Biological Forum – An International Journal **15(11): 108-112(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Genetic Variability, Heritability, Genetic Advance and Trait Association Studies in Rainfed Rice Genotypes

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(Received: 03 September 2023; Revised: 01 October 2023; Accepted: 16 October 2023; Published: 15 November 2023)
(Published by Research Trend)

ABSTRACT: Abundant variability, heritability and extent of association between yield related traits in the initial breeding material ensures better chances of producing desired forms of a crop plant. In order to study genetic variation, genetic inheritance, genetic advancement, and the relationship between yield and related characteristics of 16 advanced rice cultures, the experiment was carried out with rainfed condition. All of the treatments have significant implications for the numerous features under study, according to the analysis of variance. Straw yield had a moderate GCV and the number of effective tillers per plant, number of spikes per square metre plot area, grain yield, straw yield and harvest index showed the highest magnitude of PCV. Days to 50% blooming was shown to have a high genetic gain and high heritability, which suggests that additive gene action plays a substantial role in the generational transmission of this feature. Harvest index was found to have a positive correlation with days to 50% blooming, number of spikes per square metre and length of the panicle. These results suggest that selecting for harvest index will help develop high-yielding genotypes in rainfed environments by simultaneously improving these traits. Straw yield showed very high direct effects, while the harvest index had a high direct effect on grain production. To increase grain yield under rainfed rice cultivation, greater weight should be placed on the characteristics of days to 50% blooming, straw yield and harvest index. Hence result obtained from this study is paving way for rapid improvement in yield in rainfed environment by considering these mentioned traits during selection process.

Keywords: Variability, heritability, genetic advance, trait association, rainfed rice.

INTRODUCTION

About 90% of people in South-East Asia eat rice (*Oryza sativa* L.) as a staple diet, making it the most vital cereal food crop in the world. Rainfed rice has become more and more popular since intense cultivation of the existing high-yielding cultivars has increased genetic vulnerability, reduced irrigation water availability, and broken down resistance genes against developing pathogen races. Due to the reduced cost of production and lack of irrigation facilities, it is significant in cropping systems (Fageria *et al*., 2014). Random weather patterns, rising temperatures, dwindling water supplies, and the advance of coastal salt are only a few of the present constraints that plant breeders face in meeting the demands of rice production (Sruthi *et al.*, 2023). Furthermore, the absence of suitable varieties of rice under such ecoclimatic conditions causes poor productivity in the majority of areas under rainfed rice agriculture. Therefore, a breakthrough in the form of increased biological effectiveness through recombination and the generation of new kinds adapted to rainfed conditions would be required in order to boost the productivity level.

The best feasible utilization of the natural resources that are available determines much of India's agricultural output (Tarkeshwar and Saini 2023). It is therefore desirable to gather, assess, and make use of the diversity that is now accessible to satisfy certain needs with regard to specific ecosystems, as the success of producing new variations will rely on the effective utilization of existing variability. A thorough breeding process involves selection, the introduction of genetic variation, and the exploitation of selected genotypes to produce productive variations (Hemalatha *et al*., 2022). Crop improvement is achievable with the application of suitable selection techniques once parental variation has been established. Choosing for components of yield will make it easier to increase overall yield because these components are more frequently inherited than total yield. Determining which features should be prioritized throughout the selection process will be made much easier with an understanding of the degree of correlation between those traits and better yield.

When qualities are positively correlated, it is appropriate to focus selection on just one of the connected traits while simultaneously improving the other trait. According to Nadarajan *et al*. (2016), there is a positive connection at the genetic level resulting from the coupling phase of linkages and a negative correlation arising from the repulsion phase of linkages of alleles controlling two distinct phenotypes.

The link between predictor and responder variables has been arranged using path analysis. Path analysis has the benefit of allowing the correlation coefficient to be divided into its constituent parts. The path coefficient, also known as the standardized partial regression coefficient, is one component that assesses the direct influence of a predictor variable on its response variables, while the other component is the indirect influence(s) of a predictor variable on the response variable via additional predictor factors (Deway and Lu 1959). Plant breeders can discover features on which pressure of selection needs to be applied to improve yield with the help of path coefficient analysis. Therefore, this study was carried out to choose prospective genotypes and determine the most essential characters for breeding programs by taking advantage of 16 advanced rainfed rice genotypes' genetic variability, heritability, genetic gain, and association with yield and related attributes.

MATERIALS AND METHODS

A. Details on experimental site and traits

The sixteen advanced rice cultures that made up the experimental material were assessed in Rabi 2022–2023 at the Agricultural Research Station (TNAU), Paramakudi, India, using a randomized block design with three replications. The experimental location is 42 meters above MSL and receives an average of 840 mm of rainfall annually. It is situated at latitudes 9" 21' N and longitudes 78" 22' E. The soil type at this location is clay loam, with a pH of 8.0. Every genotype was grown on a 5 × 2 m plot with 15 × 10 cm intervals. The agronomic recommendations were adhered to in order to improve crop stand. The following quantitative traits were studied: days to blooming at fifty percent plant height (cm), number of effective tillers per plant, number of spikes per square meter plot area, panicle length, grain yield (kg), straw yield (kg), and harvest index. The data was collected on ten randomly selected plants from every replication.

B. Statistical analysis

The value of significance for every character was tested using an analysis of variance applied to mean values, following the Panse and Sukhatme (1967) technique. The formula provided by Burton (1952) was used to compute the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV). As recommended by Sivasubramanian and Menon (1973), PCV and GCV were categorized. Broad sense heritability (h^2[b]) was determined using the formulas proposed by Allard (1960). The Johnson *et al*. (1955) recommended category for heritability (h^2[b]). Genetic advance (GA) was calculated using the formula provided by Allard (1960), and Johnson *et al*. (1955) proposed a classification scheme for genetic advance expressed as a percentage over mean. The genotypic correlation coefficients among the yield components and between the yield and its components were calculated. As recommended by Al-Jibouri *et al*. (1958), the relevant genotypic variances and covariances were computed using the analysis of variance and covariance data using the mean squared values and mean sum of products. Using the path analysis approach proposed by Dewey and Lu (1959), the relative influence of eight components on yield both directly (direct effects) and indirectly (*via* other features) was assessed. For this, the already-estimated basic correlation coefficients at the genotypic level were used. In order to evaluate the direct and indirect effects, simultaneous equations expressing the fundamental link among path coefficients were solved, with yield remaining the dependent variable and the remaining eight attributes the independent variables. Lenka and Misra's (1973) scale was used to categorize the direct and indirect effects.

RESULTS AND DISCUSSION

A. Variability

For every character under study, the ANOVA showed significant variations in the genotypes, confirming the presence of genetic variability (Table 1). A breeder can compare the degree of variability across various traits by using the genotypic coefficient of variation, which quantifies the range of variability present in the crop. Examining the coefficient of variability revealed that every character under study exhibited a broad range of variability at the genotypic and phenotypic levels. For every characteristic, the magnitude of the phenotypic coefficient of variation (PCV) exceeded the genotypic coefficient of variation (GCV); this could be because genotypes and environment interact more strongly (Kavitha and Reddy 2002; Muthuramu and Ragavan 2020). For the number of effective tillers per plant, number of spikes per square metre plot area, grain yield, straw yield and harvest index, there were significant disparities in the magnitudes of PCV and GCV. The number of effective tillers per plant, number of spikes per square metre plot area, grain yield, straw yield and harvest index showed the highest magnitude of PCV while straw yield had a moderate GCV (Table 2). This is consistent with the findings of Sruthi *et al*. (2023); Muthuramu and Ragavan (2020); Kumar *et al*. (2018).

B. Heritability and Genetic advance

Burton (1952) noted that the degree of diversity in the population, along with the strength of selection and heredity, all affect the benefits of selection. Genetic progress, then, is an additional crucial selection criterion that, despite its independence, captures the anticipated genetic advancement that is being selected for. According to Panse (1957), a character with additive gene action will have high heritability and high genetic advance, while a character with non-additive gene action will likely have high heritability and low genetic advance, leaving good room for future development. Days to 50% blooming was found to have a significant genetic gain and strong heritability (Table 2). It suggests that selection might be successful and that the heritability is most likely the result of additive gene effects. This result closely aligns with the conclusions of Hemalatha *et al*. (2022); Kumar *et al*. (2018); Allam *et al*. (2015).

C. Association Studies

For each rice genotype, the following genotypic correlations were calculated: days to 50% blooming, plant height, number of effective tillers per plant, number of spikes per square meter, panicle length, straw yield per plot, and harvest index (%). Table 3 presents the findings. In the current study, grain yield had a negative and significant correlation with number of effective tillers per plant and panicle length, but a positive and significant association with days to 50% blooming and straw yield per plot (Table 3). This was consistent with the results of the following studies: Vanisree *et al.* (2013); Islam *et al*. (2015); Shinde *et al.* (2015); Muthuramu and Sakthivel (2016); Lalitha *et al.* (2019); Muthuramu and Ragavan (2020). Breeders may find it easier to choose the direction and degree of pressure for selection to apply to related qualities in order to simultaneously develop these traits if they are aware of the relationships between yield traits. In the current study, days to 50% blooming, number of spikes per square metre and panicle length, all positively and significantly correlated with harvest index. Days to 50% blooming was positively and significantly correlated with the trait plant height. Similarly, a strong and positive correlation was found between the number of effective tillers per plant and straw yield per plot. Islam *et al*. (2015); Lalitha *et al*. (2019); Muthuramu and Ragavan (2020) all reported findings that were similar.

Given the discussion above, it is possible to conclude that the days to 50% blooming and straw yield per plot should be considered during the selection process because they showed a strong and positive link with grain yield. Selection based on harvest index is very effective for generating high yielding varieties under rainfed conditions, as it will bring about concurrently processed improvement of these traits. The trait, harvest index, had a positive correlation with days to 50% blooming, number of spikes per square metre and panicle length. Hence result obtained from this study is similar to those mentioned above.

Straw yield was found to have a very high direct effect on grain yield in the current study, while the harvest index had a high direct effect (Table 4). This was consistent with the results of the following studies: Vanisree *et al.* (2013); Islam *et al*. (2015); Shinde *et al.* (2015); Muthuramu and Sakthivel (2016); Lalitha *et al.* (2019); Muthuramu and Ragavan (2020). The trait harvest index was found to have high indirect effects on grain yield through days to 50% blooming, number of spikes per square metre and panicle length. Likewise, length of the panicle had moderate indirect effects on grain yield through the number of effective tillers per plant and straw yield. 76% of the variability in grain yield is attributed to the variables under investigation, according to the genotypic residual effect (0.24). It suggests that in order to completely explain the difference in grain production, a few other factors that have not been examined here must be taken into consideration.

Table 1: Analysis of variance for different traits in rainfed rice.

Source of variation	Degrees of freedom	Days to 50% blooming	Plant Height	Effective tillers per plant	Spikes per square metre	Panicle length	Grain yield	Straw yield	Harvest index
Replication	2	4.77	2.85	5.58	5996.08	0.21	1794114.58	4738125.00	0.005
Genotypes	15	154.55**	88.52**	5.14*	2122.43*	11.11**	585163.19**	3719319.44**	0.005*
Error	30	1.19	32.40	2.87	1377.06	3.82	371725.69	1277236.11	0.004

**significant at P=0.01 level *significant at P=0.05 level

Table 2: Estimates of mean, variability, heritability and genetic advance in rainfed rice.

Traits	Mean	PV	GV	PCV	GCV	h^2	GAM
Days to 50% blooming	73.42	52.31	51.12	9.85	9.74	97.72	19.83
Plant height	73.74	51.11	18.71	9.69	5.86	36.60	7.31
Effective tillers per plant	8.77	3.63	0.76	21.72	9.92	20.86	9.33
Spikes per square metre	197.77	1625.52	248.46	20.39	7.97	15.28	6.42
Panicle length	20.02	6.25	2.43	12.49	7.79	38.87	10.00
Grain yield	3048.96	442871.53	71145.83	21.83	8.75	16.06	7.22
Straw yield	6631.25	2091263.89	814027.78	21.81	13.61	38.93	17.49
Harvest index	0.32	0.005	0.0002	21.92	4.38	3.99	1.80

GV=Genotypic Variation; **PV**=Phenotypic Variation; **GCV**=Genotypic Co-efficient of Variation; **PCV**=Phenotypic Co-efficient of Variation; **h^2**=Heritability (Broad sense); **GAM**=Genetic Advance as % of Mean.

Table 3: Genotypic correlation coefficients for yield and its related traits.

Characters	Days to 50% blooming	Plant Height	Effective tillers per plant	Spikes per square metre	Panicle length	Straw yield	Harvest index	Grain yield
Days to 50% blooming	1.0000	0.4273*	-0.2570	-0.9917**	-0.1183	-0.0114	0.7478**	0.3782*
Plant Height		1.0000	-0.3050	-0.4531**	-0.0110	-0.0530	-0.2525	-0.1813
Effective tillers per plant			1.000	-0.3886**	-0.9327**	0.9689**	-0.9756**	-0.9312**
Spikes per square metre				1.000	0.2602	-0.5589**	0.6253**	0.0762
Panicle length					1.000	-0.7455**	0.5290**	-0.4652**
Straw yield						1.000	-0.9970**	0.3812*
Harvest index							1.000	0.2802
Grain yield								1.000

Note: * indicates significance at 5%, ** indicates significance at 1%

Table 4: Direct and indirect effects of yield related traits on grain yield.

Characters	Days to 50% blooming	Plant Height	Effective tillers per plant	Spikes per square metre	Panicle length	Straw yield	Harvest index	Grain yield	Residual effect
Days to 50% blooming	**-0.3193**	0.0271	0.0716	0.0676	0.0366	-0.0121	0.5067	0.3782*	
Plant Height	-0.1364	**0.0634**	0.0850	0.0309	0.0034	-0.0565	-0.1711	-0.1813	
Effective tillers per plant	0.0820	-0.0193	**-0.2786**	0.0265	0.2883	1.0316	-2.7617	-0.9312**	
Spikes per square metre	0.3166	-0.0287	0.1083	**-0.0682**	-0.0804	-0.5951	0.4237	0.0762	0.24
Panicle length	0.0378	-0.0007	0.2599	-0.0177	**-0.3091**	-0.7938	0.3585	-0.4652**	
Straw yield	0.0036	-0.0034	-0.2700	0.0381	0.2304	**1.0648**	-0.6823	0.3812*	
Harvest index	-0.2388	-0.0160	1.1356	-0.0426	-0.1635	-1.0722	**0.6776**	0.2802	

Note: * indicates significance at 5%, ** indicates significance at 1%

CONCLUSIONS

The variability investigations lead to the conclusion that days to 50% blooming is a variable that is mostly inherited by additive gene action and has a high heritability and genetic progress. In the rainfed rice habitat, this characteristic could therefore be used as useful selection factors throughout the breeding program. According to association studies, in order to increase grain yield under rainfed rice farming technique, greater weight should be placed on the characteristics of days to 50% blooming, straw yield and harvest index.

FUTURE SCOPE

In rice, grain yield is a quantitatively inherited feature that depends on the operation of multiple different components. Because of the integrated structure of the plant, whose component traits are interdependent and controlled by a large number of genes, selecting more effective genotypes on the basis of yield is challenging. Determining which qualities should be prioritized throughout the selection process will be made much easier with knowledge of the heritable variation and degree of connection between traits that confer better yield. Information on advanced rice genotypes identified here with higher yield and its associated traits namely days to 50% blooming, straw yield and harvest index will be very much useful in high yielding varietal developmental programme in rainfed ecosystem.

Acknowledgement. The authors are thankful to Tamil Nadu Agricultural University (TNAU) to conduct this experiment by providing technical and financial support.
Conflict of Interest. None.

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How to cite this article: Muthuramu S. and Thangaraj K. (2023). Genetic Variability, Heritability, Genetic Advance and Trait Association Studies in Rainfed Rice Genotypes. *Biological Forum – An International Journal, 15*(11): 108-112.