area, chlorophyll content, milling (%) and head rice recovery (%) for cross 2 (GNR-3 X IET-25446); plant height, productive tillers per plant, grains per panicle, harvest index, amylose content, Fe content, leaf area and head rice recovery (%) for cross 3 (GNR-5 X IET-25471); 100 seed weight, grain yield per plant, kernel L:B ratio, amylose content, Zn content, chlorophyll content and leaf area in cross 4 (IET-15429 X IET-25453).

High expected genetic advance was recorded for grains per panicle, grain yield per plant, straw yield per plant and Zn content in cross 1 (NAUR-1 X IET-25457); plant height and grain yield per plant for cross 2 (GNR-3 X IET-25446); grain yield per plant, straw yield per plant, protein content and Zn content for cross 3 (GNR-5 X IET-25471); straw yield per plant, protein content and head rice recovery (%) in cross 4 (IET-15429 X IET-25453). However, most of the crosses revealed low to high genetic advance for some more traits. Low genetic advance was reported for days to 50% flowering, days to maturity, plant height, productive tillers per plant, 100 seed weight, harvest index, kernel L:B ratio, photosynthetic rate, chlorophyll content, hulling (%) and head rice recovery (%) in cross 1 (NAUR-1 X IET-25457); days to 50% flowering, days to maturity, kernel L:B ratio, photosynthetic rate and hulling (%) for cross 2 (GNR-3 X IET-25446); days to 50% flowering, days to maturity, 100 seed weight, kernel L:B ratio, photosynthetic rate, chlorophyll content, hulling (%) and milling (%) for cross 3 (GNR-5 X IET-25471); days to 50% flowering, days to maturity, plant height, productive tillers per plant, grains per panicle, harvest index, Fe content, photosynthetic rate, hulling (%) and milling (%) in cross 4 (IET-15429 X IET-25453).

High heritability coupled with high genetic advance was estimated in all the crosses for grain yield per plant except cross 4; plant height for cross 2; straw yield per plant for all crosses except cross 4; protein content for cross 3 and cross 4; Zn content for cross 1 and cross 3 and head rice recovery (%) in cross 4, which indicated that heritability of these traits were under the control of additive gene action. For improvement of such traits, selection will be rewarding. Moderate to high heritability coupled with high to moderate genetic advance was observed in majority of the crosses for grains per panicle in all crosses except cross 4; plant height in cross 2 and 3, productive tillers per plant in cross 2 and 3, 100 seed weight in cross 2 and 4; grain yield per plant and straw yield per plant in all crosses; protein content, amylose content, Fe content, Zn content and leaf area which indicate that heritability of these traits were due to additive gene action, suggesting that these characters can be further improved by adopting selections in succeeding generations. High to moderate heritability coupled with moderate to low genetic advance was observed in majority of the crosses for days to

50% flowering, days to maturity, plant height, photosynthetic rate, chlorophyll content, hulling (%), milling (%) and head rice recovery (%) shows that little progress can be made in the improvement of these traits by phenotypic selection. Low heritability coupled with low genetic advance was estimated for productive tillers per plant in cross 1; harvest index in cross 4; head rice recovery (%) in cross 3 and cross 4, which indicated that heritability of chlorophyll content was under the control of non additive gene action for this cross and selection would be ineffective for this trait.

Table 1: Estimates of heritability and genetic advance for days to 50 % flowering, days to maturity, plant height, productive tillers per plant, grains per panicle, 100 seed weight (g) and grain yield per plant (g) in four crosses of rice.

Estimates (%)	Days to 50 % flowering	Days to maturity	Plant height (cm)	Productive tillers per plant	Grains per panicle	100 seed weight (g)	Grain yield per plant (g)
Cross I (NAUR-1 X IET-25457)							
Heritability (NS) %	49.03	30.04	12.52	8.01	58.51	27.79	63.57
Genetic Advance %	5.71	3.05	2.92	2.74	29.92	7.08	30.79
Cross II (GNR-3 X IET-25446)							
Heritability (NS) %	75.39	16.42	60.28	41.07	78.54	54.53	85.87
Genetic Advance %	6.03	1.32	22.02	17.44	18.73	12.09	49.86
Cross III (GNR-5 X IET-25471)							
Heritability (NS) %	88.72	78.28	71.66	43.21	47.58	18.88	91.47
Genetic Advance %	7.97	6.91	16.30	18.78	10.65	3.56	55.67
Cross IV (IET-15429 X IET-25453)							
Heritability (NS) %	6.75	19.11	36.23	11.49	37.61	54.53	38.11
Genetic Advance %	0.73	1.47	7.61	4.53	7.17	14.37	17.95

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

Table 2: Estimates of heritability and genetic advance for straw yield per plant (g), harvest index (%), kernel L: B ratio (mm), protein content (%), amylose content (%), iron contentand zinc content in four crosses of rice.

Estimates (%)	Straw yield per plant (g)	Harvest index (%)	Kernel L:B ratio (mm)	Protein content (%)	Amylose content (%)	Fe content (ppm)	Zn content (ppm)
Cross I (NAUR-1 X IET-25457)							
Heritability (NS) %	66.38	17.88	33.14	94.49	81.94	90.51	92.46
Genetic Advance %	29.49	1.35	7.90	17.34	14.78	11.96	21.82
Cross II (GNR-3 X IET-25446)							
Heritability (NS) %	21.97	65.80	37.42	89.98	95.76	88.72	75.45
Genetic Advance %	14.66	16.51	9.45	19.99	17.97	10.69	18.31
Cross III (GNR-5 X IET-25471)							
Heritability (NS) %	76.59	60.57	5.90	90.23	91.82	95.33	94.91
Genetic Advance %	55.66	13.58	1.10	24.16	18.28	11.56	21.46
Cross IV (IET-15429 X IET-25453)							
Heritability (NS) %	54.09	17.98	65.60	97.16	53.61	87.70	89.69
Genetic Advance %	31.22	3.67	18.06	23.30	14.05	8.58	17.26

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

Table 3: Estimates of heritability and genetic advance for leaf area (cm^2), photosynthetic rate ($\mu mol/m^2/s$), chlorophyll content, hulling (%), milling (%) and head rice recovery (%) in four crosses of rice.

Estimates (%)	Leaf area (cm^2)	Photosynthetic rate ($\mu mol/m^2/s$)	Chlorophyll content	Hulling (%)	Milling (%)	Head rice recovery (%)
Cross I (NAUR-1 X IET-25457)						
Heritability (NS) %	31.13	10.89	22.13	50.81	60.28	41.81
Genetic Advance %	10.84	2.77	7.42	8.16	10.46	9.84
Cross II (GNR-3 X IET-25446)						
Heritability (NS) %	32.10	25.69	42.69	59.85	60.94	46.53
Genetic Advance %	12.53	6.39	15.43	9.68	11.07	10.96
Cross III (GNR-5 X IET-25471)						
Heritability (NS) %	37.10	3.22	17.88	58.73	53.88	76.47
Genetic Advance %	14.95	0.88	6.85	9.59	9.81	17.99
Cross IV(IET-15429 X IET-25453)						
Heritability (NS) %	47.10	23.94	49.17	53.36	50.83	84.47
Genetic Advance %	14.83	5.76	18.01	8.59	9.10	20.05

* and **, significant at 5% and 1%, respectively.

Conclusion

The higher estimates of heritability indicates that these traits were comparatively less affected by environment and their phenotypes are good reflection of genotypes and thus possessed paramount importance in making selection of superior genotype on the basis of phenotypic performance of these matric traits but in case of lower heritability, pedigree, sib or progeny test can be employed for genetic improvement. The moderate to low estimates of heritability for most of the traits including yield components indicated the preponderance of non-additive variance for yield and yield attributes in the material under study.

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