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Association studies for yield components and quality Traits in Basmati Rice (*Oryza sativa* L.)

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Abstract
The present study was conducted to elucidate character association among yield components and quality parameters utilizing the data recorded on thirty rice genotypes for twenty-two characters. Correlation analysis revealed that grain yield showed significant and positive correlation with tiller per meter, water absorb by 10g kernel, kernel breadth after cooking and breadth increase ratio after cooking. It showed significant and negative correlation with 100 grain weight, 100 kernel weight and plant height. Grain weight per panicle showed significant positive correlation with, 100 grain weight and 100 kernel weight. 100 grain weight showed highly significant and positive correlation with 100 kernel weight, kernel length before cooking and kernel breadth before cooking. kernel length after cooking, L:B. ratio and 100 kernel weight after cooking, while it showed highly significant and negative correlation with kernel elongation ratio and water absorb by 10g kernel. Therefore, we observed that morphological traits reflected positive as well as negative association with quality parameters, hence, careful selection required in enhancing characters that are negatively associated.

Keywords: Paddy, *Oryza sativa* L., correlation, yield, quality

Introduction

Rice, the most important cereal of India, occupies the largest area and ranks second in production next to China.During 2016-17, India produced 165 million tons of rice from 45 million hectares of land. Direct selection based on crop yield is often a paradox in breeding programmes because yield is a complex polygenically inherited character, influenced by its component traits. Analysis of variability among the traits and the association of a particular character in relation to other traits contributing to yield of a crop would be of great importance in planning a successful breeding program. Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement yield. While selecting the suitable plant type, correlation studies would provide reliable information in natural extent and the direction of the selection, especially when the breeder needs to combine high yield potentials with desirable agronomic traits and grain quality characters. Yield is quantitative character and is governed by many genes having smaller effects *i.e.*, polygenes. Thus, we can say that the yield is the final product of yield components. These components may affect the yield directly or indirectly. Therefore, yield can be maximized by improving the yield components provided there is no unfavourable association. The correlation study can show the magnitude of association between any two characters. Thus, the knowledge of character association is essential for simultaneous improvement of yield and yield components. Therefore, the present investigation had been conducted to estimate the extent of variability, heritability and genetic advance for yield and its components in rice and to assess the nature and magnitude of inter-character correlation for different characters among basmati rice genotypes.

Materials and Methods

The present study was conducted at Research farm of R.M.P. P.G. College, Gurukul Narsan, Haridwar (Uttarakhand) with 30 improved genotype of basmati rice. The Gurukul Narsan is situated in the foothills of Shivalik range of Himalaya and falls in the humid sub-tropical climate Zone.

The Material was planted in a randomized complete block design with three replications in the plot size of 2 m^2 keeping 20x15 cm spacing. The observations were recorded on a random sample of 10 plants from each plot for 22 quantitative characters *viz*., Days to 50% flowering, days to maturity, plant height (cm), number of tillers per plant, panicle length (cm), flag leaf length (cm), flag leaf with (cm), number of grains per panicle, grain weight per panicle (g), 100 grain weight (g), 100 kernel weight (g), hulling (%), kernel length before cooking (mm), kernel breadth before cooking (mm), kernel length after cooking (mm), kernel breadth after cooking (mm), L:B ratio, kernel elongation ratio, breath increase ratio after cooking, 100 kernel weight after cooking (g), water absorb by 10 gm kernel (ml), grain weight per plant (g). Analysis of variance was carried out following Panse and Sukhatme, (1967) [8] and correlation coefficients between all possible pairs of characters were estimated at genotypic and phenotypic level. The analysis of variance and covariance was used for the estimation of correlation coefficient as suggested by Searle, 1961. The estimated values were compared with table values of correlation coefficient to test the significance of correlation coefficient prescribed by Fisher and Yates, (1967) [4].

Results and Discussion

The estimates of correlation coefficients (Table 1) revealed that the genotypic and the phenotypic correlation coefficient generally showed similar trend but genotypic correlation coefficients were higher in magnitude than the corresponding phenotypic correlation, which might be due to masking or modifying effect of environment. Genotypic correlation coefficients between grain yield per plant and other quantitative attributing to yield showed that seed yield was significantly and positively associated with Number of tillers per plant and water absorb by kernel and significantly correlated with kernel breadth after cooking and breadth increase ratio after cooking. It showed significant and negative correlation with 100 grain weight, 100 kernel weight and plant height. Days to 50% flowering exhibited highly significant and positive correlation with plant height, water absorb by kernel and significantly correlated with number of tillers per plant. Whereas days to 50% flowering showed highly significant and negative correlation with flag leaf width, 100 kernel weight, hulling% and kernel width before cooking. The days to maturity exhibited highly significant and positive correlation with flag leaf width, kernel width before cooking. However, it showed significant and negative correlation with number of tillers per plant, kernel elongation ratio and flag leaf length. Plant height showed highly significant and positive correlation with panicle length and significant positive correlation with grain per panicle, kernel width after cooking and water absorb by kernel, while it showed highly significant negative correlation with flag leaf width, 100 kernel weight, hulling %, kernel width after cooking and width increase ratio after cooking and significant negative correlation with 100 grain weight and kernel breadth before cooking. Tiller per plant showed highly significant positive correlation with grain weight per plant, kernel elongation ratio, water absorb by kernel and significant positive correlation with kernel breadth before cooking kernel weight after cooking. Whereas it showed significantly negative correlation with L:B ratio, grain weight per panicle, 100 grain weight, 100 kernel weight and kernel length before cooking. Panicle length exhibited highly significant and positive correlation with flag leaf length. While it showed highly significant and negative correlation with grain per panicle and grain weight per panicle. Flag leaf length showed significant and positive correlation with flag leaf breadth and breadth increase ratio after cooking. Flag leaf width showed highly significant positive correlation with kernel breadth after cooking, kernel elongation ratio, breadth increase ratio after cooking, kernel weight after cooking and water absorb by kernel and signification positive correlation with hulling%.

Grains per panicle showed highly significant and positive correlation with grain weight per panicle, while it showed highly significant and negative correlation with kernel length after cooking, breath increase ratio after cooking and kernel breadth after cooking and kernel elongation ratio. Grain weight per panicle showed significant positive correlation with, 100 grain weight and 100 kernel weight and significant positive correlation with L:B ratio while it showed significant and negative correlation with hulling %, kernel elongation ratio, breadth increase ratio after cooking.100 grain weight showed highly significant and positive correlation with 100 kernel weight, kernel length before cooking and kernel breadth before cooking, kernel length after cooking, L:B. ratio and 100 kernel weight after cooking while it showed highly significant and negative correlation with kernel elongation ratio and water absorb by 10g kernel.100 kernel weight showed highly significant and positive correlation with kernel length before cooking, kernel breadth before cooking, kernel length after cooking, L:B ration and 100 kernel weight after cooking. However, it showed highly significant and negative correlation with water absorb by 10g kernel and kernel elongation ratio. Hulling percent exhibited significant and positive correlation with kernel breadth after cooking and breadth increase ratio after cooking however, it showed significant and negative correlation with kernel length before cooking.

Kernel length before cooking exhibited highly significant and positive correlation with kernel length after cooking, L:B ratio, kernel weight after cooking, kernel elongation ratio and water absorb by 10g kernel. Kernel breadth before cooking showed highly significant and positive correlation with kernel breadth after cooking. However, it showed highly signification and negative correlation with L:B ratio and water absorb by 10g kernel. Kernel length after cooking showed highly significant and positive correlation with L:B ratio, kernel elongation ratio, breadth increase ratio after cooking and kernel weight after cooking, however it showed negative correlation with water absorb by kernel. Kernel breadth after cooking showed highly significant and positive correlation with breath increase ratio after cooking and kernel weight after cooking. L:B ratio exhibited significant and positive correlation with breath increase ratio after cooking, however, it showed highly significant and negative correlation with water absorb by 10g kernel and kernel elongation ratio.Kernel elongation ratio exhibited significant and positive correlation with water absorb by 10g kernel, breadth increase ratio after cooking and kernel weight after cooking. Breadth increase ratio after cooking exhibited significant and positive correlation with kernel weight after cooking. Kernel weight after cooking showed highly significant positive association with water absorb by 10g kernel.

Genotypic correlation coefficients were of higher in magnitude than the corresponding phenotypic correlation coefficients which might be due to masking or modifying effect of environment. Very close values of genotypic and phenotypic correlations were also observed which might be due to reduction in error (environmental) variance to minor proportions as reported by Dewey and Lu, (1959) [3]. Thus, selection for higher yield on the basis of above characters would be reliable. Similar findings were also reported by Akinwale, *et al.* (2011) [1], Kumar, *et al.* (2011) [7], Krishnamurthy and Kumar, (2012) [5], Kumar and Verma, (2015) [6], Sravan *et al.* (2016) [10], Devi *et al.* (2017) [2] and Tripathi *et al.* (2018) [11].

Table 1: Phenotypic (Upper diagonal) and Genotypic (Lower diagonal) Correlation coefficients among yield components and quality parameters in basmati rice.

Character	DF	DM	PLH	TM	PL	FLL	FLW	G/PE	GW/PE	GW/P	100GW	100KW	H%	KLBC	KBBC	KLAC	KBAC	LBR	KER	BIRAC	KWAC	WA
DF	1.000	-0.105 NS	0.264*	0.185 NS	-0.069 NS	-0.025 NS	-0.194 NS	-0.083 NS	-0.040 NS	-0.063 NS	-0.169 NS	-0.241*	-0.265*	0.012 NS	-0.194 NS	0.110 NS	-0.141 NS	0.102 NS	0.135 NS	-0.020 NS	0.108 NS	0.316**
DM	-0.058 NS	1.000	-0.074 NS	-0.383**	-0.015 NS	-0.200 NS	0.139 NS	-0.103 NS	-0.072 NS	-0.049 NS	0.008 NS	0.021 NS	0.025 NS	0.093 NS	0.297**	-0.080 NS	0.164 NS	-0.075 NS	-0.281**	0.129 NS	-0.084 NS	-0.088 NS
PLH	0.365**	-0.103 NS	1.000	0.115 NS	0.358**	0.160 NS	-0.288**	0.223*	0.139 NS	-0.207 NS	-0.195 NS	-0.275**	-0.351**	-0.135 NS	-0.115 NS	-0.159 NS	-0.589**	-0.038 NS	-0.068 NS	-0.479**	-0.145 NS	0.191 NS
TM	0.228*	-0.408**	0.139 NS	1.000	0.051 NS	0.175 NS	-0.081 NS	-0.079 NS	-0.206 NS	0.275**	-0.217*	-0.253*	-0.126 NS	-0.251*	0.211*	0.048 NS	0.082 NS	-0.311**	0.423**	-0.090 NS	0.263*	0.401**
PL	-0.087 NS	-0.016 NS	0.413**	0.053 NS	1.000	0.198 NS	-0.094 NS	-0.236*	-0.215*	-0.116 NS	0.036 NS	0.037 NS	0.016 NS	-0.058 NS	0.140 NS	-0.069 NS	-0.094 NS	-0.054 NS	-0.027 NS	-0.097 NS	0.105 NS	-0.038 NS
FLL	-0.006 NS	-0.218*	0.203 NS	0.186 NS	0.209*	1.000	-0.290**	-0.077 NS	0.001 NS	0.051 NS	0.062 NS	0.028 NS	-0.133 NS	0.169 NS	-0.025 NS	0.054 NS	-0.205 NS	0.136 NS	-0.148 NS	-0.232*	-0.017 NS	-0.057 NS
FLW	-0.377**	0.290**	-0.613**	-0.135 NS	-0.192 NS	-0.564**	1.000	-0.076 NS	-0.116 NS	-0.022 NS	-0.062 NS	0.008 NS	0.231*	-0.024 NS	0.040 NS	0.076 NS	0.423**	-0.051 NS	0.149 NS	0.395**	0.192 NS	0.133 NS
G/PE	-0.092 NS	-0.118 NS	0.266*	-0.080 NS	-0.240*	-0.074 NS	-0.140 NS	1.000	0.807**	0.158 NS	-0.101 NS	-0.129 NS	-0.156 NS	-0.186 NS	-0.071 NS	-0.355**	-0.291**	-0.149 NS	-0.246*	-0.291**	-0.077 NS	0.131 NS
GW/PE	-0.050 NS	-0.071 NS	0.149 NS	-0.208*	-0.217*	-0.001 NS	-0.205 NS	0.817**	1.000	-0.026 NS	0.345**	0.308**	-0.220*	0.264*	-0.043 NS	0.002 NS	-0.257*	0.209*	-0.382**	-0.276**	0.143 NS	-0.206 NS
GW/P	-0.069 NS	-0.054 NS	-0.248*	0.276**	-0.116 NS	0.053 NS	-0.030 NS	0.157 NS	-0.026 NS	1.000	-0.389**	-0.376**	0.034 NS	-0.105 NS	-0.146 NS	-0.020 NS	0.265*	-0.037 NS	0.168 NS	0.222*	0.148 NS	0.450**
100GW	-0.161 NS	0.002 NS	-0.236*	-0.226*	0.038 NS	0.074 NS	-0.109 NS	-0.107 NS	0.349**	-0.397**	1.000	0.969**	-0.133 NS	0.679**	0.361**	0.494**	0.080 NS	0.376**	-0.278**	-0.087 NS	0.378**	-0.801**
100KW	-0.272**	0.025 NS	-0.360**	-0.265*	0.037 NS	0.043 NS	-0.056 NS	-0.134 NS	0.312**	-0.385**	0.980**	1.000	0.111 NS	0.650**	0.359**	0.472**	0.183 NS	0.354**	-0.261*	-0.006 NS	0.371**	-0.842**
H%	-0.508**	0.072 NS	-0.611**	-0.167 NS	0.010 NS	-0.142 NS	0.233*	-0.187 NS	-0.279**	0.056 NS	-0.146 NS	0.052 NS	1.000	-0.182 NS	0.023 NS	-0.144 NS	0.409**	-0.165 NS	0.076 NS	0.299**	-0.073 NS	-0.175 NS
KLBC	-0.000 NS	0.097 NS	-0.171 NS	-0.253*	-0.060 NS	0.178 NS	-0.062 NS	-0.188 NS	0.267*	-0.105 NS	0.695**	0.664**	-0.248*	1.000	-0.025 NS	0.758**	0.139 NS	0.839**	-0.337**	0.138 NS	0.364**	-0.522**
KBBC	-0.315**	0.341**	-0.231*	0.225*	0.153 NS	-0.009 NS	0.147 NS	-0.078 NS	-0.044 NS	-0.156 NS	0.395**	0.385**	-0.026 NS	-0.037 NS	1.000	-0.050 NS	0.175 NS	-0.513**	-0.054 NS	-0.251*	0.280**	-0.230*
KLAC	0.129 NS	-0.083 NS	-0.192 NS	0.049 NS	-0.070 NS	0.056 NS	0.150 NS	-0.357**	0.000 NS	-0.020 NS	0.501**	0.483**	-0.178 NS	0.761**	-0.055 NS	1.000	0.266*	0.660**	0.352**	0.268*	0.521**	-0.239*
KBAC	-0.163 NS	0.174 NS	-0.711**	0.082 NS	-0.097 NS	-0.206 NS	0.786**	-0.292**	-0.261*	0.268*	0.080 NS	0.181 NS	0.481**	0.136 NS	0.182 NS	0.267*	1.000	0.020 NS	0.181 NS	0.812**	0.460**	0.045 NS
LBR	0.150 NS	-0.090 NS	-0.021 NS	-0.324**	-0.059 NS	0.154 NS	-0.127 NS	-0.151 NS	0.219*	-0.037 NS	0.395**	0.377**	-0.185 NS	0.866**	-0.522**	0.679**	0.013 NS	1.000	-0.236*	0.237*	0.166 NS	-0.313**
KER	0.177 NS	-0.296**	-0.088 NS	0.430**	-0.027 NS	-0.157 NS	0.299**	-0.248*	-0.386**	0.168 NS	-0.287**	-0.266*	0.124 NS	-0.334**	-0.051 NS	0.352**	0.186 NS	-0.246*	1.000	0.194 NS	0.210*	0.406**
BIRAC	0.006 NS	0.128 NS	-0.569**	-0.086 NS	-0.109 NS	-0.309**	0.731**	-0.330**	-0.295**	0.254*	-0.083 NS	0.014 NS	0.453**	0.152 NS	-0.215*	0.303**	0.914**	0.264*	0.216*	1.000	0.269*	0.135 NS
KWAC	0.116 NS	-0.099 NS	-0.197 NS	0.265*	0.103 NS	-0.015 NS	0.342**	-0.082 NS	0.143 NS	0.149 NS	0.383**	0.371**	-0.128 NS	0.369**	0.290**	0.528**	0.462**	0.177 NS	0.213*	0.314**	1.000	0.153 NS
WA	0.361**	-0.099 NS	0.244*	0.417**	-0.042 NS	-0.075 NS	0.288**	0.139 NS	-0.211*	0.465**	-0.808**	-0.846**	-0.170 NS	-0.539**	-0.250*	-0.247*	0.049 NS	-0.341**	0.419**	0.145 NS	0.160 NS	1.000

* Significant at 5% level ** Significant at 1% level

DF: Days to 50% flowering, DM: Days to Maturity, PLH: Plant Height (cm.), TM: Number of Tillers per Plant, PL: Panicle Length (cm.), FLL: Flag Leaf Length (cm.), FLW: Flag Leaf With (cm.), G/PE: Number of Grains per Panicle, GW/PE: Grain Weight Per Panicle (g), GW/P: Grain Weight Per Plant (g), 100GW: 100 Grain Weight (gm), 100 KW: 100 Kernel Weight (gm), H%: Hulling (%), KLBC: Kernel Breadth Before

Cooking (mm), KBBC: Kernel Breadth Before Cooking (mm), KLAC: Kernel Length After Cooking (mm), KBAC: Kernel Breadth After Cooking (mm),LBR: L:BRatio, KER: Kernel Elongation Rations, BIRAC: Breath Increase Ratio After Cooking, KWAC: 100 Kernel Weight After Cooking (g), WA: Water Absorb by 10 gm kernel (ml).

Conclusion

In the present study the correlation analysis revealed that grain yield showed significant and positive correlation with tiller per meter, water absorb by 10g kernel, kernel breadth after cooking and breadth increase ratio after cooking while, significant and negative correlation with 100 grain weight, 100 kernel weight and plant height., Yield components such as grain weight per panicle and 100 grain weight were positively correlated themselves and also exhibited significant positive association with quality traits such as 100 kernel weight, L:B ratio, kernel length before cooking, kernel breadth before cooking, kernel length after cooking andkernel weight after cooking. These characters will be helpful in crop improvement, if selection favors high grain yield then the remaining characters which are positively associated will be automatically improved.

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