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Correlation and Path Coefficient Analysis for Some Yield-Related Traits in Rice Genotypes (*Oryza sativa* L.)

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Abstract: Correlation and path analysis of grain yield and sixteen yield-related traits were investigated. The objectives of this study were to evaluate the interrelationships between first and second-order yield related traits in rice. For this purpose, 25 lines were tested in squared lattice design with 2 replications at Chaparsar Rice Research Institute-Iran at 2005. The phenotypic and genotypic correlations among the traits and their path coefficients were estimated. The results showed that grain yield was significantly correlated with days to heading (r_p = 0.403**, r_g = 0.525**), total tillers (r_p = 0.585**, r_g = 0.524**) number of productive tillers (r_p = 0.604**, r_g = 0.570**), days to maturity (r_p = 0.296*, r_g = 0.424**), number of grain per panicle (r_p = 0.349*, r_g = 0.339*), flag leaf length (r_p = 0.350*, r_g = 0.301*), flag leaf width (r_p = 0.279*, r_g = 0.093^{ns}) and plant height (r_p = -0.220^{ns,} r_g = -0.300*). Genotypic and phenotypic path coefficient analysis revealed that the number of productive tillers had the highest positive direct effect on grain yield (p_p = 1.034, p_g = 1.196). The second and third traits were the number of grain per panicle (p_p = 0.665, p_g = 0.813) and 100-grain weight (p_p = 0.440, p_g = 0.425) respectively. According to the results of this study, it is evident that grain yield could be improved by selecting the cultivars for higher number of productive tillers and higher number of grains per panicle while 100 grain weight and flag leaf width, grain length and grain width are the copartners in grain yield gain.

Key words: Path coefficients, phenotypic and genotypic correlations, rice (*Oryza sativa* L.), yield

INTRODUCTION

Rice is an important food and feed crop in Iran. Genotypic and environmental factors have extensive affects on growth and yield of rice. Most of the characters of interest to breeders are complex and are result of the interaction of a number of components (Sarawgi *et al*., 1997). The study of relationships among quantitative traits is important for assessing the feasibility of joint selection for two or more traits instead of selection of secondary traits on genetic gain for the primary trait under consideration (Ezeaku and Mohammed, 2005). Path coefficient analysis is a statistical tool which has been used to organize and present the causal relationships between predictor variables and response variables through a path diagram that is based on experimental results (Samonte *et al*., 1998).

Partitioning of the correlation coefficient into its components of direct and indirect effects have been extensively studied (Surek and Beser, 2003). In agriculture, path analysis has been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield (Milligan *et al*., 1990). In this assay, the direct and indirect effects of some traits on grain yield were studied. It may increase the selection efficiency. Therefore it saves time and resources during the selection process.

MATERIALS AND METHODS

Twenty five genotypes from International Rice Research Institute (IRRI) and some important Iranian genotypes (Table 1) were grown and evaluated in a lattice squared design with two replications at Chaparsar Rice Research Institute that is located at 50°, 40′ eastern rather than placed at 36°, 54′ northern of Iran from 10th May to 25th August of 2005.

Each plot with size 4.5 m^2 (3×1.5 m) was consisted of 4 rows spaced 25 cm apart. The data was taken from 2 middle rows. Sixteen traits (Table 2) were measured on the basis of standard evaluation system for rice. The phenotypic and genotypic correlations were estimated from variance and covariance components practiced by Sarawgi *et al*. (1997). Partitioning of correlation coefficient of traits into direct and indirect effects were carried out using the procedure practiced by Surek and Beser (2003).

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Table 1: The twenty five rice genotypes grown in season 2004-2005

Row	Varieties	Row	Varieties	Row	Varieties
1	IR28	10	Plano	19	Hassan saraeai
2	Binam	11	Contury-Patana	20	Hassani
3	Anbarboo	12	Line 304	21	Hassan saraeai atashagh
4	Sang-e-jo	13	Line 305	22	IR58
5	Line 213	14	Domsiyah	23	Hassan saraeai pichide ghalaf
6	Alfa	15	Salari	24	Gharib-e-siyah
7	Sterella	16	Lido	25	Alikazemi
8	Sanaderia	17	Gharib		
9	Zenit	18	Mousatarom		

Table 2: Minimum, maximum, mean and standard deviation for 16 characters of 25 rice genotypes grown in season 2004-2005

Characters	Minimum	Maximum	Mean	SD
Days to heading (d)	52.00	75.00	64.12	5.28
Days to maturity (d)	88.00	103.00	94.72	3.91
Number of grain per panicle	120.00	259.00	162.5446	31.0531
Grain length (mm)	7.76	10.50	9.2538	0.7361
Grain width (mm)	2.28	4.04	2.8768	0.4207
Plant height (cm)	81.60	170.20	133.4660	24.9963
Panicle length (cm)	19.88	35.30	27.0450	4.1490
Grain yield (t ha^{-1})	3.20	7.55	4.7720	1.0349
Uppermost internodes	27.90	52.75	43.3936	5.5675
Hundred-grain weight (g)	1.27	3.46	2.6632	0.3515
Total tillers	13.20	38.60	23.2710	6.2485
The number of productive tillers	13.20	36.00	22.7060	6.0123
Flag leaf width (cm)	1.03	1.82	1.3172	0.1527
Flag leaf length (cm)	25.00	45.80	32.5430	4.6357
The ratio of brown grain length to brown grain width	1.62	4.11	2.8542	0.6416
The ratio of flag leaf length to flag leaf width	17.47	34.75	24.8874	3.6311

Table 3: Analysis of variance for sixteen quantitative traits in 25 rice genotypes grown in season 2004-2005

			Error			
Characters	Replication (df = 1)	Genotype (df = 24)	Block within replication (df = 8)	Effective (df = 16)	Intra block (df = 16)	CV(%)
Days to heading (d)	98.00	54.1**	3.00	1.30	1.60	1.82
Days to maturity (d)	92.50	23.3**	5.60	2.30	2.80	1.70
Number of grain per panicle	366.80	1865.6**	133.80	104.80	112.40	6.50
Grain length (mm)	0.20	1.05**	0.04	0.03	0.03	1.90
Grain width (mm)	0.22	0.3**	0.10	0.01	0.10	3.40
Plant height (cm)	33.13	1256.37**	17.92	13.434	20.163	3.17
Panicle length (cm)	1.10	34.65**	0.446	0.334	0.502	2.47
Grain yield (t ha^{-1})	0.23	0.069**	0.019	0.018	0.019	15.59
Uppermost internodes	0.06	57.6**	9.40	6.60	7.30	6.20
Hundred-grain weight (g)	0.001	0.2**	0.10	0.05	0.06	8.90
Total tillers	104.10	70.5**	13.40	4.50	5.50	10.10
The number of productive tillers	86.30	68.9**	13.50	2.90	3.60	8.40
Flag leaf width (cm)	0.05	0.03**	0.01	0.007	0.008	6.80
Flag leaf length (cm)	158.20	28.9**	12.60	6.30	7.30	8.30
The ratio of brown grain length to brown grain width	0.07	0.8**	0.009	0.007	0.007	3.00
The ratio of flag leaf length to flag leaf width	30.40	20.3**	7.40	5.00	5.50	9.40

** Significant at 1% level of probability

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences between genotypes (Table 3). The phenotypic and genotypic correlations among all pairs of characters are shown in Table 4. The genotypic correlations in general were higher than correspondent phenotypic correlations. This is due to the modified effect of environment on character association at the genetic level (Sarawgi, 1997).

Some of traits had significant correlation with grain yield at the 0.01 level of probability. They are includes days to heading (r_p = 0.403, r_g = 0.525), total tillers (r_p = 0.585, r_g = 0.524) and the number of productive tillers (r_p = 0.604, r_g = 0.570). Although the phenotypic correlation between grain yield and days to maturity was significant at 0.05 level (r = 0.296) but its genotypic correlation was very significant at 0.01 level (r = 0.424). There was significant ($p<0.05$) correlation between grain yield with the number of grain per panicle (r_p = 0.349, r_g = 0.339) and flag leaf length (r_p = 0.350, r_g = 0.301). The genotypic correlation between grain yield and plant height was significant and negative (r = -0.300) at 0.05 level while the phenotypic correlation wasn't

Table 4: Phenotypic (P) and genotypic (G) correlations for various characters in rice

Characters		Days to maturity (day)	Days to maturity (day)	Number of grain per panicle	Grain length (mm)	Grain width (mm)	Plant height (cm)	Panicle length (cm)	Grain yield (t ha^{-1})	Uppermost internodes	100-grain weight (g)	Total tillers	The number of productive tillers	Flag leaf width (cm)	Flag leaf length (cm)	The ratio of brown grain length to brown grain width	The ratio of flag leaf length to flag leaf width
Days to heading	P	1	0.718**	0.169	0.192	-0.158	0.300*	0.450**	0.403**	0.217	-0.179	0.351*	0.334*	0.165	0.362**	0.146	0.219
(day)	G	1	0.710**	0.187	0.224	-0.201	0.303*	0.487**	0.525**	0.181	-0.206	0.384**	0.349*	0.133	0.431**	0.1663	0.269
Days to maturity	P		1	0.22	-0.344**	0.238	0.063	0.149	0.296*	0.222	-0.199	0.235	0.233	0.352*	0.354*	-0.366**	0.073
(day)	G		1	0.298*	-0.417**	0.267	0.032	0.192	0.424**	0.076	-0.173	0.22	0.205	0.327*	0.526**	-0.432**	0.205
Number of grain	P			1	-0.456**	0.499**	-0.173	-0.409**	0.349*	-0.027	0.246	-0.414**	-0.411**	0.754**	0.192	-0.437**	-0.386**
per panicle	G			1	-0.479**	0.541**	-0.188	-0.453**	0.339*	-0.031	0.290*	-0.505**	-0.500**	0.999**	0.212	-0.454**	-0.674**
Grain length	P				1	-0.695**	0.386**	0.415**	-0.18	0.009	-0.063	0.121	0.094	-0.477**	-0.224	0.893**	0.145
(mm)	G				1	-0.765**	0.416**	0.444**	-0.214	0.005	-0.179	0.169	0.143	-0.623**	-0.292*	0.931**	0.244
Grain width	P					1	-0.396**	-0.470**	0.131	-0.007	0.573**	-0.416**	-0.395**	0.492**	0.184	-0.871**	-0.174
(mm)	G					1	-0.405**	-0.501**	0.041	0.018	0.700**	-0.569**	-0.520**	0.602**	0.122	-0.896**	-0.333*
Plant height	P						1	0.747**	-0.22	0.777**	-0.238	-0.009	-0.035	-0.145	0.305*	0.451**	0.404**
(cm)	G						1	0.764**	-0.300*	0.871**	-0.264	-0.024	-0.068	-0.227	0.469**	0.462**	0.610**
Panicle length	P							1	-0.072	0.552**	-0.349*	0.318*	0.304*	-0.365**	0.406**	0.471**	0.648**
(cm)	G							1	-0.164	0.638**	-0.561**	0.338*	0.322	-0.505**	0.564**	0.488**	0.899**
Grain yield	P								1	-0.204	0.236	0.585**	0.604**	0.279*	0.350*	-0.159	0.114
(t ha 1)	G								1	-0.273	0.044	0.524**	0.570**	0.093	0.301*	-0.163	0.197
Uppermost internodes	P									1	-0.059	-0.149	-0.171	0.045	0.377**	-0.003	0.343*
	G									1	0.03	-0.215	-0.248	0.001	0.695**	0.005	0.642**
100-grain weight (g)	P										1	-0.368**	-0.356*	0.157	0.003	-0.343*	-0.087
	G										1	-0.607	-0.516**	0.305*	-0.225	-0.432**	0.334*
Total tillers	P											1	0.991**	-0.262	0.209	0.253	0.375**
	G											1	0.998**	-0.700**	0.14	0.313*	0.669**
The number of productive	P												1	-0.274	0.195	0.228	0.372**
tillers	G												1	-0.699**	0.183*	0.275	0.705**
Flag leaf width	P													1	0.343*	-0.455**	-0.431**
(cm)	G													1	0.29	-0.567**	-0.520**
Flag leaf length	P														1	-0.149	0.695**
(cm)	G														1	-0.181	0.695**
The ratio of brown grain	P															1	0.19
length to brown grain width	G															1	0.277
The ratio of flag leaf length	P																1
to flag leaf width	G																1

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed)

Table 5: Direct and indirect effects of first yield-related traits based on phenotypic and genotypic correlation coefficients

Traits		Effect: The number of productive tillers	Effect: Number of grain per panicle	Effect: 100-grain weight	Correlation with grain yield
The number of productive tillers	Phenotypic	1.034	-0.274	-0.157	0.604**
	Genotypic	1.196	-0.407	-0.22	0.570**
Number of grain per panicle	Phenotypic	-0.426	0.665	-0.108	0.349*
	Genotypic	-0.599	0.813	0.123	0.339*
100-grain weight	Phenotypic	-0.369	0.163	0.440	0.236 ^{ns}
	Genotypic	-0.618	0.236	0.425	0.044^{ns}

**Significant at 1%, *significant at 5%, ^{ns} not significant. Phenotypic residual effect = 0.197, genotypic residual effect = 0.153

Table 6: Direct and indirect effects of second yield-related traits based on phenotypic and genotypic correlation coefficients

Traits	Effect	Path coefficients: Phenotypic	Path coefficients: Genotypic
The number of productive tillers	Direct effect of total tillers on the number of productive tillers	0.990	0.998
	Residual effect	0.133	0.063
Number of grain per panicle	Direct effect of flag leaf width on number of grain per panicle	0.754	0.999
	Residual effect	0.656	0.044
100-grain weight	The effects of grain width on 100-grain weight		
	Direct effect	0.648	0.859
	Indirect effect by grain length	-0.712	-1.039
	The effects of grain length on 100-grain weight		
	Direct effect	1.023	1.357
	Indirect effect by grain width	-0.451	-0.658
	Residual effect	0.674	0.699

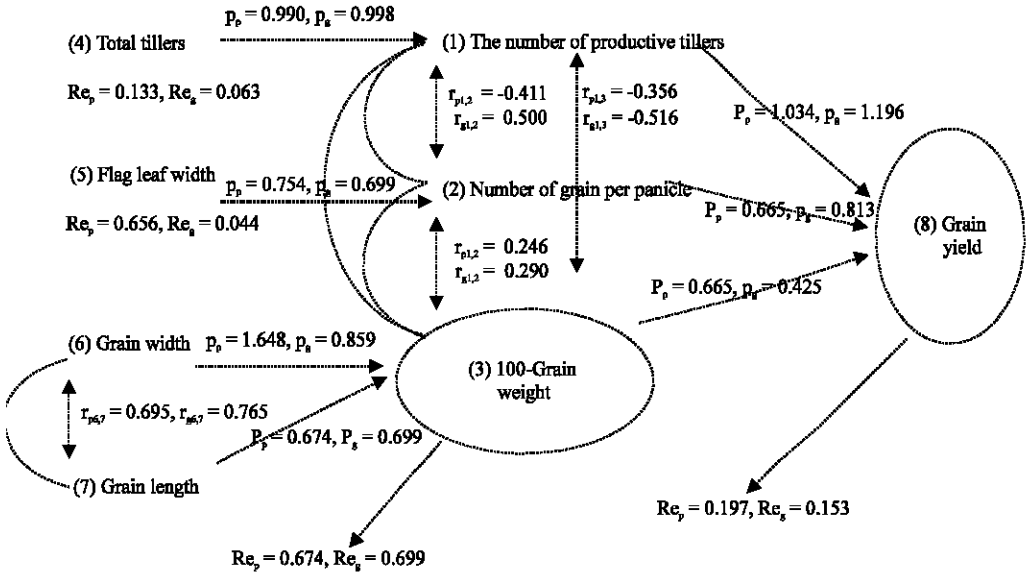

Fig. 1: Nature of causal system of variables for the path coefficient analysis in studied rice genotypes. p_p = phenotypic path coefficient, p_g = genotypic path coefficient, r_p = phenotypic correlation, r_g = genotypic correlation, Re_p = phenotypic residual effect, Re_g = genotypic residual effect

significant. On the other hand, a significant phenotypic correlation at 0.05 level was found (r = 0.279) when the genotypic correspondent correlation wasn't significant (r = 0.093). This trend was observed between grain yield and flag leaf width (Table 4). This is due to the effects of environmental factors that cause bias in genetically effects. The plant breeders should have some strategy to decrease it significantly. Path analysis results (Table 5 and 6) showed that, the number of productive tillers (which showed low indirect negative effect and had highest positive correlation with grain yield (r_p = 0.602, r_g = 0.487)) demonstrated the highest direct effect and also it was very important in both models. Number of grain per panicle was in second order (p_p = 0.665, p_g = 0.813). In fact

the negative effect of the number of productive tillers decreased the direct effect of number of grain per panicle. The next trait was 100-grain weight. Direct effect of this trait was positive but didn't show a significant correlation with grain yield, because of indirect and negative effect of the number of productive tillers that is almost strong.

The residual effects demonstrated that the effects of mentioned traits on grain yield were not complete and this means that some other effective variables should be existed. The number of grain per panicle was recommended as the selection criteria in most studies. Highly significant association of grain yield was observed with 1000-grain weight and tiller number per plant (Ram, 1992; Surek *et al*., 1998). Also grain yield has been reported to be influenced by high direct effect of 1000-grain weight (Ram, 1992; Mehertre *et al*., 1994; Samonte *et al*., 1998; Surek *et al*., 1998), plant height (Rubben and Katuli, 1989; Ibrahim *et al*., 1990; Kumar, 1992), the number of panicles per plant (Lin and Wu, 1981; Yang, 1986) productive tillers (Ram, 1992; Sundaram and Palanisamy, 1994) and total tillers (Amirthadevarathinam, 1983; Kumar, 1992).

In conclusion the findings of this research showed that, flag leaf width, grain length and grain width have indirect effect on grain yield, hence selecting for them may improve the grain yield. Path analyses based on phenotypic and genotypic correlation coefficients showed that, the number of productive tillers, number of grain per panicle and 100 grain weight were the most important effective variables on grain yield (Fig. 1). Genotypic path coefficients were generally higher than correspondent phenotypic coefficient. It was an evidence of considerable effect of environment on this trait.

Panwar and Bansal (1989), believed that, the number of grain per panicle and the number of productive tillers have the highest direct effect on grain yield. The results of this study showed that, flag leaf width, grain width and grain length are copartners in grain yield progress.

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