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Estimation of Genetic Variability and Correlation for Grain Yield Components in Rice (*Oryza sativa* L.)

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Abstract: Analysis of variance indicated highly significant differences among 25 genotypes for all the morphological traits and the six genotypes used for the grain quality studies also showed significant differences among grain quality traits except volume expansion ratio and grain elongation ratio. Broad sense heritability estimates were higher for morphological traits ranging from 67.37 to 98.24. Correlation analysis indicated that plant height had positive and significant association with all the morphological traits at genotypic level. Grain yield per plant was correlated positively and significantly with plant height, panicle length, flag leaf area and number of grains per panicle at genotypic level. Genotypic correlation of plant height with number of tillers per plant was positive. Number of grains per panicle had positive correlation with grain yield per plant. Path coefficient analysis indicated highest direct effect of number of grains per panicle on grain yield per plant. The grain quality studies revealed better performance of Basamti-385 with higher values for volume expansion, water absorption, elongation ratio and score for aroma.

Key words: Grain elongation ratio · Volume expansion ratio · Broad sense heritability · Genotypic correlation · Path coefficient analysis

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the important cereal crops and is central to the lives of billions of people around the world. Possibly the oldest domesticated grain (~10,000 years), rice is the staple food for 2.5 billion people and growing rice is the largest single use of land for producing food, covering 9% of the earth's arable land. Rice is the predominant staple food for 17 countries in Asia and the Pacific, nine countries in North and South America and eight countries in Africa. Rice provides 20 percent of the world's dietary energy supply, while wheat supplies 19 percent and maize 5 percent [1].

Pakistan is the biggest producer of fine Basmati rice, recognized world over for its aroma and cooking quality, produced mainly in 'Kallar Tract'of Punjab which is considered to be the best region in the world for the production of Basmati Rice, the most demanding commodity in the international market and plays an important role in the economy of Pakistan and accounts for 5.7 percent value added in agriculture and 1.2 percent to GDP. During the year 2006-07 the area sown was at 2581 thousand hectares and production was 5438 thousand tons [2].

Yield of paddy is a complex quantitative character controlled by many genes interacting with the environment and is the product of many factors called yield components. Selection of parents based on yield alone often misleading. Hence, the knowledge about relationship between yield and its contributing characters is needed for an efficient selection strategy for the plant breeders to evolve an economic variety. The information about phenotypic and genotypic interactions of various economic traits is the immense importance to a plant breeder for the selection and breeding of different genotypes with increasing yield potential [3]. Path coefficient analysis furnishes information of influence of each contributing trait to yield directly as well as indirectly and also enables breeders to rank the genetic attributes according to their contribution [4].

Rice is one of the cereal crop that is consumed as whole milled and broken grain. The desired properties may vary from one ethnic group or geographical region to another and may vary from country to country. The quality in rice therefore, may be considered from viewpoint of milling quality, grain size, shape and appearance and cooking characteristics. As countries reach self-sufficiency in rice production, the demand by

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the consumer for better quality rice has increased. Traditionally, plant breeders concentrated on breeding for high yields and pest resistance. Recently the trend has changed to incorporate preferred quality characteristics that increase the total economic value of rice. Grain quality is not just dependent on the variety of rice, but quality also depends on the crop production environment, harvesting, processing and milling systems. The grain quality can be improved genetically through the improvement of grain quality components.

MATERIALS AND METHODS

The study comprising of an experiment related to genetic correlations, path coefficient analysis and grain quality characters in rice (*Oryza sativa* L.) was conducted in the department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan during 2007. The experimental material was composed of 25 genotypes collected from various national and international institutes. The nursery was sown on 29-5-2007 and transplanted to the field on 27-7-2007 by dry method. The seed rate was 10-12 kg/ha. Sixty days old nursery was transplanted. The experiment was laid out in a randomized complete block design with three replications. The row to row and plant to plant distance was 22.5×22.5 cm. The NPK fertilizer was applied @ 54-27-25 kg/acre respectively with full doses of P and K and 1/3rd of N at the time of last ploughing, 1/3rd of N at 30 DAT and remaining 1/3rd of N at 45 DAT.

At the time of maturity the data on five competitive plants from each genotype in each replication were recorded for plant height (cm), days to heading, days to maturity, panicle length (cm), flag leaf area, number of tillers per plant, number of grains per panicle and grain yield per plant. The methodology given by Steel *et al.*, [5] was used for statistical analysis to compute variance and covariance from the data collected for the traits to ascertain the differences among various genotypes for variability and co-variability. The genotypic and phenotypic correlation coefficient values were calculated as suggested by Kwon and Torrie [6]. The individual genotypic means were compared by Duncan's New Multiple Range (DMR) test and the total variance was partitioned into genotypic and phenotypic components.

A comparative laboratory analysis on quality characteristics comprising six genotypes viz, Liangyoupeijiu, Super Basmati, Hua You Guan Kang Zhan, Basmati-2000, Basmati-385 and KSK-133 was completed at Rice Research Institute Kala Shah Kaku Lahore, Pakistan. Six samples were milled at 10% moisture contents, after milling, the obtained brown rice was polished. Head and broken rice were separated through a rice grader. The Graded samples comprising of full shape grains were used to proceed for the study. The length, width and thickness of milled rice (50 grains per sample) were taken with the help of micrometer. The elongation ratio test comprised of measuring 10 whole kernels by using a scale before and after cooking and then taking the ratio. Size and shape was determined according to scale of FAO standards given below. Elongation of single grain was determined and the proportionate elongation ratio was computed by the average length of cooked rice grains to the average length of raw rice grains [7].

Size category	Length in mm
Extra long	Over 7.5
Long	6.61-7.5
Medium	5.51-6.60
Short	5.50 or less

Shape category	Length/Breadth ratio
Slender	Over 3.0
Medium	2.1-3.0
Bold	1.1-2.0
Round	1.0 or less

Milled rice of known volume (in xylene) was placed in a wire basket with 1mm perforations and introduced into a container with 750 ml of boiling water. The container was covered with watch glass and the boiling was allowed to continue for 20 min. The pan was lifted out and rice drained for five minutes and weighed for water absorption. The water absorption ratio was determined as weight of cooked rice per weight of raw rice and the volume expansion (in xylene, cooked rice in graduated cylinder) ratio was calculated as volume of cooked rice to volume of raw rice. The same procedure was repeated for each sample.

A simple Laboratory technique developed at IRRI was used to evaluate the fine Basmati group and coarse varieties for presence of aroma. One gram of freshly harvested milled rice was placed into a centrifuge tube (50 ml round bottom). 20 ml of distilled water was added. The tubes were then covered with aluminum foil. The samples were place in boiling water bath for 10 minutes. The cooked samples were allowed to cool and sensory evaluation of aroma was carried out by the scoring method Singh *et al.*, [8] and Larmond, [9]. Sensory evaluation of Aroma was carried out by scoring method. Various categories of score are given below.

Category	Score given
Non aromatic	1
Slightly aromatic	2
Moderately aromatic	3
Strongly aromatic	4

RESULTS AND DISCUSSION

Analysis of variance indicated that the differences among genotypes for all the characters under study were highly significant ($\alpha = 0.01$), indicating that the genotypes were highly diversified. Genotypic and phenotypic variances, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, grand means and standard errors of eight economic traits of twenty five genotypes were calculated (Table 1). GCV ranged from 0.198822 to 8.328441, number of grains per plant had the highest GCV followed by plant height, number of tillers per plant and grain yield per plant. PCV ranged from 0.295118 to 8.596419. Phenotypic coefficients of variability were higher than genotypic coefficients of variability for all the traits Zahid *et al.*, [10] and Buu and Tuan [11]. High heritability estimates were observed for all the traits, heritability was over 50% in all the characters. So these estimates are helpful in making selection on the basis of phenotypic performance.

Correlations: The association of grain yield with other characters was estimated by genotypic and phenotypic coefficients (Table 2). Plant height was correlated positively and significantly with all the characters at genotypic level. Grain yield per plant was correlated positively and significantly with plant height at genotypic level and positively and non significantly at phenotypic level. Rasheed *et al.*, [12] and Girish *et al.*, [13] also reported the positive association of plant height with grain yield per plant at genotypic level. Genotypic correlation of plant height with number of tillers per plant was positive Rasheed *et al.,* [12]. A positive and significant correlation was present between plant height and number of grains per panicle at genotypic level and non significant at phenotypic level. Zahid *et al.*, [10]. Also reported positive correlation between plant height and number of grains per panicle both at genotypic and phenotypic level.

Panicle length and flag leaf area were correlated positively and significantly at genotypic and phenotypic levels, these results are in agreement with the findings of Ramakrishnan *et al.*, [14]. A non significant and negative association was observed between number of tillers per plant and grain yield per plant both at genotypic and phenotypic levels. These findings are in agreement with the work done by Zahid *et al.*, [10]. The negative correlation between the two characters might be due to increased frequency of barren tillers. Number of tillers per plant also correlated negatively and significantly with number of grains per panicle at the genotypic level. This again implies that tillers had not produced the grains in proportionate ratio due to higher frequency of barren tillers. Grain yield per plant was associated positively and non significantly with days to maturity both at genotypic and phenotypic levels Habib *et al.*, [15], also reported the positive association between grain yield per plant and days to maturity.

Path Coefficient Analysis: Table 3 revealed the results of direct and indirect effects of various grain yield components on grain yield per plant. The highest positive direct effect of number of grains per panicle on grain yield was observed (5.017) followed by plant height (4.97) days to maturity (4.306). The direct positive effect of days to heading on grain yield per plant and positive genotypic correlation between these two traits indicates that a direct selection through this trait would be much effective for the improvement of grain yield per plant. The research work of Mahto *et al.,* [16] also confirmed the findings of present study.

The direct effect of days to maturity on grain yield (4.306) was positive, the genotypic correlation coefficient between the two traits was also positive. The direct effect of plant height (4.97) on grain yield per plant was observed the genotypic correlation coefficient between these two traits was also positive indirect effects through number of grains per panicle was positive Iftikharuddaula *et al.*, [17].

Negative direct effect (-2.919) of tillers per plant on grain yield was observed. Zahid *et al.*, [10] also found the negative direct effect of number of tillers per/ plant on grain yield. Although, tillers per plant had the negative direct effect on grain yield but its indirect effect through plant height was positive (0.363) which consequently increased the correlation coefficient of tillers per plant with grain yield. Positive direct effect (5.017) of number of grains per panicle on grain yield per plant was observed Surek and Beser Baser [18].

Grain Quality Traits: "Duncan' s multiple range test" was utilized for the pair wise comparison of significantly different genotypic means. (Table 2.1-3.1). Grain size and shape are among the first criteria of rice quality that breeders consider in developing new varieties for releasing for commercial production Adair *et al.*, [19]. All the genotypes were slender in shape and long in size except Liangyoupeijiu which was medium in size.

Table 1: Mean squares, heritability (broad sense) and coefficients of variability estimates for grain yield components in rice (*Oryza sativa* L.)

	Mean ± S.E		Variances				
Traits	Mean	S.E	δ^2_g	δ^2_p	GCV	PCV	h^2_b
Plant height	105.759	0.01076	324.316	340.368	3.0666	3.218	0.9528
Days to heading	111.000	0.024846	61.768	62.875	0.5565	0.5664	0.9824
Days to maturity	134.080	0.017478	124.762	127.115	0.9305	0.9480	0.9815
Panicle length	26.165	0.076329	5.203	7.722	0.1988	0.2951	0.6737
Flag leaf area	28.339	0.031166	32.243	45.643	1.1378	1.6106	0.7064
tillers /plant	24.053	0.024927	60.2883	63.551	2.5065	2.6421	0.9486
Grains /panicle	103.213	0.006637	859.603	887.262	8.3284	8.5965	0.9688
Grain yield /plant	40.086	0.023828	62.804	72.419	1.5667	1.8066	0.8672

Table 2: Genotypic and phenotypic correlation matrix, upper diagonal phenotypic correlations and lower diagonal genotypic correlations

Variables	Plant height	Days to heading	Days to maturity	Panicle length	Flag leaf area	Tillers /plant	Grains /panicle	Grain yield /plant
Plant height		0.49718 **	0.55475 **	0.071032 **	0.394674 **	0.044194	0.071103	0.08876
Days to heading	0.52067 *		0.96197 **	0.31383 *	0.23024	-0.03559	-0.18144	0.03476
Days to maturity	0.578509 *	0.969948 *		0.38771 **	0.25984	0.015456	-0.13395	0.02554
Panicle length	0.808304 *	0.38505 *	0.472637 *		0.48027 **	-0.10179	0.39755 **	0.37442 **
Flag leaf area	0.4636 *	0.2878 *	0.324353 *	0.51156 *		-0.3528 *	0.5179 **	0.64056 **
Tillers /plant	0.73203 *	-0.03689	0.013121	-0.11481	-0.41921		0.01206	-0.174
Grains /panicle	0.9069 *	-0.19127	-0.14067	0.499037 *	0.629079 *	-0.00862		0.35807 *
Grain yield /plant	0.15498 *	0.029315	0.02173	0.488173 *	0.794116 *	-0.25903	0.346769 *	

Table 3: Direct and indirect effects Matrix

Traits	Plant height	Days to heading	Days to maturity	Panicle length	Leaf area	Tiller/plant	Grains/ panicle	Grain yield/ plant
Plant height	4.97	1.412	2.49	-4.41	-1.72	-0.2137	0.455	0.1547
Days to heading	2.505	2.711	4.177	2.101	-1.068	0.1076	0.959	0.029315
Days to maturity	2.073	2.629	4.306	2.579	-1.204	-3.829	-0.705	0.02173
Panicle length	4.014	-1.044	2.035	-5.457	-1.899	0.335	2.503	0.488173
Leaf area	2.302	-0.780	1.396	-2.792	-3.713	1.224	3.156	0.794116
Tillers /plant	0.363	0.10002	0.056	0.626	1.556	-2.919	-4.325	-0.25903
Grains/panicle	0.450	0.518	-0.606	-2.723	-2.335	2.516	5.017	0.346769

Table 1.2: Mean squares for physical and cooking quality characteristics of rice grain

Source	d.f.	Length (mm)	Width (mm)	L/W ratio	Vol. expention ratio	Water absorption ratio	Elongation ratio	Bursting %age	Aroma
Replication	2	0.009	0.002	0.010	0.434	0.381	0.020	7.389	0.111
Treatment	5	0.280^{**}	0.062^{**}	0.635^{**}	0.076^{ns}	0.147^{**}	0.062^{ns}	419.022^{**}	3.378^{**}
Error	10	0.012	0.001	0.008	0.055	0.006	0.025	4.189	0.324

**= Highly significant at $p \leq 0.01$

Table 2.1: Mean values of the physical characteristics of rice grain

Varieties	Length (mm)	Breadth (mm)	Length/ Breadth ratio	Size	Shape
Liangyoupeijiu	6.387^{c}	1.947^{a}	3.282^{c}	Medium	Slender
Super Basmati	7.123^{a}	1.613^{de}	4.415^{a}	Long	Slender
Hua You Guan Kang Zhan	6.770^{b}	1.803^{c}	3.756^{b}	Long	Slender
Basmati-2000	7.230^{a}	1.660^{d}	4.356^{a}	Long	Slender
Basmati-385	6.720^{b}	1.583^{e}	4.245^{a}	Long	Slender
KSK-133	6.740^{b}	1.860^{b}	3.624^{b}	Long	Slender

Means followed by a common letter (s) within a column do not differ at 5%level by DMRT

Table 3.1: Comparison of significantly different genotypic means

Genotype	Vol. expansion ratio	Water absorption ratio	Elongation ratio	Bursting %age	Aroma
Super Basmati	3.71	2.954^{a}	1.915533	3.67^{b}	***3.00^{a}
Basmati-2000	3.46	2.939^{a}	1.896933	6.67^{b}	***3.00^{a}
Basmati-385	3.86	2.991^{a}	2.167567	5.67^{b}	***3.00^{a}
Hua You Guan Kang Zhan	3.5	2.429^{c}	1.851333	35.00^{a}	** 2.00^{b}
Liangyoupeijiu	3.712	2.674^{b}	1.806633	8.67^{b}	* 1.00^{b}
KSK-133	3.50	2.678^{b}	1.757233	7.00^{b}	* 1.00^{b}

Means followed by a common letter (s) within a column do not differ at 5% level by DMRT

*= non aromatic **= slightly aromatic ***= moderately aromatic

Basmati-2000 had the maximum grain length and was statistically similar to super Basmati Hua You Guan Kang Zhan, KSK-133 and Basmati -385 were statistically non significant, while the Liangyoupeijiu had the minimum length of grain and fall in medium size category. Liangyoupeijiu had the maximum grain width followed by KSK-133 and Hua You Guan Kang Zhan significantly different from the remaining ones. The slender shape variety Super Basmati had the maximum L/B ratio statistically similar to Basmati-2000 and Basmati-385. The genotypes Hua You Guan Kang Zhan and KSK-133 were statistically similar, while the genotype Liangyoupeijiu had the minimum L/B ratio. Basmati-2000 showed a minimum value of volume expansion. The genotypes Liangyoupeijiu and Super Basmati had the similar trend towards volume expansion. Liangyoupeijiu expands more in volume than Hua You Guan Kang Zhan. Significant differences among genotypes for water absorption were observed Ahmed and Khalid [20]. Basmati-385 had the maximum water absorption ratio and is statistically similar to Super Basmati and Basmati-2000, while the Liangyoupeijiu had the minimum water absorption ratio and was statistically different from rest of all the genotypes. Length-wise expansion without increase in girth is considered highly desirable trait in some high quality rices Singh *et al.*, [8] Basmati-385 had the greater elongation while the genotype 'KSK-133' had the minimum elongation ratio. The minimum longitudinal and transverse bursting is desirable for better cooking quality. Hua You Guan Kang Zhan had the higher bursting percentage (35.00%) while the genotype Super Basmati had the minimum bursting percentage (3.67%). All the genotypes were statistically similar for bursting %age except Hua You Guan Kang Zhan. The genotypes Basmati-2000, Super Basmati and Basmati-385 were moderately aromatic and statistically similar to each other. The coarse variety 'KSK-133' was non aromatic statistically non significant to Liangyoupeijiu and Hua You Guan Kang Zhan. The genotype Hua You Guan Kang Zhan was moderately aromatic (Table 3.1).

The present study indicated that among yield components number of grains per panicle had the highest genotypic and phenotypic coefficient of variability. Days to heading and days to maturity had the highest heritability. The highest positive direct effect of number of grains per panicle on grain yield was observed (5.017) followed by plant height (4.97) days to maturity (4.306). In conclusion, number of grains per panicle, plant height and days to heading are most important traits for use in selection program among grain quality traits the performance of Basamti-385 was statistically at par with Super Basmati as both have higher volume expansion, water absorption, elongation ratio and aroma. Basmati 2000 exceeds in grain length close to super Basmati. The bursting of Super Basmati was two percent less than Basmati-385. The Hua You Guan Kang Zhan was better in elongation ratio close to Super Basmati and Basmati-2000, while Liangyoupeijiu exceeded in water absorption with respect to Hua You Guan Kang Zhan depending upon the varietal character.

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