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Correlation and Path Co-efficient Analysis for Yield and its Components in Rice (*Oryza sativa* L.)

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Abstract: Investigation of path coefficient analysis for yield and yield components in rice (*Oryza sativa* L.) was conducted involving 15 genotypes. Analysis of variance indicated highly significant differences among the genotypes for all the traits studied. Covariance studies reflected significant to highly significant as well as negative differences among majority of character combinations. Broad sense heritability estimates for productive tillers per plant, grain yield per plant and plant height ranged from 0.55 to 0.705. All the traits viz. total number of tillers, number of productive tillers, flag leaf area, straw yield, harvest index and fertility index except plant height revealed significant genotypic correlation to grain yield. Among the characters studied, harvest index depicted the highest direct contribution of 0.665 and fertility index show highest indirect contribution of 0.873 towards grain yield. Path coefficient analysis demonstrated that harvest index, straw yield and fertility index should be improved for the improvement of grain yield.

Key words: Path analysis, heritability, genotypic and phenotypic correlation, yield, rice

Introduction

Rice (*Oryza sativa* L.) is one of the principal food crops and one third of the world population is utilizing rice as a staple food (David, 1991). Pakistan is an agricultural based country and its economy is largely based on agriculture (26% of GDP). Rice is an important crop grown for export and unlike other South East Asian countries, it is not considered as a subsistence crop in Pakistan. However, it is second major food crop after wheat with a share of about 17-19 percent in food grain. It grown from latitude 24° to 36°N, from sea level in the south to 2500m high altitude in North mountain valleys and terraces, in the arid hot zones to tropical humid areas. Soils in the rice growing zone are clay loam to heavy dispersing clays with minimum percolation losses. This type of agro-climatic parameters is ideal for bumper rice harvest. However, Pakistani rice yields are very low and deemed to be unprofitable. Its annual production is 3.99 million tones with foreign exchange return of 23 4.5 million US$. In spite of lowest yield (30,274 Hg Ha^{-1}) among major rice producing countries like Japan (67,023 Hg Ha^{-1}), USA (70,365 Hg Ha^{-1}), Vietnam (42,527 Hg Ha^{-1}), South Korea (65,924 Hg Ha^{-1}) and China (62,344 Hg Ha^{-1}) (FAO, 2000), Pakistan is the fifth biggest rice exporting country and export more than one million tons of rice annually, which is 10 percent of the total rice trade.

The information about phenotypic and genotypic interactions of various economic traits is of immense importance to a plant breeder for the selection and breeding of different varieties/lines of rice with increased yield potential (Agrawal *et al.*, 1978; Amin, 1979; Ragarathinam, 1992). For the inception of any varietal improvement programme it is a vital obligate to have the knowledge about the inter-relationship of various quantitative characters with grain yield, where as path analysis evaluate the participation of each component to the resultant variable directly as well as indirectly (Dewey and Lu, 1959).

The present studies, therefore aimed at assessing phenotypic and genotypic association between various components of grain yield to provide basis of selection in segregating populations.

Materials and Methods

The experiment relating to genetics correlations and co-efficient analysis in fine quality rice was conducted in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. The experimental material was composed of 14 different fine quality rice genotypes along with a standard variety, (Basmati-385) as a check variety. The details of 14 different fine quality rice genotypes including one standard variety are mentioned in Table 2.

The breeding nursery was collected from Rice Research Institute, Kala Shah Kaku. Two seedling of each genotype were transplanted into normal field soil contained in earthen pots (30x30 cm^2). There were 15 earthen pots for each genotype and the experiment was planned in Completely Randomized Design (CRD). Each replication consisted of ten plants in five pots for each genotype. Required irrigations, fertilizations and plant protections were carried out for all the genotypes, during the growth period. At the time of maturity data per plant basis were recorded in the field as well as in the laboratory for the following morphological traits:

Plant height (cm), total number of tillers per plant, productive tillers per plant, flag leaf area (cm^2), straw yield per plant (gm), harvest index, fertility index and grain yield per plant (gm). The height of the main tillers of the plant was measured from ground level to the tip of the plant (including panicle length) with the help of meter rod. Total number of tillers was counted at maturity for each plant. Tillers per plant bearing harvestable panicles were counted at maturity for each genotype in each repeat. Flag leaf area from five tillers per plants were measured with automatic leaf area meter. With the help of triple beam balance the dried straw from each plant was weighed and recorded in grams. Dry straw of the plants was weighed and harvest index for each plant in each repeat was computed as a ratio of economic yield to biological yield. Fertility index was calculated for each genotype in each repeat, as a ratio of number of grains per panicle number of spikelets per panicle.

Statistical analysis: The statistical analysis of variance and co variance for the data collected for the traits to ascertain the differences among various genotypes for variability and co variability were carried out by using the procedure of Steel and Torrie (1980). The pair wise comparison of genotypic means were accomplished by using, Duncan's New Multiple Range Test. The method of Burton and Devane (1953) was used for estimating heritability (Broadsence) as an index of transmissibility associated with various plant performance traits.

In order to determine the extent of characters association at genotypic and phenotypic levels, genotypic and phenotypic correlations were calculated by using the technique given by Kwon and Torrie (1964). Genetic correlation were tested for their statistical significance by using the methodology given by Lothrop *et al.* (1985). Standard error for heritability was computed according to the method proposed by Reeve (1955) and Robertson (1959). If absolute value of a genetic co relation exceeded the twice of the respective standard error then that genetic correlation was considered to be significant statistically. The methodology proposed by Dewey and Lu (1959) was used to perform path analysis in grain yield and its components keeping grain yield as resultant variable and its components as causal variables.

Results and Discussion

Analysis of variance and heritability: Mean squares, heritability, co-efficient of variability genotypic and phenotypic for grain yield and its components presented in Table 1, revealed that genotypic differences among genotypes for all the traits, were highly significant ($\alpha = 0.01$), so, these genotypes are highly diversified for the performance and selection can be performed for various morpho-genetic traits. Maximum variability is recorded in grain yield per plant followed by productive tillers per plant and total number of tillers per plant, where as most consistent performance is observed in plant height. It is observed that phenotypic coefficients of variability were higher than

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

Trait estimates	Mean squares Treatment	Mean squares Error	Co-efficient of variability Genotypic	Co-efficient of variability Phenotypic	Heritability ± standard error h^2 ± SE
Plant height	313.496**	38.328	9.321	11.099	0.705±0.018
Total number of tillers/plant	57.375**	18.543	17.384	27.113	0.411±0.037
Productive tillers per plant	24.303**	5.161	19.686	26.477	0.553±0.612
Flag leaf area	116.076**	32.765	16.768	24.756	0.459±0.027
Straw yield per plant	181.247**	58.041	15.340	23.831	0.414±0.021
Harvest index	54.151**	16.758	11.879	18.188	0.427±0.039
Fertility index	218.62**	90.619	9.808	17.324	0.321±0.018
Grain yield per plant	66.508**	13.258	23.717	31.347	0.572±0.037

Treatment degree of freedom, 14; **,Highly significant; NS, non-significant; Error degree of freedom =30

Table 2: Mean performance of various genotypes and their statistical significance for grain yield and its components in rice (*Oryza sativa* L.)

Genotypes	Plant height (cm)	Total No. of tiller plant	Productive tiller plant	Flag leaf area (cm^2)	Straw yield/ plant	Harvest index	Fertility index	Grain yield/plant (gms.)
40083	96.00c-f	23.22a-c	12.45b-e	29.79b-d	46.55a-c	24.52c-e	60.44b-d	14.67de
40084	95.33d-f	19.17b-d	11.33b-e	31.88a-d	31.5de	30.27a-d	55.45cd	13.60de
40086	109.7b	17.67b-d	12.00b-e	27.47cd	43.00a-d	29.60a-d	71.61a-c	19.67b-d
40097	106.7b-d	22.67a-d	9.333d-e	35.60a-c	49.00ab	21.43e	57.22b-d	13.33de
41004	101.1b-e	28.67a	17.55a	24.17d	47.33ab	36.58a	67.56a-d	26.64a
41011	103.8b-d	17.89b-d	11.00b-e	28.48b-d	39.00a-e	28.87a-d	60.81b-d	15.72c-e
41012	96.67c-f	23.50a-c	14.00a-c	33.67a-d	46.50a-c	31.93a-c	75.43ab	21.83a-c
41013	125.9a	16.00cd	9.887c-e	38.62ab	39.88a-d	28.44b-e	69.92a-c	15.26c-e
41016	102.3b-e	17.00cd	13.58a-d	42.56a	43.58a-d	35.39ab	84.89a	23.84ab
41024	91.58ef	27.58a	17.17a	29.93cd	50.00ab	29.27a-d	69.96a-c	19.50b-d
41025	88.00f	17.17cd	12.17b-e	25.33cd	35.83b-e	23.47de	51.03d	10.92e
41026	107.9bc	14.33d	8.33e	42.67a	25.11e	32.11a-c	67.00a-d	13.44de
41028	120.3a	21.50a-d	14.33ab	33.66a-d	51.83a	28.14b-e	69.30a-d	20.17a-d
41030	98.08b-f	25.67ab	17.25a	26.50cd	45.67a-d	34.00ab	67.58a-d	13.44ab
Basmati-385	97.92b-f	18.42b-d	12.08b-e	26.09cd	31.83c-e	31.77a-c	71.70a-c	14.44de

Means followed by a common letter are not significantly different from each other at 5% level by DMRT

Table 3: Mean products for analysis of covariance for grain yield and its components in all possible combination in rice (*Oryza sativa* L.)

Traits	S.O.V	df	Plant height	Total number of tillers\plant	Productive tillers per plant	Flag leaf area	Straw yield per plant	Harvest index	Fertility per index
Total no of tillers/plant	Treatment	14	-45.950**						
Error		30	0.542						
Productive tillers per plant	Treatment	14	30.635**	29.956					
Error		30	2.858	7.329					
Flag leaf area	Treatment	14	98.780**	44.627**	-29.917**				
Error		30	13.025	9.653	0.610				
Straw yield	Treatment	14	24.067**	72.786**	39.733**	-32.263**			
per plant	Error	30	5.052	24.580	12.911	-2.276			
Harvest index	Treatment	14	1.841NS	8.044NS	17.435	3.958NS	-0.092NS		
	Error	30	0.818	-4.6441	2.68	2.589	-0.53		
Fertility index	Treatment	14	73.070**	0.896NS	22.453**	54.647**	44.366**	73.013**	
	Error	30	1.522	0.818	-3.559	-11.56	-6.33	13.901	
Grain yield	Treatment	14	7.825NS	34.839**	31.367**	-9.763**	63.113**	43.933**	81.725**
per plant	Error	30	7.293	6.379	4.913	0.389	13.116	9.603	9.564

NS, Non-significant **, Highly significant

Table 4: Genotypic and phenotypic correlation coefficients among grain yield and its components in rice

Traits	Correlation	Plant height	Total number tiller plant	Productive tillers per plant	Flag leaf area	Straw yield per plant	Harvest index	Fertility index
Total number of	Genotypic	0.45+0.27						
tillers per plant	Phenotypic	-0.234						
Productive tillers	Genotypic	0.333+0.032	0.830+0.022					
per plant	Phenotypic	0.313	0.780**					
Flag leaf area	Genotypic	0.566+0.019	-0.6115+0.032	-0.734+0.020				
	Phenotypic	0.469	-0.488	-0.393				
Straw yield	Genotypic	0.103+0.025	0.697+0.025	0.552+0.037	-0.296+0.035			
per plant	Phenotypic	0.100	0.728**	0.646	-0.158			
Harvest index	Genotypic	-0.091+0.031	0.333+0.57	0.642+0.042	0.025+0.051	-0.00064+0.065		
	Phenotypic	0.059	-0.014	0.326	0.072	-0.00083		
Fertility index	Genotypic	0.38+0.020	0.001+0.051	0.525+0.041	0.641+0.024	0.403+0.032	0.854+0.041	0.45+0.27
	Phenotypic	0.193	0.013	0.130	0.117	0.092	0.538	0.393
Grain yield	Genotypic	0.004+0.029	0.626+0.038	0.829+0.019	-0.152+0.043	0.617+0.025	0.769+0.022	0.87+0.10
per plant	Phenotypic	0.118	0.508	0.726**	-0.069	0.537*	0.699**	0.52*

*, Statistically significant **, Statistically highly significant

Table 5: Direct and indirect effect of various plant traits to grain yield in rice (*Oryza sativa* L.)

Traits	Plant height	Total no. of tillers per plant	Productive tillers per plant	Flag leaf area	Straw yield per plant	Harvest index	Fertility index	Genotypic correlation with grain yield
Plant height	(-0.058)	0.070	0.005	-0.087	0.063	-0.054	-0.066	0.0044
Total No. of tillers per plant	0.026	(-0.155)	0.010	0.094	0.425	0.226	0.002	0.626
Productive tillers per plant	-0.022	-0.129	(0.012)	0.133	0.337	0.427	0.091	0.0829
Flag leaf area	-0.033	0.095	-0.009	(-0.154)	0.0180	0.016	0.112	-0.152
Straw yield per plant	-0.006	-0.108	0.007	0.045	(0.609)	-0.0004	0.070	0.617
Harvest index	0.005	-0.053	0.008	-0.004	-0.0004	(0.665)	0.149	0.769
Fertility index	-0.022	-0.0002	0.006	-0.098	0.246	0.568	(0.174)	0.873

genotypic coefficients of variability for all traits (Buu and Tuan, 1991). Plant height, number of tillers per plant and grain yield per plant showed high heritability of 0.705, 0.553 and 0.572, respectively, which indicated that selection of these traits would be more effective as compared to traits like number of tillers per plant, flag leaf area, straw yield per plant and harvest index having moderate heritability. The data on mean performance of genotypes mentioned in Table 2 indicated that the mean values for plant height, number of tillers per plant, number of productive tillers per plant, flag leaf area, straw yield per plant, harvest index, fertility index and grain yield per plant ranged from 88 to 125.9 cm, 8.33 to 28.67, 8.33 to 17.55, 24.17 to 42.67 cm^2, 25.11 to 51.83 gm, 21.43 to 36.58 %, 51.03 to 84.89 % and 10.92 to 26.64 gm respectively. The data revealed a tremendous scope for improvement in grain yield.

Maximum plant height was recorded in genotype 41013 followed by 41028, while least plant height was noted in genotype 41025, genotype 41004, had maximum total number of tillers per plant followed by 41024 but these two genotypes are non-significantly different from 400831 , 40097, 41028 and 41030. Maximum numbers of productive tillers were reported in genotype 41004 followed by 41030 and 41024, these genotypes are non-significantly different from 41028, 41012 and 41016, minimum number of productive tillers was reported in genotype 41026. Genotype 41026 has the maximum flag leaf area (42.67 cm^2) and it is closely followed by genotype 41016. Genotype 41004 has the minimum flag leaf area (24.17cm^2).

The maximum straw yield was observed in genotype 41028 (51.83 gm) followed by genotype 41024 (50.00 gm), whereas it was minimum in genotype 41026 (25.11 gm). Genotype 41028 differed significantly in straw yield from Basmati-385. Genotype 41004 had the maximum harvest index (36.58%) followed by genotypes 41016 and 41030, while genotype 40097 had minimum harvest index (21.43%). Genotype 41016 appeared most fertile where as 41025 most sterile. The highest yield was recorded in the genotype 41004 followed by genotypes 41016 and 41030. These three genotypes are significantly different from the standard variety (Basmati-385). The lowest yield per plant was observed in the genotypes 41025. The outstanding performance of 41004 for grain yield per plant seems due to its superiority for total number of tillers per plant, productive tillers per plant and harvest index.

Analysis of covariance: The mean products for the traits studied are presented in Table 3 revealed that the mean products for all the traits studied in all possible combinations exhibited significant to highly significant co-variability except that of harvest index with plant height, total number of tillers per plant, flag leaf area and straw yield per plant while fertility index with total number of tillers per plant and grain yield per plant with plant height. Reflected that majority of the combinations expressed highly significant covariance although the values varied in magnitude and direction of covariance (positive and negative covariance) Table 3. This indicated that a great amount of co-variability present in the breeding material.

Correlations: The association of grain yield with other characters was estimated by genotypic and phenotypic correlation coefficients (Table 4). Plant height had significant correlations at genotypic level with all other traits except grain yield per plant. At phenotypic level plant height had non-significant association with all other traits, while it has negative and significant association with harvest index. This result indicated that decrease in plant height will bring increase in harvest index. Genotypic correlation between plant height and total number of tillers per plant was positive and significant. Hence results from the present studies do not coincide with the findings of khan *et al*. (1991), who reported negative correlation between plant height and productive tillers per plant. Sharma and Reddy (1991) observed positive correlation between plant height and grain yield per plant. Kupkanchanakul *et al*. (1991) reported negative correlation between plant height and grain yield per plant. But in this study non-significant results might be due to difference in genetic constitution in breeding material and different locations of experimentation. Total number of tiller per plant had significant genetic correlation with all other characters of rice except fertility index, while it had highly significant phenotypic correlation with productive tillers per plant and with straw yield per plant whereas other phenotypic correlations of total tillers per plant were non-significant. This finding had analogy with studies already reported by Khan *et al*. (1991) and Kupkanchanakul *et al*. (1991). While Rangel *et al*. (1980) reported negative correlation between total number of tillers per plant and grain yield per plant. Productive tillers per plant had highly significant phenotypic correlation with straw yield per plant and grain yield per plant, while it had non- significant phenotypic correlation with flag leaf area, harvest index and fertility index. Ise (1992) reported that harvest index showed negative and non – significant phenotype correlation with productive tillers per plant. Ganesan and Subramanian (1990), Deshmukh and Chau (1992) reported positive and significant genetic association between productive tillers per plant and grain yield per plant.

Flag leaf area had significant genotypic negative correlation, while negative and non–significant correlation at phenotypic level with straw yield per plant. It is also evident from Table 4 that flag leaf area had positive but non – significant correlation at both genotypic and phenotypic levels with harvest index. Flag leaf area also had positive and significant genetic association with fertility index. More over it had significant and negative genetic association while non-significant and negative phenotypic association, with grain yield per plant. Straw yield per plant had significant positive correlation both at genotypic and phenotypic levels with grain yield per plant while non–significant negative correlation both at genotypic and phenotypic levels with harvest index, moreover it had positive and significant association while non–significant phenotypic association with fertility index. Positive and significant association both at genetic and phenotypic levels were existed between harvest index, fertility index and grain yield per plant. Positive and significant correlation existed between fertility index and grain yield per plant both at genotypic and phenotypic levels.

Path analysis: Path coefficient analysis as an effort to assess the magnitude of contribution of various agro morphological characters to yield in the form of cause and effect. Table 5 revealed the results of direct and indirect effects of various traits to grain yield per plant. The direct effect of plant height was negative and low (-0.058). Indirect effects through total number of tillers per plant, number of productive tillers per plant, straw yield and fertility index were positive. But through flag leaf area and harvest index indirect effects were negative. Maximum positive indirect effect (0.070) was observed through total number of tillers per plant. Present findings coincide with the results of Ibrahim *et al*. (1990). Highly significant genotypic correlation was present between total tillers per plant and grain yield, but the direct effect of total tiller number was negative (-0.155). Positive indirect effects through plant height, productive tillers, flag leaf area, straw yield, harvest index and fertility index were observed. Number of productive tillers per plant showed positive direct effect (0.012). Indirect effect through plant height and total tillers were negative while through flag leaf area, straw yield, harvest index and fertility index was positive. Highly significant positive genotypic correlation (0.829) between number of productive tillers and grain yield is present. Ibrahim *et al*. (1990) and Soares *et al*. (1990) reported that productive tillers had direct effect on grain yield. Negative direct effect was reported by Buu and Truong (1988). The difference in results may be attributed to the difference in genetic material and environmental condition of the experiment. The direct effect of flag leaf area was negative and genotypic correlation between flag leaf area and grain yield was also negative. Straw yield effected grain yield positively (0.609). Indirect effects of this trait to grain yield were positive through number of productive tillers, flag leaf area and fertility index. Through plant height, number of total tillers and harvest index, indirect effect were negative but very low.

The highest direct effect of harvest index to grain yield per plant is (0.665) present. Indirect effects through plant height, number of productive tillers and fertility index were also positive. Fertility index directly affecting positively to grain yield. Its maximum positive indirect effect was through harvest index (0.568). While indirect effects through plant height, total number of tillers and flag leaf area were negative. Soares *et al.* (1990) also concluded the positive direct effect of fertility index to grain yield per plant.

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