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Variability, correlation and path analysis in drought tolerant rice (*Oryza sativa* L.)

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ABSTRACT

Yield contributing traits in thirty three rice genotypes were studied for variances, heritability, correlation (genotypic and phenotypic) and path coefficient analysis. The highest phenotypic variation (σ2p), was found for No. of grain per panicle and the lowest was observed in 100 grain wt. High genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for No. of unfilled grains per panicle, No. of grains per panicle and grains yield per hill, indicated that selection of these traits would be effective. The high heritability estimates along with low genetic advance indicates that non-additive type of gene action and genotype-environment interaction plays a significant role in the expression of the traits as observed in days to 50% flowering, No. of tillers per hill days to harvesting and panicle length (cm). No. of grains per panicle with grains yield per hill as well as length showed significant and positive correlation but No. of tillers per hill showed highly significant and negative correlation with days to 50% flowering both at genotypic and phenotypic level. Path coefficient analysis showed that No. of grains per panicle had maximum direct effect on grain yield followed by No. of panicles per hill, and No. of tillers per hill. The lowest direct effect on grain yield was exhibited by No. of unfilled grains (0.0732) followed by plant height, No. of primary branches per panicles, and No. of secondary branches per panicles respectively. Number of grains per panicle had maximum direct effect on grain yield followed by No. of panicles per hill and No. of tillers per hill. The results prescribed that there is a highly significant positive correlation with positive direct effect was observed in No. of grains per panicle, No. of panicles per hill, No. of unfilled grains per panicle, No. of primary branches and No. of secondary branches.

Key Words: *Genetic variability, heritability, character association, and path coefficient analysis*

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I. Introduction

Rice (*Oryza sativa* L.), the main cereal crop and staple food, is produced 33.80 million metric ton from 74.85% cropped area of Bangladesh (BBS, 2017). Bangladesh has achieved self-sufficiency in cereal production, but there is still a large gap between the production and demand. We need to produce more rice in per unit of area. Sustainable success and self-sufficiency in rice production and maintaining price stability are important political objectives in countries where rice provides food security and generates employment and income for people (Hossain, 1995). More than 50% of the world's rice area is under rainfed culture where drought is the major limiting factor to rice production. Drought is a crucial climatic phenomenon, just after the soil fertility severely limits to rice production (Caldo *et al.*, 1996). Grain yield, is a complex quantitative trait of any crop. Different morphological and physiological traits contribute to plant yield. These yield contributing components are interrelated with each other showing a complex chain of relationship and also highly influenced by the environmental conditions (Prasad *et al.*, 2001). Strategy of rice breeding mainly depends on the degree of associated traits as well as its magnitude and nature of variation (Zahid *et al.*, 2006; Prasad *et al.*, 2001). Information on correlation coefficient is always helpful for selection in a breeding program. Path coefficient analysis is a meaningful way partitions into direct and indirect matrix presenting correlation (Mohsin *et al.*, 2009). The concept of path analysis was first used for plant selection by Dewey and Lu in 1959, Path coefficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects. Grafius (1959) suggested that there may not be only one gene for yield per seed, rather for various components, the multiplicative interaction of many genes result in the yield. The present research study was conducted to find out the genetic variability among different plant traits, direct and indirect contribution of these traits towards rice yield and to identify better combinations as selection criteria for developing high yielding drought tolerant rice genotypes.

II. Materials and Methods

The experiment was conducted with 33 rice genotypes including two checks varieties at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) campus of Bangladesh during May to July 2009 to determine the genotypic and phenotypic correlation along with their direct and indirect effects through path coefficient analysis in rice considering 12 morphological characters as most important characters towards yield. Experiment was laid out in randomized completed block design (RCBD). The field was divided into three blocks; they were subdivided into thirty three plots where genotypes were randomly assigned. The unit plot size was 8 m × 2.5 m and 20 cm respectively. The genotypes were distribution to each plot within each block randomly. Weeds and stubbles were removed and land was finally prepared by the addition of basal dose of fertilizers and the experimental plot was fertilizer by applying urea, TSP, MoP and Gypsum @ 180-100-70-60 kg/ha respectively. Total TSP, MoP and Gypsum were applied at final land preparation. Total urea was applied in three installments, at 15 days after sowing (DAS), 30 DAS and 50 DAS recommended by BSMRAU (Anonymous, 1999).

Data were collected from 5 hills of each genotype on individual plant basis. Data for 12 quantitative traits such as plant height, Days to 50% flowering, Number of tillers per plant, Days to harvesting, No. of panicles per hill, Panicle length (cm), No. of primary branches per panicle, No. of secondary branches per panicle, No. of grains per panicle, No. of unfilled grains per panicle, 100 grain weight (g), Yield per hill (g). The collected data were subjected for analyzing Phenotypic (P) and Genotypic correlation coefficient among various pairs of 12 characters of 33 diverse genotypes.

III. Results and Discussion

Variability, heritability and genetic advance

Highly significant variation was observed among the genotypes for all the parameters in this experiment which revealed the presence of variability among the genotypes. The estimates of genotypic variation (σ^2g), phenotypic variation (σ^2p), genotypic coefficient of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2_b) and genetic advance (GA)

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for different characters have been presented in Table 01. The highest σ^2g was found for grains per panicle (318.41) and the lowest magnitude of σ^2g was observed in 100 grain wt (0.01). The highest σ^2p was found for grains per panicle (354.24) and the lowest magnitude of $\sigma^2p$was observed in 100 grain wt (g) (0.06).

The GCV and PCV were the highest for No. of unfilled grains (28.95 and 31.31) followed by yield per hill (22.90 and 24.43), No. of grains per panicle (22.81 and 24.06) (Table 01). High GCV and PCV for No. of unfilled grains per panicle, yield per hill (g) and No. of grains per panicle indicated that selection of these traits would be effective. The GCV and PCV were the lowest for days to 50% flowering (1.55 and 2.69) and days to harvesting (1.97 and 2.86) PCV were slightly higher than GCV in case of all the traits, indicating presence of environmental influence to some digress in the phenotypic expression of the characters. Akanda *et al.,* (1997) also reported similar result. High GCV and PCV were recorded for unfilled grains per panicle, yield per hill, No. of grains per panicle but it was moderate for No. of secondary branch per panicle (14.32 and 18.62). The finding was supported by Saravanan and Senthil (1997) who observed high GCV and PCV for grains per panicle and moderate for hill height and 1000 grain weight in rice. Days to harvesting and days to 50% flowering exhibited low genotypic as well as phenotypic coefficient of variation in the present study which may be due to present of both positive and negative alleles in the population. High heritability was observed in No. of grains per panicle (89.88), plant height (88.37cm), yield per hill (87.89 g), No. of unfilled grains (85.51) but for No. of panicles per hill (30.51). Days to 50% flowering (33.20) heritability was low. Bhatti *et al.* (1998) reported high heritability for spikelet's per panicle, 1000-grain weight and panicles per hill in rice. High heritability estimates have been found to be effective in the selection of superior genotypes on the basis of phenotypic performance. High heritability associated with high genetic advance was obtained in No. of grains per panicle and No. of unfilled grains per panicle. The result also had close agreement with the findings of Hossain and Haque (2003) and Iftekharuddaula *et al.,* (2001), Grain yield per hill, filled grains per panicle and spikelet sterility had moderate heritability with moderate genetic advance, Kumar *et al.,* (2006) also reported that traits exhibited high heritability along with high to moderate genetic advance suggesting that these characters could be of high importance for selecting better genotypes in rice improvement program.

Table 01. Estimation of genetic parameters of thirty three rice genotypes with three check varieties

Characters	MSG	MSE	Grand mean	σ2g	σ2p	GCV	PCV	h2b	GA	GA (%)
Plant height (cm)	270.87	11.38	114.71	86.49	97.87	8.10	8.62	88.37	18.01	15.70
No. of tiller/hill	20.06	3.05	17.81	5.67	8.71	13.36	16.57	65.05	3.95	22.20
Days to 50% flowering	6.46	2.59	73.15	1.28	3.88	1.55	2.69	33.20	1.34	1.84
Days to maturity	12.37	1.92	94.40	3.48	5.40	1.97	2.46	64.49	3.08	3.27
No. of panicle/ hill	8.82	3.81	12.99	1.67	5.47	9.95	18.01	30.51	1.47	11.32
Panicle length (cm)	16.42	2.06	23.33	4.78	6.84	9.37	11.21	69.91	3.76	16.15
No. of primary branches	2.82	0.28	11.06	0.84	1.12	8.32	9.58	75.38	1.64	14.88
No. of secondary branches	48.79	9.12	25.38	13.22	22.33	14.32	18.62	59.19	5.76	22.70
No. of grain/panicle	991.07	35.83	78.21	318.4	354.24	22.81	24.06	89.88	34.85	44.55
No. unfilled grain/panicle	242.71	12.97	30.21	76.58	89.55	28.95	31.31	85.51	16.67	55.16
100 grain wt(g)	0.11	0.05	2.61	0.01	0.06	5.17	10.06	26.44	0.14	5.48
yield per hill(g)	116.7	5.12	26.62	37.19	42.31	22.90	24.43	87.89	11.77	44.24

MS_G= Mean sum of squares due to genotypes, MS_E= Mean sum of squares due of error, σ^2g = Genotypic variance, σ^2p = Phenotypic variance, GCV= Genotypic coefficient of variance, PCV= Phenotypic coefficient of variation, h^2_b= Heritability and GA= Genetic advance.

The mean, range, CV (%) and the grain yield and yield contributing characters among 33 drought tolerant rice genotypes are presented in Table 02. Variations were observed among the genotypes for

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all characters studied. The percent of highest co-efficient of variation (CV %) was recorded in the characters of No. of panicle per hill (15.02) followed by the No. of secondary branches (11.90). The minimum variation was observed in the character days to harvesting (1.47) and days to 50% flowering (2.20) (Table 02).

Table 02. Range, mean, CV (%) value and yield contributing characters of 33 drought tolerant rice genotypes

Characters	Range	Mean	Standard error	CV (%)
Plant height (cm)	135.200-92.533	114.714	1.654	2.94
No of tiller/hill	22.333-12.000	17.818	0.450	9.80
Days to 50% flowering	76.667-71.00	73.152	0.255	2.20
Days to harvesting	98.000-91.667	94.404	0.353	1.47
No. of panicle/ hill	16.333-10.00	12.99	0.299	15.02
Panicle length (cm)	29.233-17.520	23.333	0.407	6.15
No. of primary branches	12.800-9.133	11.069	0.169	4.75
No. of secondary branches	33.533-10.187	25.381	0.702	11.90
No. of grain/panicle	113.00-44.07	78.219	3.164	7.65
No. unfilled grain/panicle	52.533-13.600	30.219	1.566	11.92
100 grain wt(g)	2.993-2.283	2.615	0.033	8.62
Yield per hill(g)	40.847-11.427	26.62	1.086	8.50

Correlation

Correlation analysis among agronomic traits (Table 03) revealed that the genotypic correlation coefficient were higher that the corresponding phenotypic correlation coefficients in most cases. Accordingly, Bai *et al*., (1992) reported that the genotypic correlations were greater than the phenotypic values in medium durated rice varieties. From the study, yield per hill (g) was found positive and highly significant association with filled grains per panicle and panicle length (cm) both at genotypic and phenotypic levels (Table 03). Plant height showed significant and positive correlation with panicle length (cm), No. of secondary branches, No. of grains per panicle at both level (Table 03). Days to 50% flowering were highly significant with days to harvesting at both genotypic and phenotypic level. Panicle length (cm) showed highly significant positive correlation with No. of primary branches, No. of secondary branches, No. of grains per panicle and with yield per hill at both genotypic and phenotypic level. Primary branches had significant and positive association with No. of secondary branches, No. of grains per panicle and with grain yield per hill at both genotypic and phenotypic level. No. of secondary branches had significant positive correlation with No. of grains per panicle and grain yield per hill. No. of filled grain per panicle had highly significant and positive correlation with grain yield per hill at both genotypic and phenotypic level.

Days to 50% flowering had non-significant negative association with No. of panicles per hill, No. of grains per panicle and with grain yield per hill at both genotypic and phenotypic level as well as plant height and significant negative correlation with No. of tillers per hill at both level of correlation. No. of tillers per hill had significant negative correlation with days to 50% flowering at both level but with panicle length (cm) had significant negative correlation at genotypic level and non-significant at phenotypic level (Table 03). Similar associations in rice were also reported by Ogunbayo *et al.* (2005). However, the correlation study revealed that grain yield, days to 50% flowering, days to harvesting No. of panicle No. of panicles per hill. Panicle length (cm), grains per panicle, unfilled grains per panicle, were the important characters to be considered in the selection for improvement of drought tolerant rice genotypes.

Path Coefficient Analysis

Determination of association among the traits by correlation co-efficient may not provide correct idea of the relative importance of direct and indirect effect of each yield contributing characters towards yield. By using path analysis, direct and indirect effect were work out to find out the clear idea of inter relationship between yield and yield contributing characters. The results of path analysis (Table 04) revealed that No. of grains per panicle had maximum direct effect (0.5618) on grain yield followed by No. of panicles per hill (0.3981), and No. of tillers per hill (0.2062). The lowest direct effect on grain yield was exhibited by No. of unfilled grains (0.0732) followed by plant height (0.0845), No. of primary

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branches per panicles (0.0854), and No. of secondary branches per panicles (0.0816) respectively. Number of grains per panicle had maximum direct effect (0.5618) on grain yield followed by No. of panicles per hill (0.3981) and No. of tillers per hill (0.2062). The results prescribed that there is a highly significant positive correlation with positive direct effect was observed in No. of grains per panicle, No. of panicles per hill, No. of unfilled grains per panicle, No. of primary branches and No. of secondary branches.

The residual effect of the study was 0.1260 indicating the variability of grain yield per hill was contributed by the twelve characters studied in the path analysis. Similar findings (R-0.766) were fund by Mojumder (2009). From path coefficient analysis, it was observed that plant height had highly positive direct effect on yield per hill at both genotypic (0.084) and phenotypic (0.136) level of coefficient. This character had high negative indirect effect with No. of tiller per hill, days to 50% flowering, days to harvesting and with No. of unfilled grain per panicle at genotypic level of coefficient. Only positive indirect effect of plant height on yield per hill was observed in case of 100 grain wt (0.00891) at phenotypic level of coefficient. No. of tiller/hill had highly positive direct effect on yield per hill (g) at both genotypic (0.2062) and phenotypic (0.2359) level of coefficient. Positive indirect effect of this character on yield per hill was found in 100 grain wt (g) as (0.00162) at genotypic level but it shown positive indirect effect of this character on yield per hill in case of phenotypic (-0.0577) level of coefficient (Table 04 and 05). This parameter had positive indirect effect on yield via days to 50% flowering, No. of panicle per hill, and No. of unfilled grain per panicle at both level of coefficient. In both level this trait also shown negative indirect effect on yield per hill via plant height, Days to harvesting, panicle length (cm), No. of primary branches, No. of secondary branches, No. of grain per panicle.

The character days to 50% flowering had high negative direct effect on yield at both genotypic (-0.0288) and phenotypic (-0.0834) level and this trait had negative effect on yield per hill at both genotypic (-0.059) and phenotypic (-0.038) level. This trait had positive indirect effect on yield via plant height, days to maturity, panicle length (cm), No. of primary branches, No. of secondary branches, No. of unfilled grained per panicle at both level of path coefficient. Days to harvesting had high and positive direct effect on yield per hill at both genotypic (0.01716) and phenotypic (0.249) level and had highly positive indirect effect on yield per hill via No. of panicle per hill, panicle length (cm), no .of primary branches, No. of secondary branches, No. of grain per panicle, No. of unfilled grain per panicle and 100 grain weight (g) at both level of coefficient plant height, (cm), No. of tiller per hill, days to 50% flowering should indirect negative effect on yield at both level (Table 04 and 05). No. of panicle per hill had highly positive direct effect at both genotypic (0.3981) and phenotypic (0.3528) and highly positive indirect effect on yield via No. of tiller per hill, days to 50% flowering, days to harvesting, No. of primary branches, No. of unfilled grain per panicle and 100 grain wt (g), No. of panicle per hill also showed negative indirect effect though plant height, panicle length (cm), No. of secondary branches and No. of grain/panicle on yield per hill.

Panicle length (cm) had highly positive direct effect on yield at both genotypic (0.1342) and phenotypic (0.0539) and highly positive indirect effect on yield per hill via plant height, days to maturity, No. of primary branched, No. of secondary branches, No. of grains per panicle, and No. of unfilled grain per panicle at both level of coefficient. 100 grain wt (g) had also positive indirect effect on yield at phenotypic level of coefficient (Table 04) where 100 grain wt (g) showed negative on yield at genotypic level panicle length (cm) also showed negative indirect effect on yield through No. of tiller per hill, days to say flowering and No. of panicle per hill at both level. No. of primary branches had highly positive direct effect on yield at both genotypic (0.0854) and phenotypic (0.1104) level of coefficient and highly indirect positive effect on yield via plant height, days to maturity, No. of panicle per hill, panicle length (cm), No. of secondary branches, No. of grain per panicle, No. of unfilled grain per panicle on yield per hill at both level of coefficient. 100 grain wt (g) had negative indirect effect on yield at genotypic level of coefficient but had indirect positive effect on yield per hill (g) at phenotypic effect of coefficient. Negative indirect effect was found on No. of tiller per hill and on days to 50 % flowering at both level.

No. of secondary branches had highly positive direct effect on yield at both genotypic (0.0866) and phenotypic (0.1042) level and also had positive indirect effect via plant height, days to harvesting,

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panicle length (cm), No. of primary branches, No. of grain per panicle, No. of unfilled grain per panicle, and yield per hill (g) at both genotypic and phenotypic level of coefficient. 100 grain wt (g) had indirect positive effect on yield per hill at phenotypic level of coefficient where it had negative indirect effect on yield per hill at genotypic level of coefficient. No. of tiller per hill, days to 50% flowering, No. of panicle per hill had indirect negative effect on yield per hill. From path coefficient analysis it was observed that No. of grain per panicle had highly positive direct effect on yield per hill (g) at both genotypic (0.5618) and phenotypic (0.5549) level. This trait had negative indirect effect on yield via No. of tiller per hill, and No. of panicle per hill both genotypic and phenotypic level of path coefficient (Table 04 and 05).

No. of unfilled grain per panicle had positive direct effect on yield per hill at both level of path coefficient. No. of tiller per hill, days to harvesting, No. of panicle per hill, panicle length (cm) (cm), No. of primary branches, No. of secondary branches, No. of grain per panicle had positive indirect effect on yield per hill at both level of coefficient and 100 grain wt (g) had positive indirect effect on yield at phenotypic level of coefficient whereas 100 grain wt (g) showed negative indirect effect on yield per hill, plant height (cm), days to 50% flowering. 100 grain wt (g) had positive direct effect on yield at phenotypic level of coefficient. It had negative direct effect on yield per hill at genotypic level of coefficient and indirect positive effect on yield per hill via plant height, No. of panicle per hill, panicle length (cm), No. of primary branched, No. of secondary branches, No. of unfilled grain per panicle at genotypic level of coefficient and plant height, days to harvesting, No. of panicle per hill, panicle length (cm), No. of primary branches, No. of secondary branches, No. of grain per panicle, No. of unfilled grain per panicle had shown indirect positive effect on yield per hill at phonotypic level of coefficient. It had indirect negative effect on yield per hill through No. of tiller per hill, days to 50% flowering, days to harvesting and No. of grain per panicles at genotypic level of coefficient whereas it shown indirect negative effect via No. of tiller per hill and days to 50% flowering on yield per hill at phenotypic level of path coefficient respectively.

IV. Conclusion

Wide variability's have been found among the genotypes for all traits. The results of the experiment will help the breeders to develop desirable drought tolerant plant types with high yield and early maturity. Analyzed data from genotypic and phenotypic coefficient of variation, heritability and genetic advance, correlation co-efficient and even path coefficient, No. of unfilled grains per panicle, No. of grains per panicle and grains yield per hill, indicated that selection of these traits would be effective for further hybridization program.

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Table 03. Genotypic (r_g) correlation and phenotypic (r_p) correlation coefficient among 33 rice genotypes with two check varieties

Characters		No. of tiller/hill	Days to 50% flowering	Days to harvesting	No. of panicle/ hill	Panicle length (cm)	No. of primary branches	No. of secondary branches	No. of grain/ panicle	No. of unfilled grain/panicle	100 grain wt.(g)	Yield per hill(g)
Plant height (cm)	r_g	-0.346*	0.278	-0.088	-0.217	0.673**	0.394*	0.456**	0.542**	-0.004	0.246	0.368*
	r_p	-0.332*	0.264	-0.092	-0.219	0.655**	0.387*	0.451**	0.530**	-0.007	0.196	0.364*
No. of tiller/hill	r_g		-0.401*	-0.160	0.487**	-0.343*	-0.020	-0.049	-0.134	0.185	-0.117	0.243
	r_p		-0.410*	-0.193	0.444**	-0.322	-0.004	-0.066	-0.124	0.175	-0.127	0.246
Days to 50% flowering	r_g			0.593**	-0.090	0.178	0.019	0.038	-0.118	0.182	0.286	-0.050
	r_p			0.580**	-0.117	0.222	0.042	0.035	-0.066	0.159	0.178	-0.038
Days to harvesting	r_g				0.129	0.090	0.048	0.088	0.063	0.301	-0.002	0.247
	r_p				0.093	0.078	0.048	0.064	0.059	0.281	0.002	0.244
No. of panicle/ hill	r_g					-0.181	0.190	-0.068	-0.270	0.284	0.099	0.359*
	r_p					-0.137	0.133	-0.079	-0.267	0.273	0.038	0.332*
Panicle length (cm)	r_g						0.580**	0.690**	0.696**	0.260	0.312	0.574**
	r_p						0.568**	0.680**	0.687**	0.242	0.247	0.563**
No. of primary branches	r_g							0.572**	0.544**	0.274	0.241	0.648**
	r_p							0.566**	0.535**	0.252	0.247	0.633**
No. of secondary branches	r_g								0.728**	0.339*	0.193	0.675**
	r_p								0.702**	0.325*	0.182	0.655**
No. of grain/panicle	r_g									0.025	-0.034	0.692**
	r_p									0.017	0.006	0.695**
No. unfilled grain/panicle	r_g										0.165	0.371*
	r_p										0.141	0.353*
100 grain wt(g)	r_g											0.086
	r_p											0.114

* Indicates significant at 5% level of significance, ** indicates significant at 1% level of significance
Legend: r_g indicates genotypes correlation coefficient and r_p indicates phenotypic correlation coefficient.

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Table 04. Path coefficient analysis (on genotypic value) showing direct effect (bold) and indirect effect of 12 characters on drought tolerant rice genotypes

Characters	Plant height (cm)	No. of tiller/hill	Days to 50% flowering	Days to harvesting	No. of panicle/ hill	Panicle length (cm)	No. of primary branches	No. of secondary branches	No. of grain/ panicle	No. unfilled grain/panicle	100 grain wt(g)	Yield per hill(g)
Plant height (cm)	**0.0845**	-0.0713	-0.00801	-0.0863	-0.0864	0.0903	0.0337	0.0395	0.3045	-0.00029	-0.0034	0.368*
No. of tiller/hill	-0.0292	**0.2062**	0.0116	-0.0274	0.1939	-0.0460	-0.00171	-0.0042	-0.0752	0.0137	0.00162	0.243
Days to 50% flowering	0.0235	-0.0827	**-0.0288**	0.1017	-0.0358	0.0238	0.0016	0.00329	-0.0663	0.0135	-0.00396	-0.050
Days to harvesting	-0.0074	-0.0329	-0.0171	**0.1716**	0.0513	0.0121	0.0041	0.0076	0.0354	0.0224	0.00003	0.247
No. of panicle/ hill	-0.0183	0.1004	0.0026	0.0221	**0.3981**	-0.0243	0.0162	-0.0059	-0.152	0.0210	-0.0014	0.359*
Panicle length (cm)	0.0569	-0.0707	-0.0051	0.0154	-0.0721	**0.1342**	0.0495	0.0598	0.399	0.0193	-0.0043	0.574**
No. of primary branches	0.0333	-0.0041	-0.00055	0.00823	0.0756	0.0778	**0.0854**	0.0495	0.3055	0.0203	-0.0033	0.648**
No. of secondary branches	0.0385	-0.0101	-0.0109	0.0151	-0.0271	0.0926	0.0488	**0.0866**	0.4089	0.0252	-0.0027	0.675**
No. of grain/panicle	0.0458	-0.0276	0.0034	0.0108	-0.1075	0.0934	0.0465	0.0631	**0.5618**	0.00185	0.00047	0.692**
No. unfilled grain/panicle	-0.00034	0.0381	-0.00525	0.0516	0.1131	0.0349	0.0234	0.0294	0.0140	**0.0743**	0.00229	0.371*
100 grain wt(g)	0.0207	-0.0241	-0.0082	-0.00034	0.0394	0.0419	0.0206	0.0167	-0.0191	0.01226	**-0.0139**	0.086

Note: Bold and diagonal figures indicate the direct effect, Residual effect: 0.1260

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Table 05. Path coefficient analysis (on phenotypic value) showing direct effect (bold) and indirect effect of 12 characters on drought tolerant rice genotypes

Characters	Plant height (cm)	No. of tiller/hill	Days to 50% flowering	Days to harvesting	No. of panicle / hill	Panicle length (cm)	No. of primary branches	No. of secondary branches	No. of grain/ panicle	No. unfilled grain/ panicle	100 grain wt (g)	Yield per hill(g)
Plant height (cm)	**0.1369**	-0.0783	-0.0220	-0.0229	-0.0773	0.0353	0.0427	0.0470	0.2940	-0.00048	0.00891	0.364*
No. of tiller/hill	-0.0455	**0.2359**	0.0342	-0.0481	0.1566	-0.0174	-0.00044	-0.00687	-0.0688	0.0121	-0.00577	0.246
Days to 50% flowering	0.0362	-0.0967	**-0.0834**	0.1446	-0.0413	0.0119	0.00464	0.00365	-0.0366	0.0109	0.0081	-0.038
Days to harvesting	-0.0126	-0.0455	-0.0484	**0.2493**	0.0328	0.00421	0.0053	0.00667	0.0327	0.0193	0.000091	0.244
No. of panicle/ hill	-0.0299	0.1047	0.00976	0.0232	**0.3528**	-0.00738	0.0147	-0.00823	-0.1481	0.0188	0.00173	0.332*
Panicle length (cm)	0.0897	-0.0759	-0.0185	0.0194	-0.0483	**0.0539**	0.0627	0.0708	0.3811	0.01668	0.0112	0.563**
No. of primary branches	0.0530	-0.00094	-0.00351	0.0119	0.0469	0.0306	**0.1104**	0.0589	0.2968	0.0174	0.0112	0.633**
No. of secondary branches	0.0618	-0.0156	-0.00292	0.0159	-0.0279	0.0367	0.0625	**0.1042**	0.3895	0.0224	0.00827	0.655**
No. of grain/panicle	0.0725	-0.0293	0.00551	0.0147	-0.0942	0.0371	0.0591	0.0732	**0.5549**	0.00117	0.00027	0.695**
No. unfilled grain/panicle	-0.00096	0.0413	-0.0133	0.0701	0.0963	0.0131	0.0278	0.0339	0.00943	**0.0689**	0.00641	0.353*
100 grain wt (g)	0.0268	-0.0299	-0.0149	0.000498	0.0134	0.0133	0.0273	0.0189	0.0033	0.0097	**0.0454**	0.114

Note: Bold and diagonal figures indicate the direct effect, Residual effect: 0.1272

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