Original Research Article

Exploring the Relationship between Yield and Yield Attributing Traits in Advanced Breeding Lines of Rice (*Oryza sativa* L.)

ABSTRACT

Aim: Study endeavors to explore the genetic variability for various agro-morphological and quality traits.

Study design: Randomized Complete Block Design

Place and Duration of Study: Division of Plant Breeding and Genetics, She-e-Kashmir University of Agricultural Sciences and Technology of Jammu during *kharif* 2020.

Methodology: A experiment was carried out to determine the association between grain yield and yield attributing components among advanced breeding lines of rice to establish a well grounded selection criteria for developing rice varieties with improved grain yield. Phenotypic coefficient of variation (PCV) was found to be relatively greater than the genotypic coefficient of variation (GCV) for most of traits indicating role of environment in the phenotypic expression of traits. Characters viz., plant height, total number of tillers per plant, number of effective tillers per plant, panicle length and grain yield per plant exhibited high heritability coupled with high genetic advance indicating their efficient inheritance from preceding generations.

Results: Association studies indicated that characters viz., Plant height, total number of tillers per plant, number of effective tillers per plant, panicle length, 1000 grain weight and grain yield per plant had a significant positive relationship with grain yield per plot indicating their role in breeding rice varieties for higher grain yield.

Conclusion: Cause and effect relationship revealed that traits viz., days to 50 per cent flowering, total number of tillers per plant, days to maturity, panicle length and grain yield per plant can be exploited for indirect selection for improving grain yield.

Keywords: Rice, PCV, GCV, Heritability, Association, Cause and Effect

1. INTRODUCTION

Rice (*Oryza sativa* L.) belonging to the family Poaceae is one of the most essential and prominent cereal crops in India and also contributes significantly towards global food grain output. It is the source of carbohydrates, proteins, foodstuffs and is believed to feed far more people than any other crop. It is called the '**grain of life'** because it is a source of basic nourishment for more than 70 percent of the population. Grain yield being a polygenic trait is regulated by the interaction of numerous components, as a result identifying key components and concurrently associating them yield and its attributing characteristics is very beneficial in initiating an effective breeding strategy to develop high yielding cultivars. Correlation, a statistical indicator of an association between two variables helps plant breeders in indirect selection for complex polygenic traits, since direct selection for yield is unreliable due to environmental influences, path coefficient analysis helps in the formation of appropriate selection criteria for successful yield enhancement by identifying the component traits influencing yield. Heritability in broad sense shows the relative magnitude of genotypic and phenotypic variations for various characters and is important during selection, however heritability is not very useful on its own since it incorporates both additive and non-additive gene activity, as a result estimation of heritability combined with genetic advance are thought to be more accurate in estimating the genetic gain under selection. Studies have reported that selection would be more remunerative for a character with high genetic advance (GAM) and high correlation with grain yield. Simultaneously, inter-relationship between characters revealed by path coefficient analysis can be used in a breeding program to exploit the yield potential within the breeding population. Present study endeavors to explore the genetic variability for various agro-morphological and quality traits as well as to delineate the association between grain yield and its yield attributing components to establish well grounded selection criteria for developing rice varieties with improved grain yield.

2. MATERIAL AND METHODS

Experimental material for present study consisted of twenty seven advanced/stable breeding lines of rice viz., SJR-82-4-1, SJR-92-2-2, SJR-98-2-1, SJR-103-2-2, SJR-103-2-2, SJR-103-4-1, SJR-103-4-1, SJR-108-1-2, SJR-120-2-1, SJR-121-2-2, SJR-121-5-1, SJR-121-6-1, SJR-121-6-2, SJR-122-1-1, SJR-122-2-1, SJR-123-2-1, SJR-49-1-1-2, SJR-103-2-3, SJR-81-1-1, SJR-92-2-1, SJR-82-2-3, SJR-76-1-1, SJR-74-1-1, SJR-72-1-1, SJR-102-4-1, SJR-123-2-2 and SJR-49-1-1-2. About 25 days old seedlings of experimental material were transplanted in a Randomized Complete Block Design with three replications having a plot size of $5m^2$ (5 rows each of 5.0m length) with spacing of 20 x15 cm during *kharif* 2020. Single seedling per hill was transplanted and all the recommended practices were followed in order to produce a healthy crop. Observations were recorded on thirteen agro-morphological and quality traits viz., Days to 50 per cent flowering (no.), plant height (cm), total number of tillers per plant, number of effective tillers per plant, days to maturity (no.), panicle length (cm), 1000 grain weight (g), kernel length (mm), kernel breadth (mm), length-breadth ratio, amylose content (%), grain yield per plant (g) and grain yield per plot (kg). Amylose content was estimated using standard protocol as described by Hall and Johnson (1966), Components of variation (σ^2_g and σ^2_p) were estimated using the formula proposed by Syukur *et al*., (2012). Broad sense heritability and genetic advance of the all traits was calculated according to the formula described by Johnson *et al*. (1955) and Allard (1960). Pearson correlation coefficient was used to predict the association between yield and other yield attributing traits. Path coefficient analysis as described by Dewey and Lu (1959) was used to identify the direct and indirect effects of agro-morphological and quality traits on grain yield.

3. RESULT AND DISCUSSION

Genetic parameters for agro-morphological and quality traits (Table 1) depicted that PCV was relatively greater than the GCV, indicating the effect of environment on the expression of the traits. Phenotypic coefficient of variation varied from 28.56 per cent to 6.39 per cent, while as genotypic coefficient of variation ranged from 4.06 per cent to 23.31 per cent. Maximum genotypic and phenotypic coefficient of variation was observed for traits viz., total number of tillers per plant, amylose content, number of effective tillers per plant, grain yield per plant and grain yield per plot, indicating these traits may be relied upon for improvement of advanced breeding lines through phenotypic selection. The characters viz., days to 50 percent flowering, days to maturity, panicle length, 1000 grain weight, kernel length, kernel breadth and length-breadth ratio were reported to have moderately high value of PCV and GCV, indicating that there is scope for improvement of these traits through positive selection based on phenotypic variability. These results are in agreement with the findings of previous workers viz., Paikhomba *et.al*., 2014 and Kumar *et.al*., 2018 for traits such as total number of tillers per plant, grain yield per plant, grain yield per plot and 1000 grain weight respectively. Estimates of heritability in broad sense depict the proportion of total variation which can be inherited from generation to generation and guide plant breeders to develop efficient and goal oriented breeding programme. Heritability estimates for different traits ranged from 21 per cent to 84.2 per cent, while as genetic advance as per cent of mean ranged from 5.31 per cent to 39.52 per cent. Govintharaj *et al.,* (2018); Adhikhari *et al.,* (2018) and Dhavaleshvar *et.al.,*(2019) also found similar results in their research findings. Traits viz., total number of tillers per plant, number of effective (productive) tillers per plant, grain yield per plant and grain yield per plot were found to have high genetic advance (GAM) coupled with high heritability implying that these traits have been efficiently inherited from generation to generation. High heritability associated with low genetic advance was reported for traits viz., panicle length, days to 50% flowering and amylose content whereas, traits viz., days to maturity, kernel length, kernel breadth and length-breadth ratio were found to have low heritability coupled with low genetic advance suggesting that selection shall be ineffective for these traits. Similar trends in genetic advance were reported by earlier researchers viz., Abebe *et.al*., (2017) and Sandeep *et.al*., (2018).

Correlation coefficients (Table 2) revealed that genotypic correlation coefficient was greater than phenotypic correlation coefficient for most of the traits. Further, correlation results revealed that traits viz., plant height (0.327), total number of tillers per plant (0.360), number of effective (productive) tillers per plant (0.418), days to maturity (0.365), panicle length (0.531), 1000 grain weight (0.492) and kernel breadth (0.358) showed a significant positive association with the grain yield which is economically most important plant attribute, thereby suggesting that during selection these traits must be given top priority to maximize the yield potential. Sarawgi *et al*., (1996); Akinwale *et al*., (2011) and Li *et al*., (2019) reported similar results while investigating rice accessions for the presence of genetic variability. Results of path coefficient analysis (Table 3) revealed that direct and positive effect on grain yield per plot was demonstrated by days to 50 per cent flowering (0.409), panicle length (0.981), number of tillers per plant (0.458), 1000 grain weight (0.387) and grain yield per plant (0.090). Simultaneously direct but negative effects on grain yield per plot was shown by plant height (-0.925), effective tillers per plant (-0.464), days to maturity (-0.72), kernel length (-0.49), kernel breadth (-0.35) and length-Breadth ratio (-1.24). Panicle length was found to have maximum direct effect and significant positive association with grain yield per plot, because of positive indirect effects due to traits such as days to 50% flowering, total number of tillers per plant, number of effective tillers per plant, 1000 grain weight, kernel length, kernel breadth and grain yield per plant. These results are in agreement with the experimental findings of earlier workers viz., Ratna *et al*., (2015); Kalyan *et al*., (2017) and Saleh *et al.,* (2020).

4. CONCLUSION

Genetic parameters for agro-morphological and quality traits depicted that PCV was relatively greater than the GCV, indicating the effect of environment on the expression of the traits.Traits viz., total number of tillers per plant, number of effective (productive) tillers per plant, grain yield per plant and grain yield per plot were found to have high genetic advance (GAM) coupled with high heritability implying that these traits have been efficiently inherited from generation to generation. Correlation results revealed that traits viz., plant height (0.327), total number of tillers per plant, number of effective (productive) tillers per plant, days to maturity, panicle length, 1000 grain weight and kernel breadth showed a significant positive association with the grain yield which is economically most important plant attribute, thereby suggesting that during selection these traits must be given top priority to maximize the yield potential. Panicle length was found to have maximum direct effect and significant positive association with grain yield per plot, because of positive indirect effects due to traits such as days to 50% flowering, total number of tillers per plant, number of effective tillers per plant, 1000 grain weight, kernel length, kernel breadth and grain yield per plant.

Genetic parameters	Days to 50 % flowering (no)	Plant Height (cm)	Total Number of tillers per plant	Number of effective tillers per plant	Days to maturity (no)	Panicle length (cm)	1000 grain weight (g)	Kernel length (mm)	Kernel breadth (mm)	L/B ratio	Amylose content (%)	Grain yield per plant (g)	Grain yield per plot (kg)
GCV (%)	6.27	9.28	23.31	21.87	4.06	9.07	6.23	11.27	9.10	6.04	22.45	14.04	18.37
PCV (%)	9.05	10.11	28.31	28.56	6.39	11.65	9.65	18.34	16.74	12.98	23.46	19.0	24.72
Heritability h^2(bs)%	48	84.2	67	58	40	60	41	37	29	21	49	54	55
Genetic advance 5%	8.39	20.39	5.27	4.10	7.08	3.97	2.27	1.40	0.22	0.34	9.10	5.01	0.47
GAM (5%)	8.69	17.55	39.52	34.50	5.313	14.56	8.28	14.26	10.19	5.79	13.26	21.38	28.13

Table 1: Estimates of genetic parameters among agro-morphological and quality traits

Table 2: Genotypic and phenotypic correlation coefficients among agro-morphological and quality characters

Agro-morphological and quality traits	Days to 50% Flowering (no)	Plant Height (cm)	Total number of tillers per plant	Number of effective tillers per plant	Days to maturity (no)	Panicle length (cm)	1000 grain weight (g)	Kernel length (mm)	Kernel breadth (mm)	L/B ratio	Grain yield per plant (g)	Grain yield per plot (kg)
Days to 50%flowering (no)	1.000	0.017 **-0.039**	-0.076 **-0.102**	0.016 **-0.078**	0.462** **0.206**	0.211 **0.098**	-0.156 **-0.162**	-0.240* **-0.098**	0.361** **-0.043**	-0.333** **-0.220**	0.094 **-0.038**	0.643** **0.292****
Plant height (cm)		1.000	0.396** **0.308****	0.252 **0.202**	0.157 **0.126**	0.651** **0.539****	0.469** **0.328****	0.130 **0.119**	0.023 **0.092**	0.197 **0.157**	0.327** **0.268***	-0.182 **-0.063**
Total number of tillers per plant			1.000	0.994** **0.898****	0.220* **0.188**	0.150 **0.030**	0.171 **-0.058**	-0 299** **-0.214**	0.385** **0.237***	-0.352** **-0.129**	0.360** **0.272***	0.242* **-0.065**
Number of effective tillers per plant				1.000	0.176 **0.079**	-0.260* **0.021**	-0.081 **-0.006**	-0.303** **-0.168**	0.399** **0.268***	-0.312** **-0.102**	0.418** **0.256***	0.199 **-0.053**
Days to maturity (no)					1.000	0.302** **0.139**	-0.018 **0.079**	-0.199 **-0.100**	0.270* **0.127**	-0.457** **-0.078**	0.365** **0.116**	0.326** **0.102**
Panicle length (cm)						1.000	0.590** **0.446***	0.669** **0.280***	-0.225* **-0.122**	0.613** **0.181**	0.531** **0.277***	-0.140 **0.049**
1000 grain weight (g)							1.000	0.470** **0.282***	0.043 **0.029**	0.308** **0.305****	0.492** **0.113**	0.031 **-0.093**
Kernel length (mm)								1.000	- 0.754** **-0.122**	0.973** **0.795****	-0.069 **0.029**	-0.472** **-0.291****
Kernel breadth (mm)									1.000	-0.945** **0.085**	0.358** **0.182**	0.881** **0.287****

L/B ratio	1.000	-0.061 **0.011**	-0.460** **0.296****
Grain yield per plant (g)		1.000	0.388** **0.347****

Bold numbers indicate phenotypic correlation coefficient values

Normal numbers indicate genotypic correlation coefficient values

* ' ** Significant at 5 percent and 1 percent level of significance

Table 3: Direct (diagonal) and indirect (off-diagonal) effects of agro-morphological and quality traits

Agro-morphological and quality traits	Days to 50% flowering (no)	Plant height (cm)	Total no.of tillers per plant	No.of effective tillers per plant	Days to maturity (no)	Panicle length (cm)	1000 grain weight (g)	Kernel length (mm)	Kernel breadth (mm)	L/B ratio	Grain yield per plant (g)	Grain yield per plot (kg)
Days to 50% flowering (no)	**0.409** **(0.229)**	-0.015 (0.005)	-0.035 (0.016)	-0.008 (0.008)	-0.333 (-0.005)	0.271 (0.012)	-0.061 (0.006)	0.119 (0.019)	-0.128 (-0.013)	0.416 (0.056)	0.009 (-0.016)	0.643** (0.292**)
Plant height(cm)	0.007 (-0.009)	**-0.925** **(-0.120)**	0.135 (-0.047)	-0.071 (-0.022)	-0.114 (-0.003)	0.834 (0.066)	0.181 (-0.012)	-0.059 (-0.027)	-0.008 (0.029)	-0.192 (-0.028)	0.030 (0.110)	-0.182 (-0.063)
No.of tillers per plant	0.031 (-0.023)	-0.274 (-0.037)	**0.458** **(-0.153)**	-0.461 (-0.097)	-0.159 (-0.005)	0.192 (0.004)	-0.066 (0.002)	0.148 (0.041)	-0.137 (0.073)	0.439 (0.018)	0.033 (0.111)	0.242* (-0.065)
Effective tillers per plant	0.007 (-0.018)	-0.141 (-0.024)	0.455 (-0.138)	**-0.464** **(-0.108)**	-0.127 (-0.002)	-0.333 (0.003)	-0.032 (0.000)	0.150 (0.033)	-0.142 (0.083)	0.390 (0.015)	0.038 (0.105)	-0.199 (-0.053)
Days to maturity (no)	0.189 (0.047)	-0.146 (-0.015)	0.101 (-0.029)	-0.082 (-0.009)	**-0.721** **(-0.024)**	0.386 (0.017)	-0.007 (-0.003)	0.098 (0.019)	-0.096 (0.039)	0.571 (0.011)	0.033 (0.048)	0.326** (0.102)
Panicle length (cm)	0.086 (0.022)	-0.602 (-0.065)	0.069 (-0.005)	0.120 (-0.002)	-0.218 (-0.003)	**0.981** **(0.122)**	0.228 (-0.016)	0.331 (-0.054)	0.080 (-0.038)	-0.766 (-0.026)	0.048 (0.113)	0.140* (0.049)
1000 grain weight (g)	-0.064 (-0.037)	-0.434 (-0.039)	-0.079 (0.009)	0.038 (0.001)	0.013 (-0.002)	0.757 (0.055)	**0.387** **(-0.037)**	-0.232 (-0.055)	-0.015 (0.009)	-0.384 (-0.044)	0.045 (0.046)	0.031 (-0.093)
Kernel length (mm)	-0.098 (-0.022)	-0.111 (-0.017)	-0.137 (0.033)	0.140 (0.018)	0.143 (0.002)	0.857 (0.034)	0.182 (-0.010)	**-0.495** **(-0.193)**	0.268 (-0.035)	-1.215 (-0.113)	-0.006 (0.012)	-0.472** (-0.291**)
Kernel breadth (mm)	0.147 (-0.010)	-0.022 (-0.011)	0.176 (-0.036)	-0.185 (-0.029)	-0.195 (-0.003)	-0.288 (-0.015)	0.017 (-0.001)	0.373 (0.022)	**-0.356** **(0.309)**	1.181 (-0.012)	0.032 (0.074)	0.881** (0.287**)
L/B ratio	-0.136 (-0.050)	-0.142 (-0.024)	-0.161 (0.020)	0.145 (0.011)	0.329 (0.002)	0.786 (0.022)	0.119 (-0.011)	-0.481 (-0.154)	0.336 (0.026)	**-1.249** **(-0.143)**	-0.006 (0.004)	-0.460** (-0.296**)

Grain yield /plant (g)	0.039 (-0.009)	-0.303 (-0.032)	0.165 (-0.042)	-0.194 (-0.028)	-0.263 (-0.003)	0.680 (0.034)	0.191 (-0.004)	0.034 (-0.006)	-0.127 (0.056)	0.077 (-0.002)	**0.090** **(0.409)**	0.388** (0.374**)

Bold numbers with out parentheses indicate direct effect based on genotypic correlations
Bold numbers with parentheses indicate direct effect based on phenotypic correlations
Normal numbers with out parentheses indicate indirect effects based on genotypic correlations
Normal numbers with in parentheses indicate indirect effects based on phenotypic correlations
* , ** Significant at 5 percent and 1 percent level of significance

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