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Correlation and path coefficient analysis of rice genotypes for their yield components under drought condition

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Abstract
During *Kharif* 2016, 56 rice genotypes were screened phenotypically to study genetic variability and evaluated with the main aim to analyse yield component in rice under drought condition. All the experiments were laid out in an alpha lattice design and consisted of three replications under two different hydrological conditions viz., non-stress (favourable or irrigated as per needed) & stress under rainfed condition. Data were recorded on days to fifty percent flowering, plant height (cm), harvest index (%), biological yield (gm), plot yield, panicle number, 1000 seed weight (gm), seed fertility (%), culm height (cm), panicle length (cm), filled grains per panicle, chaffy grains per panicle: economic yield (gm) leaf rolling, drought Score. These data were analyzed for analysis of variance, mean performance of genotypes, coefficient of variability, heritability in broad sense, genetic advance in percent of mean, correlation coefficient, path analysis and genetic divergence. Experimental results discovered that Disang, Apo, ARC-10985, Kaliaus, Dikhow, NLR33671, NLR3083, NLR3217 and Ranjith varieties are being recommended for its cultivation in drought prone environment release and/or may be used in marker assisted breeding.

Keywords: Conservation tillage, crop growth, yield, production

Introduction
Drought is one of the most important abiotic stresses causing drastic reductions in yield in rainfed rice environments (Vikram *et al*., 2011) [15]. Worldwide, it reduce yield by 15-50% depend on the stress impact on crop growth period (Srividhya *et al*., 2011) [14]. Rice (*Oryza sativa* L.) is the major staple cereal of India cultivated in about 45 million hectares area with a rice production of 87.00 million tonnes. According to united nation estimate, the world population will grow from 6.3 million in 2003 to 8.0 million in 2025, requiring about 40% more rice production to cater the demand of the burgeoning global population. India is the foremost country of the world in area of rice cultivation and second to the China in rice production. In recent years, the increased occurrence and severity of drought stress has led to a yield decline in rice. So, developing varieties with high yield potential and improved drought tolerance could reduce risk and help alleviate poverty in drought-prone rice growing areas. The effect of drought on rice plants considerably varies with genotypes, developmental stages, and degree and duration of drought stress (Wang *et al*., 2011) [16]. Therefore, the present study was conducted to screen out the 56 varieties that perform better under drought condition and to find out all the morphological parameters, both under control and drought related traits that are more effective in favour of plant under drought condition at the same time.

Materials and Methods
The present investigation was carried out during *Kharif* season (June to November 2016) at the Institute of Frontier Technology, Regional Agricultural Research Station (RARS), and wetland farm, S V Agricultural College, Tirupati. The farm is geographically 13°37'29N and 79°22'35E at altitude of 162m above mean sea level and fall under southern part of Andhra Pradesh. In this study, a total of fifty six (56) rice genotypes were different ecotypes and geographical origins that were pooled from Central Rainfed Upland Rice Research Station (CRURRS), Assam Agricultural University (AAU) and Acharya N G Ranga Agricultural University (ANGRAU). The materials consisted of landraces, varieties, and cultivars. The details of genotypes was given in table 1. All 56 rice genotypes were planted in three replications with alpha lattice design (5x10 cm).

Method
The 56 rice genotypes were sown in a raised bed nursery. Later, 25-30 day-old single seedlings were transplanted to the main field that had three rows of 10 m with the spacing of 20 cm

between rows and 15 cm between plants within a row per genotype in an alpha lattice design with three replications under drought stress and control (irrigated) condition. Gap of 50 cm spacing was maintained between the replications. The crop was maintained properly at 120:60:60 kg/ha NPK level. Regular irrigation was given until 75 days of crop from date of sowing; Drought stress was imposed 75 days of sowing by withholding the water. The stress was continued till the harvesting stage with intermittent falsh floodings whenever severe leaf rolling appeared. Crop was harvested when the grains reached physiological maturity stage. All the observations were recorded on randomly selected five plants from each entry line in each replication at maturity. These plants were harvested and threshed separately. The data were recorded on days to fifty percent flowering, plant height (cm), harvest index (%), biological yield (gm), plot yield, panicle number, 1000 seed weight (gm), seed fertility (%), culm height (cm), panicle length (cm), filled grains per panicle, chaffy grains per panicle: economic yield (gm) leaf rolling, drought Score.

Results and Discussion

Correlation coefficient analysis under drought

The correlation coefficient between different yields attributes and drought indicators were significantly correlated with each other. Correlation coefficient were estimated among the fifteen characters under drought and thirteen characters under control conditions are presented in Table 1(a) and 2(b), respectively.

Yield per plant exhibited highly significant and positive correlation with biological yield (0.88), plot yield (0.85), filled grains per panicle (0.37), harvest index (0.35), panicle number (0.24), days to fifty percent flowering (0.24), panicle length (0.21), seed fertility (0.20), 1000 seed weight (0.17). However, Chand *et al*., (2004) [4] found significant positive correlation of grain yield with grains per panicle. Days to fifty percent flowering was highly significant and positive correlation with filled grains per panicle (0.43), biological yield (0.29), plot yield (0.24), chaffy grains per panicle (0.23). The higher degree of phenotypic correlation for various traits in rice have also been reported by Gurudachalan (1972) [5] and Bai *et al*., (1992) [2], Janardanam *et al*., (2002) [6] and Borbora *et al*., (2005) [3]. Plant height highly significant and positive correlation with culm height (0.81), panicle length (0.40), 1000 seed weight (0.31), negative correlated with filled grains per panicle (-0.21), chaffy grains per panicle (-0.21). Harvest index significant and positive correlation with plot yield (0.35). Biological yield highly significant and positive correlation with plot yield (0.88), filled grains per panicle (0.41), panicle number (0.32), seed fertility (0.20), chaffy grains per panicle (0.16). Plot yield highly significant and positive correlation with filled grains per panicle (0.37), panicle number (0.24), panicle length (0.21), seed fertility (0.20). Panicle number highly significant and positive correlation with only filled grains per panicle (0.16).1000 Seed Weight highly significant and positive correlation with panicle length (0.35), culm height (0.25). Seed fertility highly significant and positive correlation with filled grains per panicle (0.40). Borbora *et al*., (2005) [3] reported that grain yield per plant showed significant and positive association with grain yield per panicle and significant negative correlation with plant height, panicle number per plant and chaffy grain number per panicle.

Phenotypic correlation under controlled

Grain yield exhibited highly significant and positive correlation with biological yield (0.92), plot yield (0.87), harvest index (0.48), panicle number (0.43), filled grains per panicle (0.40), chaffy grains per panicle (0.21), days to fifty percent flowering (0.25). Days to fifty percent flowering highly significant and positive correlation with filled grains per panicle (0.57), chaffy grains per panicle (0.39), biological yield (0.27), plot yield (0.25), Plant height highly significant and positive correlation with culm height (0.91), panicle length (0.45), negative correlated with Filled grains per panicle (-0.22), harvest index (-0.22).Harvest index significant and positive correlation with plot yield (0.48), filled grains per panicle (0.18). Biological yield highly significant and positive correlation with plot yield (0.92), panicle number (0.50), filled grains per panicle (0.36), chaffy grains per panicle (0.20).1000 Seed Weight highly significant and positive correlation with culm height (0.26). Seed fertility highly significant and positive correlation with filled grains per panicle (0.22).

Path coefficient analyses were assessed at phenotypic levels to decide the direct and indirect effects of different characters on grain yield under drought and controlled conditions (Table 2a and 2b).

Phenotypic path coefficient analysis under drought condition

Harvest index (0.452) showed maximum direct effect on grain yield followed by biological yield (0.056), 1000 seed weight (0.032), and plot yield (0.029).The contributions of other characters were too low to be considered important. Harvest index exhibited highest indirect effect on grain yield via biological yield per plant (0.625) followed by 1000 seed weight (0.215), and plot yield (0.265). Biological yield exhibited high indirect effect on grain yield via harvest index (0.612) fallowed by 1000 seed weight (0.213) and filled grains (0.324). The contributions of other characters were too low to be considered important. Bagali *et al*., (1999) [1] reported a high positive indirect effect of panicle weight on grain yield through harvest-index and number of grains per panicle in indica X japonica double haploid population of 114 homozygous lines in rice.

Table 1a: Correlation coefficients among traits under Drought Stress condition

	PHT-D	HI-D	BY-D	PYD-D	PN-D	1000 SW-D	SF-D	CH-D	PL-D	FG-D	CG-D	LR-D	DS-D	EY-D
DFF	-0.02	-0.04	0.29**	0.24**	-0.09	-0.10	0.12	-0.01	0.10	0.43**	0.23**	-0.30**	-0.42**	0.24**
PHT	1	-0.02	0.17*	0.13	-0.06	0.31**	-0.05	0.95**	0.40**	-0.21**	-0.21**	0.20**	0.19*	0.13
HI		1	-0.10	0.35**	-0.08	0.09	0.04	-0.07	0.01	-0.03	-0.09	-0.04	0.01	0.35**
BY			1	0.88**	0.32**	0.13	0.20**	0.09	0.21**	0.41**	0.16*	-0.29**	-0.36**	0.88**
PYD				1	0.24**	0.16*	0.20**	0.03	0.21**	0.37**	0.12	-0.31**	-0.35**	0.85**
PN					1	-0.09	-0.05	-0.07	-0.08	-0.16*	-0.12	0.13	0.10	0.24**
1000 SW						1	0.04	0.25**	0.35**	-0.11	-0.12	0.12	0.14	0.17*
SF							1	-0.07	0.04	0.40**	-0.58**	-0.25**	-0.34**	0.20**
CH								1	0.21**	-0.24**	-0.22**	0.23**	0.25**	0.03

PL									1	0.11	0.04	0.02	-0.01	0.21**
FG										1	0.44**	-0.38**	-0.47**	0.37**
CG											1	-0.15	-0.17*	0.12
LR												1	-0.35**	0.02
DS													1	0.13
EY														1

**. Correlation is significant at 1 % level. *. Correlation is significant at 5% level.

DFF: Days to fifty percent flowering, PHT: Plant height (cm), HI: Harvest index (%), BY: Biological yield (gm), PYD: Plot yield, PN: Panicle number, 1000SW: 1000 Seed Weight (gm), SF: Seed fertility (%), Culm height(cm), PL: Panicle length (cm), FG: Filled grains per panicle, CG: Chaffy grains per panicle: EY: Economic yield (gm) LR: leaf rolling, DS: Drought Score

Table 1b: Correlation coefficients among traits under control condition

	DFF	**PHT**	**HI**	**BY**	**PYD**	**PN**	**1000 SW**	**SF**	**CH**	**PL**	**FG**	**CG**	**EY**
DFF	1	-0.08	-0.01	0.27**	0.25**	-0.05	-0.10	-0.05	-0.10	0.13	0.57**	0.39**	0.25**
PHT		1	-0.22**	0.07	-0.03	-0.03	0.26**	0.02	0.91**	0.45**	-0.22**	-0.14	-0.03
HI			1	0.12	0.48**	-0.04	0.10	0.02	-0.23**	-0.04	0.18*	0.09	0.48**
BY				1	0.92**	0.50**	0.13	-0.02	0.05	0.17*	0.36**	0.20**	0.92**
PYD					1	0.43**	0.14	-0.01	-0.06	0.12	0.40**	0.21**	0.87**
PN						1	-0.08	-0.06	-0.02	-0.09	-0.10	0.01	0.43**
1000SW							1	0.13	0.26**	0.11	-0.01	-0.12	0.14
SF								1	0.04	-0.10	0.22**	-0.78**	-0.01
CH									1	0.32**	-0.23**	-0.17*	-0.06
PL										1	0.02	0.06	0.12
FG											1	0.38**	0.40**
CG												1	0.21**
EY													1

**. Correlation is significant at 1% level. *. Correlation is significant at 5% level.

DFF: Days to fifty percent flowering, PHT: Plant height (cm), HI: Harvest index (%), BY: Biological yield (gm), PYD: Plot yield, PN: Panicle number, 1000SW: 1000 Seed Weight (gm), SF: Seed fertility (%), Culm height(cm), PL: Panicle length (cm), FG: Filled grains per panicle, CG: Chaffy grains per panicle: EY: Economic yield (gm) LR: leaf rolling, DS: Drought Score

Table 2a: Different characters effects on grain yield per plant at phenotypic level in 56 rice genotypes under drought condition

	DFF	**PHT**	**HI**	**BY**	**PYD**	**PN**	**1000 SW**	**SF**	**CH**	**PL**	**FG**	**CG**	**LR**	**DS**	**EY**
DFF	-0.0128	-0.0062	0.0061	0.0041	0.0000	-0.0024	-0.0021	0.0026	0.0000	0.0000	-0.0061	-0.0120	-0.0070	0.0240	-0.4870
PHT	-0.0026	-0.1661	0.0383	0.0133	0.0060	-0.0041	-0.0438	0.0078	-0.1644	-0.0754	-0.0258	0.0099	0.0099	-0.0129	-0.0362
HI	0.0000	0.0000	0.4526	0.6123	0.0010	0.2130	0.2135	0.5621	-0.0210	0.0100	0.3241	0.0010	-0.2100	0.0140	0.3139**
BY	0.0000	0.0000	0.0027	0.0567	-0.0001	-0.0001	0.0789	-0.2156	0.0000	0.0000	-0.2310	0.0061	0.0000	-0.2140	0.9235**
PYD	0.2871	-0.0362	0.3140	0.9236	0.0298	0.4306	0.1137	0.0845	-0.0558	0.1088	-0.0174	0.0396	0.0396	-0.0303	0.9811**
PN	0.0000	0.0000	-0.0025	-0.0031	0.0041	0.0021	-0.0020	0.0000	0.1400	0.0010	-0.1450	-0.0140	0.0040	0.0000	0.3524
1000 SW	0.0000	0.0000	0.0012	0.0031	0.0160	0.0020	0.0321	0.0000	0.1300	0.0010	0.0146	0.0012	0.0000	-0.1700	0.1137
SF	0.0000	0.0000	0.0032	0.0624	0.0000	0.0120	-0.2560	0.0012	0.0000	0.0200	0.1250	-0.0121	-0.0014	0.0000	0.0845
CH	-0.0061	0.1546	-0.0371	0.0099	-0.0087	-0.0033	0.0410	0.0088	0.1562	0.0504	-0.0370	0.0389	-0.0080	0.0121	-0.0559
PL	0.0035	0.0114	-0.0012	0.0034	0.0027	-0.0024	0.0028	-0.0018	0.1240	0.0250	0.0006	-0.0019	-0.0019	-0.2140	0.1088
FG	0.0000	0.0000	-0.0025	0.0741	0.0378	0.0024	-0.0258	0.0546	0.1200	0.0000	0.0289	0.0000	0.0000	0.0346	0.4649**
CG	0.0000	0.0000	0.0010	-0.0015	0.0020	0.0030	0.0001	0.0012	0.0000	0.0000	-0.0241	0.2340	0.0090	0.0000	0.1818
LR	0.0000	0.0000	0.0013	-0.0021	0.0060	-0.0010	-0.0120	-0.1200	0.0210	0.0000	-0.0012	0.0070	-0.0051	0.1450	0.0440
DS	0.0000	0.0000	0.0000	0.0001	0.0410	-0.0020	0.0000	-0.0021	0.0000	0.0000	0.0000	0.0010	0.0040	0.0564	0.0396
EY	-0.3214	-0.1654	0.6254	0.5126	0.2654	-0.1462	0.2156	0.0315	0.2156	0.0264	-0.0352	-0.1250	0.0024	0.0012	0.9122**

Residual effect = 0.0746

Table 2b: Different characters effects on grain yield per plant at phenotypic level in 56 rice genotypes under control condition

	DFF	**PHT**	**HI**	**BY**	**PYD**	**PN**	**1000 SW**	**SF**	**CH**	**PL**	**FG**	**CG**	**EY**
DFF	0.0564	0.0258	-0.0024	0.2471	0.0541	0.0214	0.0127	0.0245	0.0000	0.0101	0.4560	0.0014	0.3145**
PHT	-0.0132	-0.0807	-0.0208	-0.0245	-0.0033	0.0156	-0.0204	-0.0064	0.0788	0.0335	-0.0176	-0.0157	0.4123**
HI	-0.0274	0.1240	0.6241	0.1287	0.2647	0.2145	0.1291	-0.0652	0.0214	0.0312	0.0564	-0.0245	0.7165**
BY	0.3125	0.3957	0.1985	0.7981	0.0298	0.0958	0.2896	0.0658	0.0150	0.0246	0.2145	-0.1420	0.835**
PYD	0.4432	-0.0403	0.4288	0.8349	0.0841	0.1722	0.0647	0.1967	-0.0968	0.2262	0.5143	0.2522	0.9874**
PN	0.0025	-0.0045	0.0089	0.0014	0.0051	0.0098	-0.0054	0.0041	0.0213	0.0021	0.0451	0.0210	0.1722
1000 SW	-0.0154	-0.0165	-0.2410	-0.0042	-0.0245	0.0025	-0.0987	0.0014	0.0016	0.0320	0.0547	0.0024	0.0647
SF	-0.0015	-0.0068	0.0054	-0.0025	0.0017	-0.0125	0.0156	-0.0689	-0.0154	0.0245	0.0152	-0.0024	0.1967
CH	0.0143	-0.0733	0.0203	0.0038	0.0073	0.0040	-0.0180	0.0065	-0.0751	-0.0157	0.0195	0.0168	-0.0968
PL	-0.0011	-0.0074	0.0005	-0.0038	-0.0040	0.0009	-0.0063	-0.0002	-0.0037	-0.0177	-0.0020	-0.0011	0.2263
FG	0.0254	0.0687	0.0258	0.0845	0.0054	0.0546	-0.0045	0.0257	0.0645	0.0457	0.0874	-0.0147	0.5143**
CG	-0.0014	0.0001	0.0210	0.0002	0.0140	-0.0010	0.0005	0.0080	-0.0001	0.0004	0.0010	0.0050	0.2523

Residual effect = 0.0989

Phenotypic path coefficient analysis under control condition

Biological yield (0.798) showed maximum direct effect on grain yield followed by harvest index (0.624) and filled grains (0.087) and plot yield (0.084). The contribution of other characters was too low to be considered important. Biological yield exhibited highest indirect effect on grain yield via plant height (0.395) followed by test weight (0.289), days to 50% flowering (0.265), filled grains (0.214) and harvest index (0.198). Harvest index exhibited highest indirect effect on grain yield via plot yield (0.264) fallowed by panicle number (0.214), 1000 seed weight (0.129), biological yield (0.128). The contributions of other characters were too low to be considered important.

Conclusion

Drought is most important limiting factor for rice yield in rainfed areas. Developing rice cultivars with drought tolerance is the most effective way to solve this problem. In present investigation 56 rice genotype were evaluated under drought and control condition. The genotypic correlations were generally related in nature and higher in magnitude with the corresponding phenotypic correlation coefficients.

Studies on correlation and path analysis in rice revealed that grain yield was positively and highly significantly correlated with harvest index, biological yield and height under both conditions. The path coefficient analysis indicated that harvest index, biological yield and test weight had maximum direct effect on grain yield at phenotypic and genotypic level under drought condition. Biological yield and harvest index had maximum direct effect on grain yield at phenotypic level and grains per panicle and panicles per plant had maximum direct effect on grain yield at genotypic level under control condition. Biological exerted very high positive indirect effect on grain yield at phenotypic and genotypic level under control conditions via plant height.

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