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Correlation and Path Analysis of Morphological and Grain Yield Traits in Iranian Rice Genotypes under Drought Stress Conditions

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ABSTRACT: Drought stress is a major factor limiting rice production and cause severe threat to rice production. Studying causal relationships of morphological traits and analysis of relationships between grain yield as dependent trait and morphological traits as independent traits of rice is a useful way to finding out genetic basis of drought tolerance. For this purpose, an experiment was conducted to determine analysis of relationships between grain yield as dependent trait and morphological traits as independent traits in rice Iranian rice genotypes. The study was conducted using a factorial RCBD design with three replications under greenhouse condition. The experimental factors were different levels of drought stress (non-stress, drought stress with re-irrigation and drought stress without re-irrigation) and rice genotypes. The result of correlation among measured traits under drought stress with re-irrigation and without re-irrigation (severe drought tolerance) showed that grain yield had a significantly positive correlation with number of filled grains per panicle and 100 grain weight. As number of filled grains per panicle had the highest significantly positive direct effect (0.714) on grain yield in the drought without re-irrigation and also had a significant positive correlation with grain yield under the two drought conditions, therefore, this trait can be used as an indicator for breeding of grain yield under drought stress conditions.**

Keywords: *Oryza sativa*, correlation, path analysis, drought stress, re-irrigation

INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal crop that requires relatively higher amount of water for its normal growth in comparison with other crops (Pandey and Shukla, 2015). Therefore, water stress is a major factor limiting rice production that cause great threat to rice production. Hence, due to diminishing quantities of water supplies worldwide, screening of rice genotypes for drought tolerance are becoming increasingly a useful approach (Serraj *et al.,* 2009). Approximately 27 million hectares of rice are grown is subject to drought stress (Zu *et al.,* 2017). Developing of new rice cultivars with improved drought tolerance is a useful approach to conferring this issue (Zu *et al.,* 2017). In spite of many studies on drought tolerance of crops for many years (Zhu *et al.,* 2016), the improvement of drought-tolerant crops is hindered greatly due to largely unknown mechanisms used by different crops respond to drought stress (Zu *et al.*, 2017).

Grain yield in rice increasing through yield component traits if they are highly heritable and positively correlated with grain yield (Hasan *et al*., 2013). Therefore, plant breeders used indirect selection for yield based on plant traits that are positively correlated with grain yield. Because genetic gain in yield potential of crops is more difficult to achieve in a breeding program,(Yuan, *et al.* 2011). A large number of researchers have worked on selection for yield in several crop species and illustrated that indirect selection for yield based on yield components was more efficient than direct selection for yield (Takeda and Frey, 1976; Kumar and Bahl, 1992; Saadalla, 1994; Totok *et al*., 1998).

Grain yield is generally regarded as an important and complex trait for the genetic improvement of crops (Xue *et al.,* 2008). Also, the grain yield of rice is consisting of a number of yield component traits (Liu *et al.,* 2008).

The main objective of the present investigation is to study on causal relationships of morphological traits and analysis of relationships between grain yield and morphological traits in order to breeding of rice genotypes that can be tolerant to drought stress. For this purpose, we considered relationship of rice traits and causal relationships of traits affected on grain yield under two different drought stress conditions.

MATERIAL AND METHODS

This study was conduct on 19rice genotypes (Table 1) including 16 Iranian genotypes and 3 control genotypes in the greenhouse conditions at the Sari Agricultural sciences and Natural Resources University (SANRU), Mazandaran, Iran. The experimental control genotypes included two tolerant genotypes (Kinangpatong and Arias halus) and a sensitive genotype (IR64) were obtained from International Rice Research Institute (IRRI).

Table 1: Characteristics of the rice genotypes used in the study.

Genotype number	Name	Characteristics	Genotype number	Name	Characteristics
1	Fajr	Breeding variety	11	Abji-Booji	Iranian local variety
2	Sange-Tarom	Iranian local variety	12	Unknown	Iranian local variety
3	Anbarboo	Iranian local variety	13	Tarom-Chaloos	Iranian local variety
4	Tabesh	Breeding variety	14	Tarom-Sadri	Iranian local variety
5	Gardeh	Iranian local variety	15	Tarom-Salati	Iranian local variety
6	Tarom-Amrollahi	Iranian local variety	16	Champamelo	Iranian local variety
7	Amol1	Breeding variety	17	Kinangpatong	Drought tolerant
8	Tarom-Jelodar	Breeding variety	18	Arias halus	Drought tolerant
9	Jahesh	Breeding variety	19	IR64	Drought sensitive
10	Kadoos	Breeding variety			

The experiment was performed using a factorial RCBD design with three replications under greenhouse condition. The experimental factors were different levels of drought stress (non-stress, drought stress with re-irrigation in the booting stage and drought stress without re-irrigation) and rice genotypes. The common agronomical practices and plant protection measures were followed to obtain a normal plant. Total nutrient input was 200 kg/ha urea, 100kg/ha ammonium phosphate, 150 kg/ha sulphate potassium and 40 kg/ha zinc sulphate. At the seedling stage, the seedlings were transplanted into the 30×35 cm plastic pots. Seventeen traits (Table 2) were recorded based on standard evaluation system rice (IRRI, 2002).

Table 2: Measured traits of the rice genotypes.

Trait number	Name	Abbreviation	Trait number	Name	Abbreviation
1	Panicle Length (cm)	PaL	11	Grain Thickness (mm)	GT
2	Flag Leaf Width (cm)	FLW	12	Grain Width (mm)	GW
3	Flag Leaf Length (cm)	FLL	13	Grain Length (mm)	GL
4	Tiller Length (cm)	TL	14	100 Grain Weight (g)	100GW
5	Peduncle Length (cm)	PeL	15	Plant Height (cm)	PH
6	No. of Filled Grains/panicle	NFG	16	No. Tillers/Plant	NT
7	No. of Unfilled Grains/panicle	NUG	17	Yield (g/plant)	Y
8	No. of Grains/panicle	NG			
9	No. of Primary Panicles	NPP			
10	No. of Secondary Panicles	NSP			

Statistical analysis including Pearson correlation coefficients between traits and path analysis was done under two drought conditions included drought stress with re-irrigation and drought stress without re-irrigation using SPSS software ver.24.

RESULTS AND DISCUSSION

A. Correlation

The result of correlation analysis under drought stress with re-irrigation and without re-irrigation (severe drought tolerance) showed that grain yield hada significantly positive correlation with number of filled grains per panicle and 100 grain weight (Table 3). Consequently, these traits are suitable factors for breeding for grain yield of rice under drought stress with re-irrigation in the booting stage.

Correlation between the traits under stress conditions is an important factor for breeding complex traits such as yield for environmental stresses such as drought (Hasheminasab *et al*., 2012).

A significant positive correlation of grain yield with number of filled grains per panicle and 100 grain weight was supported by earlier researchers such as Chakraborty *et al*. (2001) for 100 seed weight; Ismail and Alvarez (1986), Rao and Srivastava (1999) and Rajeshwari and Nandrajan (2004) for number of filled grains per panicle. Also, Guimarães *et al*. (2013) revealed that grain yield under water stress was significantly and positively correlated with tiller fertility, number of panicles, 100 grain weight and plant height.

Table 3: Pearson correlation coefficients of the traits in 19 rice genotypes under two drought conditions.

	Drought stress with re-irrigation																
	PaL	**FLW**	**FLL**	**TL**	**PeL**	**NFG**	**NUG**	**NG**	**NPP**	**NSP**	**GT**	**GW**	**GL**	**100GW**	**PH**	**NT**	**Y**
PaL	1	-.212	-.266	.645**	0.390	.007	.044	.017	-.019	.031	.29	.39	-.238	.263	.45	.055	-.033
FLW	-0.115	1	.383	-.004	-0.120	.551*	.042	.466*	.590**	.555*	.159	-.182	-.242	.351	.022	-.284	.264
FLL	-.473*	.547*	1	-.017	0.148	.046	-.002	.010	.030	.223	-.390	-.282	-.144	-.263	.110	-.077	.126
TL	0.271	0.286	-0.034	1	0.092	-.150	-.206	-.337	-.269	-.235	-.129	.403	-.426	.024	.568*	-.162	.028
PeL	0.333	0.092	0.189	0.417	1	-.027	.481*	.417	.252	.436	.223	.163	.164	.071	.600**	.280	-.192
NFG	0.258	0.456*	0.058	0.350	-0.184	1	-.318	.536*	.658**	.568*	.444	-.070	-.184	.536*	.273	-.351	.599**
NUG	0.294	0.403	0.083	0.100	.486*	0.081	1	.628**	.332	.565*	.240	.168	.303	.139	-.148	.599**	-.455
NG	0.34	0.426	0.029	0.131	0.414	0.243	.980**	1	.831**	.959**	.585**	.090	.139	.543*	.095	.243	.066
NPP	-0.004	0.552*	0.150	-0.133	0.082	0.16	.780**	.791**	1	.822**	.577**	-.093	.007	.526*	.020	.032	.281
NSP	0.188	0.478*	0.125	-0.041	0.224	0.208	.931**	.941**	.883**	1	.471*	.028	.109	.532*	.176	.191	.189
GT	-0.287	0.045	0.122	0.021	-0.222	-0.048	-0.07	-0.076	0.060	0.071	1	.258	-.055	.509*	.118	.222	-.098
GW	0.292	0.264	-0.016	0.366	0.149	.460*	0.304	0.380	0.020	0.194	0.050	1	-.525*	.330	.326	.125	-.213
GL	0.290	-0.118	-0.106	-0.018	0.342	-0.069	0.352	0.333	0.361	0.301	-0.243	-0.287	1	-.003	-.188	.528*	.145
100GW	0.384	0.087	0.056	0.157	-0.017	0.383	-0.33	-0.268	-0.292	-0.308	-0.102	-0.02	0.274	1	.186	.106	.483*
PH	0.240	0.14	0.276	0.774**	0.490*	0.229	0.204	0.200	-0.095	0.062	0.008	0.248	0.169	0.099	1	-.149	.101
NT	0.043	-0.417	-0.004	-0.422	0.371	-.645**	0.097	-0.003	0.003	-0.014	-0.184	-0.446	.660**	0.103	-0.160	1	-.201
Y	0.125	0.333	0.148	0.322	0.127	.686**	0.023	0.151	0.178	0.056	-0.293	0.137	0.324	.466*	0.286	-0.147	1
Drought stress without re-irrigation																	

* = significant at P<0.05; ** = significant at P<0.01; ns = non-significant.

Path analysis

The direct and indirect coefficients of the measured traits on grain yield in the rice genotypes were calculated separately under post-drought recovery upon re-watering in booting stage and without re-irrigation (Tables 4 and 5). The path coefficient analysis in the drought stress with re-irrigation showed that number of primary panicles (0.521**), grain length (0.335*) and 100 grain weight (0.398**) had significantly positive direct effects on grain yield. Also, grain thickness had a negatively direct effect (- 0.480**) on the grain yield (Table 4). Furthermore, in the drought stress without re-irrigation, number of filled grains per panicle had a significantly positive (0.714**) and grain thickness had a significantly negative (-0.286*) direct effect on grain yield.

Table 4: Direct and indirect effects of the traits on grain yield in 19 rice genotypes under drought stress with re-irrigation.

	PaL	FLW	FLL	TL	PeL	NFG	NUG	NG	NPP	NSP	GT	GW	GL	100GW	PH	NT
PaL	**0.123**	-0.021	-0.030	0.073	0.044	0.004	0.002	0.002	-0.004	0.004	0.032	0.041	-0.027	0.029	0.051	0.006
FLW	0.025	**-0.149**	-0.054	0.001	0.009	-0.077	-0.003	-0.067	-0.082	-0.075	-0.019	0.024	0.033	-0.046	-0.003	0.034
FLL	-0.035	0.052	**0.144**	-0.005	0.011	-0.004	0.003	-0.003	0.004	0.020	-0.043	-0.032	-0.014	-0.033	0.014	-0.005
TL	0.060	-0.001	-0.003	**0.100**	0.013	-0.011	-0.016	-0.026	-0.022	-0.019	-0.011	0.039	-0.036	0.005	0.055	-0.016
PeL	-0.039	0.007	-0.008	-0.014	**-0.107**	-0.003	-0.049	-0.047	-0.030	-0.048	-0.021	-0.018	-0.021	-0.004	-0.057	-0.028
NFG	0.024	0.341	-0.019	-0.075	0.021	**0.666**	-0.223	0.343	0.370	0.374	0.258	-0.048	-0.123	0.331	0.173	-0.226
NUG	-0.002	-0.002	-0.002	0.015	-0.042	0.031	**-0.091**	-0.055	-0.031	-0.048	-0.017	-0.013	-0.028	-0.005	0.013	-0.050
NG	-0.011	-0.270	0.015	0.155	-0.264	-0.310	-0.364	**-0.602**	-0.472	-0.548	-0.276	-0.038	-0.084	-0.253	-0.053	-0.131
NPP	-0.017	0.287	0.014	-0.115	0.146	0.289	0.177	0.408	**0.521****	0.410	0.246	-0.042	0.022	0.211	0.022	0.030
NSP	0.003	0.054	0.015	-0.020	0.048	0.060	0.056	0.098	0.085	**0.107**	0.044	0.003	0.012	0.049	0.020	0.018
GT	-0.125	-0.062	0.143	0.051	-0.092	-0.186	-0.090	-0.220	-0.227	-0.199	**-0.480****	-0.130	0.013	-0.245	-0.061	-0.105
GW	0.022	-0.011	-0.015	0.026	0.011	-0.005	0.009	0.004	-0.005	0.002	0.018	**0.067**	-0.030	0.021	0.021	0.009
GL	-0.073	-0.074	-0.033	-0.119	0.066	-0.062	0.101	0.047	0.014	0.037	-0.009	-0.151	**0.335***	0.007	-0.051	0.167
100GW	0.096	0.122	-0.091	0.021	0.015	0.197	0.021	0.167	0.161	0.182	0.203	0.124	0.008	**0.398****	0.081	0.038
PH	-0.029	-0.002	-0.007	-0.038	-0.037	-0.018	0.010	-0.006	-0.003	-0.013	-0.009	-0.021	0.010	-0.014	**-0.069**	0.010
NT	0.004	-0.019	-0.003	-0.013	0.021	-0.028	0.045	0.018	0.005	0.014	0.018	0.011	0.041	0.008	-0.012	**0.081**

* = significant at P<0.05; ** = significant at P<0.01; ns = non-significant.

Table 5: Direct and indirect effects of four traits on grain yield in 19 rice genotypes under drought stress without re-irrigation.

	PaL	FLW	FLL	TL	PeL	NFG	NUG	NG	NPP	NSP	GT	GW	GL	100GW	PH	NT
PaL	**-0.298**	0.032	0.128	-0.082	-0.076	-0.075	-0.064	-0.083	-0.019	-0.057	0.054	-0.078	-0.084	-0.105	-0.073	-0.010
FLW	-0.008	**0.074**	0.039	0.019	0.007	0.027	0.026	0.028	0.035	0.033	0.002	0.019	-0.006	0.006	0.012	-0.028
FLL	0.045	-0.055	**-0.105**	0.005	-0.019	-0.007	-0.004	-0.002	-0.011	-0.011	-0.012	0.000	0.011	-0.007	-0.028	0.001
TL	0.010	0.010	-0.002	**0.037**	0.016	0.009	0.004	0.006	-0.001	0.001	0.004	0.011	0.001	0.005	0.025	-0.011
PeL	0.048	0.018	0.035	0.079	**0.187**	-0.015	0.085	0.098	0.040	0.061	0.006	0.027	0.056	0.010	0.090	0.057
NFG	0.179	0.264	0.046	0.171	-0.055	**0.714****	-0.048	0.096	0.106	0.103	0.119	0.256	-0.020	0.275	0.148	-0.378
NUG	-0.012	-0.020	-0.002	-0.006	-0.025	0.004	**-0.056**	-0.051	-0.039	-0.048	0.008	-0.015	-0.018	0.014	-0.011	-0.007
NG	-0.002	-0.002	0.000	-0.001	-0.003	-0.001	-0.006	**-0.006**	-0.004	-0.006	0.001	-0.002	-0.002	0.001	-0.002	0.000
NPP	0.014	0.106	0.024	-0.006	0.048	0.033	0.157	0.155	**0.225**	0.178	0.005	-0.005	0.081	-0.040	0.007	0.003
NSP	-0.037	-0.085	-0.021	-0.005	-0.062	-0.028	-0.165	-0.171	-0.152	**-0.192**	0.000	-0.037	-0.059	0.048	-0.026	0.000
GT	0.051	-0.006	-0.033	-0.033	-0.010	-0.048	0.042	0.024	-0.007	0.001	**-0.286***	-0.016	0.051	-0.011	-0.024	0.025
GW	0.007	0.007	0.000	0.008	0.004	0.010	0.007	0.008	-0.001	0.005	0.001	**0.027**	-0.007	0.000	0.006	-0.010
GL	0.024	-0.007	-0.009	0.002	0.026	-0.002	0.029	0.029	0.031	0.027	-0.015	-0.021	**0.086**	0.023	0.015	0.050
100GW	0.070	0.016	0.014	0.025	0.010	0.076	-0.048	-0.034	-0.035	-0.050	0.008	-0.004	0.052	**0.197**	0.028	0.016
PH	0.032	0.020	0.035	0.089	0.063	0.027	0.026	0.032	0.004	0.018	0.011	0.030	0.022	0.018	**0.131**	-0.015
NT	0.007	-0.074	-0.002	-0.060	0.059	-0.103	0.025	0.005	0.003	0.000	-0.017	-0.072	0.113	0.016	-0.022	**0.194**

* = significant at P<0.05; ** = significant at P<0.01; ns = non-significant.

As there are many traits affecting grain yield, splitting the total correlation into direct and indirect effects of cause would give more understanding to the cause of relationship between the yield as dependent trait and independent trait such as yield component traits (Nandan *et al.,* 2010).

Since, number of filled grains per panicle had the highest significantly positive direct effect (0.714**) on grain yield in the drought stress without re-irrigation and also showed a significant positive correlation with grain yield under the two drought conditions, therefore, this trait can be used as a useful indicator for indirect selection of grain yield in screening for drought tolerance in drought breeding programs. In a study, Chavan and Lal (2014) reported a positive direct effect of number of seeds per panicle and percent filled grains traits on yield under drought condition.

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