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EFFECT OF WATER STRESS ON DIFFERENT MORPHOLOGICAL TRAITS OF RICE (*Oryza sativa* L.) GENOTYPES IN RED & LATERITE ZONE OF WEST BENGAL

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ABSTRACT
To estimate genetic variability and relationships among different morphological traits of rice an experiment was conducted with 12 genotypes of rice under two irrigation regimes at tillering stage in the red and laterite zone of district Paschim Medinipur, West Bengal, India. A significant variation among the rice genotypes was observed. The genotype Dular showed highest performance under both irrigation regimes followed by Jaldi Dhan 13, Heera and Kalinga III. The traits plant height, number of filled grains per plant, spikelet fertility percentage, root length, panicle length and test weight exhibited high heritability under both control and stress conditions. The lowest and highest phenotypic and genotypic co-efficient of variation under both hydrological regimes were observed for number of filled grains/panicle and number of tillers/plant. Furthermore, the lowest and highest expected genetic advance in percent of mean were evaluated for flag leaf length and number of filled grains/panicle under both hydrological regimes, respectively. The characters number of filled grains/panicle, yield/plant and panicle length showed high heritability with high genetic advance under both stress and non stress condition. Under both hydrological conditions number of filled grains/panicle and spikelet fertility percentage were found to be highly correlated with grain yield/plant consistently, when compared to other quantitative traits as well as these characters had high positive direct effect on grain yield. These traits indicate as ideal for improvement through selection and that they may provide a high response to selection.

KEYWORDS: Correlation, drought, grain yield, genetic advance, heritability, path coefficient, rice

INTRODUCTION
Rice is considered as main staple food for more than 50% of the world's population and particularly important in Asia, where approximately 90% of world's rice is produced and consumed (Zeigler and Barclay, 2008; Khush, 2004). Being the staple food for almost two third of the population supplying almost 31% of calories of Indian diet, rice plays a pivotal role in Indian economy (Ravindra Babu, 2013). India ranks first in the world in area of rice cultivation with 43.97 million ha and second in production with 104.32 million tons (Anon., 2013). Rice is probably the most diversely cultivated crop under varied environments including: i) irrigated, ii) rainfed sloping uplands, iii) rainfed plain upland and iv) rainfed lowland to deepwater conditions. Irrigated rice is the most common rice ecosystem occupying 55% of the total 158 million ha of cultivated rice area, while rainfed lowland rice harbours (34%) 54 million ha, rainfed upland (9%) 14 million ha and flood prone rice areas (7%) 11 million ha (Bouman et al., 2007). The upland ecosystem presents 12% of global rice area, which is the lowest yielding rice ecosystem (Khush, 1997). The recent scenario of global climate change and unpredictable rainfall patterns lead to severe drought spells in rain-fed areas. Drought stress is a multidimensional stress which is not only limited to arid or semi arid areas, but also sometimes, due to irregular distribution of rain, causes unfavourable conditions for plant growth at different stages and development. In addition, majority of the rice area under irrigated conditions is also subjected to periodic water deficit (Khush, 1984). It is highly likely that in the future, rainfed rice growing areas will face severe spells of drought stress, consequently with high yield decline. To fight poverty and provide food security, rice production must increase from the present level to at least 760 mt by the year 2020 (Kundu and Ladha, 1995) from same or even shrinking land due to increasing competition for land and declining water availability. Improving the yield of rainfed crops can be achieved by selecting directly for yield. However, the ability to select for yield is severely hampered year to year variability in rainfall patterns (Ludlow and Muchow, 1990). Alternatively, yield improvement in water-limited environments could be achieved by identifying the traits contributing to drought resistance and selecting for those traits in breeding programs. Selection on the basis of a single parameter could not provide the true picture of a genotype that responds to stress and therefore at least two or more parameters (Tyagi and Narendrakumar Sairam, 1999) along with association between grain yield and its component traits as well as inter-correlation between component traits under moisture stress should be used for identifying drought tolerant genotypes (Manickavelu *et al*., 2006). Therefore, the present study is to identify and develop suitable and efficient varieties with drought tolerance traits which would allow profitable rice cultivation under limited water availability.

MATERIALS & METHODS

Twelve rice genotypes were planted in the field The experiment was carried out in randomized block design (RBD) with three replications under optimum irrigation and drought stress conditions at Red and Laterite Zone in the district of Paschim Medinipur of West Bengal, India. To run this experiment twelve rice genotypes Dular, Kalinga III, Heera, Mtu 1010, Jaldi Dhan-13, IR-30, IR-36, IR-50, IR-64, Satabdi, Sitabhog and Jhu 11-26 were provided from Chinsurah Rice Research Institute, West Bengal, India. The experiment was conducted in two different conditions irrigated and drought stress. The genotypes were planted in plot size of 1m x 1m with spacing of 25 x 20 cm. The recommended agronomic practices were followed up to tillering stage. After tillering stage irrigation was withheld for 10 days in one set of experiment to impose artificial drought. Thirteen morphological characters such as plant height (cm), number of tillers/plant, flag leaf angle, flag leaf length (cm), flag leaf breadth (cm), flag leaf area (cm^2), root characters like maximum root length (cm), root to shoot ratio and yield related characters panicle length (cm), number of filled grains/panicle, test weight (g) and yield/plant (g) were considered in the present investigation. The data were subjected to Analysis of Variance (Singh and Chaudhary, 1985), Genotypic and Phenotypic Co-efficient of Variation (Burton, 1952), Genetic Advance (Johnson *et al.,* 1955 and Lush, 1949), broad sense Heritability (Hanson *et. al.*, 1956), Correlation Co-efficient and Path Co-efficient analysis (Dewey and Lu, 1959).

RESULTS & DISCUSSION

The analysis of variance for two hydrological regimes (optimum irrigation and drought stress) for the characters considered in the experiment has been presented in Table 1. The results showed significant differences among genotypes for the characters which suggested presence of high genetic diversity in studied population.

TABLE 1: Analysis Of Variance (ANOVA) for Thirteen Different Characters of Rice Genotypes

Source of Variation		d.f	Mean sum of square												
			PH	FLL	FLB	FLA	FLAn	RL	RSR	T/P	PL	FG	SF	TW	YP
Genotype	NS	11	54.00**	9.27**	0.006**	6.33**	16.46**	7.40**	0.00	0.57	28.83**	2470.45**	92.09**	13.28**	7.40**
	S	11	38.99**	7.05**	0.005**	2.54**	37.14**	19.02**	0.01**	1.22**	20.27**	2195.06**	124.06**	18.51**	10.50**
Replication	NS	2	0.34	1.15	0.001**	0.07	1.03	0.07	0.00	0.36	0.44	20.03	5.36**	0.27	0.07
	S	2	0.59	0.69	0.000	0.31	0.49	0.26	0.00	0.08	0.23	8.53	2.72	0.02	0.39
Error	NS	22	1.16	0.73	0.000	0.48	0.87	0.22	0.00	0.30	0.35	24.79	2.72	0.18	0.22
	S	22	0.49	0.25	0.000	0.17	0.87	0.44	0.00	0.24	0.15	9.50	2.67	0.22	0.97
SE_d	NS		0.88	0.70	0.01	0.57	0.76	0.38	0.01	0.45	0.48	4.06	1.35	0.35	0.38
	S		0.57	0.40	0.01	0.34	0.76	0.54	0.01	0.40	0.31	2.52	1.33	0.38	0.80
CD (5%)	NS		1.83	1.44	0.02	1.17	1.58	0.79	0.02	0.93	1.00	8.43	2.79	0.72	0.79
	S		1.19	0.84	0.02	0.70	1.58	1.12	0.03	0.82	0.65	5.22	2.77	0.79	1.67

PH: Plant Height (cm) **FLL:** Flag Leaf Length (cm) **FLB:** Flag Leaf Breadth (cm) **FLAn:** Flag Leaf Angle (^{o}) **RL:** Root Length (cm)
RSR: Root to Shoot Ratio **T/P:** Number of Tillers/Plant **PL:** Panicle Length **FG:** Filled Grains/Panicle **SF:** Spikelet Fertilty %
TW: Test Weight **Y/P:** Grain Yield/Plant **CD:** Critical Difference **SE_d:** Standard Error Deviation **S:** Stress **NS:** Non Stress
**significant at 5% level

The mean of all traits for two environments showed lower value for drought stress condition than to optimum environment (Table 1). Yield/plant was significantly highest in genotypes Heera (26.94 g), Mtu 1010 (23.21 g), Sitabhog (23.57 g) followed by IR-50 (19.29 g), Jaldi Dhan 13 (18.38 g) and Satabdi (18.77 g) in non stress condition but under drought stress environment the lowest yield/plant was obtained from Satabdi (11.38 g) and Zhu 11-26 (10.96 g) folowed by IR-50 (13.73 g) and IR-30 (12.44 g). The genotypes which showed good performances for yield/plant for both the environments are Dular, Heera, Jaldi Dhan 13 and Kalinga III. The cultivar Dular showed highest phenotypic value under both irrigation regimes in respect of the important traits under study. Jaldi Dhan 13, Heera and Kalinga III are good performers for both environmental conditions. Zhu 11-26 showed medium performance under both water stress and non stress condition. Estimation of coefficient of variation and genetic parameters are presented in Table 3. Magnitude of PCV was found to be higher than GCV for most of the traits under both control and stress condition but maintained lower difference between them which indicated less environmental effect on expression of the traits and reflected variation for genetic variability which is supported by higher values of heritability. Therefore, selection on the basis of phenotype alone can be effective for the improvement of these traits. Girish *et al*., (2006) had also reported the presence of environmental effect on the characters for PCV was higher than GCV. The character number of tillers/plant displayed very high co-efficient of variation (GCV and PCV) under both the conditions indicating the influence of environment (water stress), in the expression of this trait. The genotypic and phenotypic co-efficient of variation was highest for the characters number of filled grains/panicle (28.66% & 29.09% in non stress and 31.27% & 31.48% in stress) and yield/plant (14.47% & 12.23% in non stress and 12.99% & 14.84% in stress). Flag leaf angle had moderate genotypic and phenotypic co-efficient of variation in both hydrological regimes (13.03% & 14.07% in non stress and 18.74% & 19.35% in stress). The high variation in number of filled grains/panicle and yield/plant could be considered in selection of desirable lines in both the environments especially in development of drought resistant lines. Heritability is the ability of the characters to inherit into subsequent generations. Heritability of a trait is important because it determines the extent to which plant improvement through selection is possible. Some traits showed high heritability under stress condition as compared to irrigated condition which suggested differential selection pressure should be imposed on the traits under stress and non stress situation to identify genotypes adaptable to different situations according to water availability. High heritability was observed for the characters flag leaf length, flag leaf breadth, flag leaf area, flag leaf angle, root length, root-shoot ratio, filled grains/panicle and yield/plant and selection would be effective for improvement of these traits. Blum (1988) and Efisue *et al*., (2009) reported that genetic variance and heritability for grain yield decline under stress. Therefore, they stressed the importance of secondary traits as predictors of grain yield under stress conditions.

TABLE 2: Mean Performance of Twelve Rice Genotypes for Thirteen Different Characters:

		PH	FLL	FLB	FLA	FLAn	RL	RSR	TP	PL	FG	SF	TW	YP
DUlAR	NS	50.45	34.00	0.67	22.68	15.67	26.44	0.52	6.33	24.30	84.67	81.65	26.30	17.63
	S	49.29	28.46	0.62	17.55	15.00	24.87	0.51	5.67	25.23	74.33	77.43	26.68	15.35
IR-64	NS	43.73	31.29	0.72	22.43	21.67	24.06	0.55	5.67	29.10	102.33	74.27	23.46	18.51
	S	41.95	25.12	0.64	16.16	19.67	20.67	0.49	4.67	26.43	84.33	66.37	22.89	12.42
IR-30	NS	44.56	29.21	0.72	21.13	18.67	25.18	0.56	6.33	25.75	81.67	68.06	23.20	16.29
	S	42.88	23.84	0.64	15.18	20.33	18.29	0.43	5.67	24.75	73.00	62.78	22.38	12.44
IR-50	NS	44.79	29.96	0.77	22.97	17.67	25.27	0.56	6.00	26.65	87.00	69.77	24.00	19.29
	S	42.00	25.25	0.64	16.24	20.00	18.50	0.44	4.67	25.32	73.67	62.79	22.67	13.73
IR-36	NS	44.37	29.38	0.74	21.64	20.00	23.34	0.53	6.33	25.23	95.00	68.33	22.07	17.36
	S	42.84	25.67	0.63	16.09	20.33	20.51	0.48	5.33	24.56	80.33	62.61	21.50	13.50
JALDI DHAN 13	NS	53.18	31.00	0.64	19.94	15.33	27.69	0.52	6.33	22.74	109.67	79.86	21.97	17.51
	S	51.30	28.29	0.54	15.18	16.00	26.18	0.51	5.00	22.88	105.00	75.38	22.82	16.05
HEERA	NS	45.96	28.59	0.67	19.15	14.67	23.81	0.52	5.33	24.81	148.67	78.93	20.80	18.01
	S	44.13	26.85	0.59	15.93	16.00	22.46	0.51	6.00	24.14	145.00	72.50	21.67	16.73
MTU 1010	NS	45.50	29.59	0.68	20.02	18.33	24.64	0.54	5.67	23.31	98.00	74.27	24.80	18.87
	S	44.29	26.03	0.60	15.62	20.67	19.46	0.44	4.33	22.49	85.67	66.08	23.50	13.74
SITABHOG	NS	52.95	32.88	0.60	19.83	18.67	25.53	0.48	5.33	25.57	157.00	63.14	19.02	17.90
	S	47.52	28.99	0.57	16.42	21.00	22.92	0.48	4.33	24.50	126.67	54.14	17.19	11.51
KALINGA III	NS	41.10	28.79	0.68	19.48	15.33	22.61	0.55	5.67	21.58	75.33	76.63	24.63	17.71
	S	41.84	26.17	0.61	16.06	14.33	24.42	0.58	5.00	22.25	63.67	71.00	24.90	15.73
SATABDI	NS	45.95	31.96	0.69	22.04	19.67	25.43	0.55	5.33	26.24	100.67	77.16	20.87	22.59
	S	44.85	25.77	0.64	16.58	26.67	20.84	0.47	4.33	25.47	76.33	66.75	20.40	12.51
ZHU 11-26	NS	39.45	28.93	0.66	19.00	14.67	22.26	0.56	6.33	16.70	55.67	74.55	24.87	13.40
	S	38.18	25.67	0.54	13.77	15.33	21.44	0.56	6.00	16.50	47.67	70.08	25.57	10.96
Overall Mean	NS	46.00	30.46	0.69	20.86	17.53	24.69	0.54	5.89	24.33	99.64	73.89	23.00	17.92
	S	44.26	26.34	0.61	15.90	18.78	21.72	0.49	5.08	23.71	86.31	67.33	22.68	13.72

PH: Plant Height (cm) FLL: Flag Leaf Length (cm) FLB: Flag Leaf Breadth (cm) FLAn: Flag Leaf Angle (^{0}) RL: Root Length (cm)
RSR: Root to Shoot Ratio T/P: Number of Tillers/Plant PL: Panicle Length (cm) FG: Filled Grains/Panicle NS: Non Stress
SF: Spikelet Fertilty % TW: Test Weight (g) Y/P: Yield/ Plant (g) S: Stress

TABLE 3: Genetic Variability Parameters for Thirteen Differnt Characters of Twelve Rice Genotypes for Two Hydrological Regimes:

Characters		Mean ± SE	Co-efficient of variation (%)		Heritability (Broad sense)	Genetic advance	Genetic advance as % of mean
			GCV	PCV			
PH	NS	46.00 ± 0.88	9.12	9.42	93.80	8.37	18.20
	S	44.26 ± 0.57	8.09	8.25	96.32	7.24	16.37
FLL	NS	30.46 ± 0.70	5.54	6.21	79.66	3.10	10.19
	S	26.34 ± 0.40	5.72	6.02	90.24	2.95	11.19
FLB	NS	0.69 ± 0.01	6.44	6.57	96.02	0.09	13.00
	S	0.61± 0.01	6.37	6.78	88.18	0.08	12.32
FLA	NS	20.86 ± 0.57	6.70	7.48	80.23	2.58	12.36
	S	15.90 ± 0.34	5.59	6.16	82.36	1.66	10.46
FLAn	NS	17.53 ± 0.76	13.03	14.07	85.83	4.36	24.87
	S	18.78 ± 0.76	18.74	19.35	93.82	7.02	37.39
Rl	NS	24.69 ± 0.44	6.27	6.55	91.72	3.05	12.37
	S	21.72 ± 0.48	11.46	11.86	93.40	4.96	22.82
RSR	NS	0.54 ± 0.01	4.27	5.07	70.88	0.04	7.40
	S	0.49 ± 0.01	9.39	10.05	87.28	0.09	18.07
T/P	NS	5.89 ± 0.45	5.05	10.59	22.73	0.29	4.96
	S	5.08 ± 0.40	11.27	14.76	58.30	0.90	17.73
PL	NS	24.33 ± 0.48	12.67	12.89	96.49	6.24	25.63
	S	23.71 ± 0.31	10.92	11.04	97.85	5.28	22.26
FG	NS	99.64 ± 3.89	28.66	29.09	97.05	57.94	58.15
	S	86.31 ± 2.94	31.27	31.48	98.71	55.24	64.01
SF	NS	73.89 ± 1.48	7.39	7.72	91.62	10.76	14.57
	S	67.33 ± 1.29	9.45	9.76	93.81	12.69	18.85
TW	NS	23.00 ± 0.35	9.09	9.27	95.98	4.22	18.34
	S	22.68 ± 0.38	10.89	11.08	96.59	5.00	22.05
YP	NS	17.92 ± 1.64	11.47	12.23	87.89	3.97	22.15
	S	13.72+ ± 0.95	12.99	14.84	76.60	3.21	23.42

PH: Plant Height (cm) **FLL:** Flag Leaf Length (cm) **FLB:** Flag Leaf Breadth (cm) **FLAn:** Flag Leaf Angle (^{0}) **RL:** Root Length (cm)
T/P: Tillers/Plant **RSR:** Root to Shoot Ratio **PL:** Panicle Length (cm) **FG:** Filled Grains/Panicle **SF:** Spikelet Fertilty %
TW: Test Weight **PCV:** Phenotypic CV **CV:** Co-efficient of Variation GCV**:** Genotypic CV **ECV:** Environmental CV
Gen: Genotypic **Phen:** Phenotypic **YP:** Yield/Plant (g)

Selection for grain yield under drought stress is now a well-recommended selection criterion for breeding drought-tolerant rice varieties (Kumar *et al.*, 2008). High heritability across water regimes has also been reported in rice (Jonaliza *et al*., 2004). High to moderate heritability was reported for different quantitative traits studied in rice (Berneir *et al*., 2007; Abarshahr *et al*., 2011; Akinwale *et al*., 2011; Sadeghi *et al*., 2011; Vikram *et al*., 2011; Saikumar *et al*., 2014). Since high heritability does not always indicate high genetic gain, heritability with genetic advance should be used in predicting selection of superior genotypes (Ali *et al*., 2002). Genetic advance in percent of mean was estimated high for the characters number of filled grains/panicle (58.15 & 64.01) and grain yield/plant (22.15 & 23.42) and moderate for panicle length (25.63 & 22.26) and flag leaf angle (24.87 & 37.39) and low for the characters root to shoot ratio (7.40 & 18.07), tillers/plant (4.96 & 17.73) and flag leaf length (10.19 & 11.19) in both hydrological regimes. Other traits such as number of filled grains/panicle, spikelet fertility percentage and yield/plant recorded high heritability coupled with high genetic advance under both control and stress conditions. Similar results were reported by Manickavelu *et al*., 2006; Yadav *et al*., 2011. In general, the characters that show high heritability with high genetic advance are controlled predominantly by additive gene action and simple breeding method like pedigree selection may be practiced to evolve desirable line through breeding and such characters were filled grains/panicle, spikelet fertility percentage and grain yield/plant and Warkad *et al*., 2008 also gave similar conclusion. The traits which showed high heritability and moderate genetic advance may respond to selection provided complex breeding method like population improvement could be followed. Phenotypic and genotypic correlation coefficients of the concerned traits for both optimum and drought conditions were presented in Table 4 and 5 respectively.

TABLE 4: Genotypic and Phenotypic Correlation Co-efficient among Thirteen Characters of Rice Genotypes under Irrigated Condition:

		PH	FLL	FLB	FLA	FLAn	RL	RSR	TP	PL	FG	SF	TW	YP
PH	GCV													
	PCV													
FLL	GCV	0.74**												
	PCV	0.63**												
FLB	GCV	-0.50**	-0.38*											
	PCV	-0.48**	-0.31											
FLA	GCV	0.09	0.44**	0.66**										
	PCV	0.07	0.54**	0.64**										
FLAn	GCV	-0.03	0.25	0.45**	0.64**									
	PCV	-0.01	0.17	0.38*	0.48**									
RL	GCV	0.88**	0.69**	-0.19	0.37*	0.03								
	PCV	0.84**	0.60**	-0.19	0.31	0.03								
RSR	GCV	-0.79**	-0.52**	0.71**	0.29	0.11	-0.41*							
	PCV	-0.74**	-0.37*	0.57**	0.22	0.06	-0.26							
TP	GCV	-0.09	-0.28	0.36*	0.12	-0.22	0.19	0.43**						
	PCV	-0.05	0.07	0.22	0.26	-0.21	0.08	0.18						
PL	GCV	0.31	0.37*	0.44**	0.72**	0.75**	0.37*	-0.14	-0.48**					
	PCV	0.29	0.32	0.42*	0.63**	0.70**	0.35*	-0.12	-0.26					
FG	GCV	0.64**	0.28	-0.43**	-0.20	0.11	0.32	-0.85**	-0.91**	0.45**				
	PCV	0.63**	0.23	-0.42*	-0.20	0.13	0.31	-0.74**	-0.47**	0.45**				
SF	GCV	0.01	0.11	-0.16	-0.04	-0.55**	0.16	0.15	0.15	-0.27	-0.21			
	PCV	0.04	0.07	-0.17	-0.07	-0.46**	0.15	0.07	-0.03	-0.23	-0.16			
TW	GCV	-0.43**	-0.12	0.29	0.21	-0.26	-0.18	0.61**	0.76**	-0.35*	-0.81**	0.41*		
	PCV	-0.43**	-0.07	0.29	0.23	-0.26	-0.19	0.52**	0.39*	-0.35*	-0.79**	0.36*		
YP	GCV	0.27	0.36*	0.22	0.51**	0.48**	0.36*	-0.05	-0.90**	0.67**	0.34*	0.12	-0.33	
	PCV	0.26	0.35*	0.18	0.44**	0.42*	0.38*	-0.02	-0.41*	0.62**	0.34*	0.12	-0.32	

Correlation studies depicted the relationship between the component traits of yield and the yield itself. It is an index of degree of relationship between two continuous variables. Correlating traits under drought situation is helpful in development of rice varieties tolerant to drought stress. Genotypic and phenotypic correlations in optimum condition showed positive significant correlation between paddy yield/plant and flag leaf length (0.36* & 0.35*), flag leaf area (0.51** & 0.44**), flag leaf angle (0.48** & 0.42*), root length (0.36* & 0.38*), panicle length (0.67** & 0.62**) and filled grains/panicle (0.34* & 0.34*) but negative significant correlation among grain yield/plant with number of tillers/plant (-0.90** & -0.41*). Bapo and Soundarapandian, 1992; Choudhury and Das, 1998 and Padmavathi *et al*., 1996 also reported presence of positive significant correlation between yield and panicle length. Under stress condition grain yield/plant was significantly and positively correlated with plant height (0.46** & 0.42*), root length (0.58** & 0.49**), number of filled grains/panicle (0.39* & 0.33*) and spikelet fertility percentage (0.72** & 0.58**). Garrity and O'Toole (1994) had also reported presence of positive correlation between panicle fertility percentage and yield under water stress conditions. Lanceras *et al*., 2004; Berneir *et al*., 2007 and Vikram *et al*., 2011 also mentioned the presence of positive correlation between grain yield and plant height, filled grains/panicle, spikelet fertility percentage, test weight, biomass yield and harvest index. Under both hydrological conditions number of filled grains/panicle and spikelet fertility percentage were found to be highly correlated with grain yield/plant. In the present study, under stress condition panicle length among the yield contributing traits was significantly correlated with plant height. Plant height is a manifestation of inter node elongation which might have also an impact on the panicle length as mentioned by Yosidha (1981). The characters root to shoot ratio and spikelet fertility percentage were significantly and negatively correlated with grain yield/plant in optimum irrigated condition but in stress condition the traits showed significant positive correlation with grain yield/plant. Plant height, flag leaf length, root length, panicle length and number of filled grains/panicle could be considered as determining factors for selection of high yielding genotypes under water stress condition. Correlation co-efficient alone could not provide a comprehensive picture on direct and indirect influences of each character to the yield/plant for which path coefficient analysis was done. To get an understanding on direct and indirect influence of the traits on yield/plant and results were presented in Table 6.

Table 5: Genotypic and Phenotypic Correlation Co-efficient among Thirteen Characters of Rice Genotypes under Stress Condition

		PH	FLL	FLB	FLA	FLAn	RL	RSR	TP	PL	FG	SF	TW	YP
PH	GCV													
	PCV													
FLL	GCV	0.79^{**}												
	PCV	0.74^{**}												
FLB	GCV	-0.24	-0.58^{**}											
	PCV	-0.24	-0.54^{**}											
FLA	GCV	0.50^{**}	0.35^{*}	0.56^{**}										
	PCV	0.42^{**}	0.37^{*}	0.58^{**}										
FLAn	GCV	-0.02	-0.32	0.50^{**}	0.22									
	PCV	-0.04	-0.28	0.47^{**}	0.23									
RL	GCV	0.63^{**}	0.83^{**}	-0.58^{**}	0.18	-0.60^{**}								
	PCV	0.59^{**}	0.74^{**}	-0.49^{**}	0.18	-0.56^{**}								
RSR	GCV	-0.14	0.33	-0.53^{**}	-0.25	-0.74^{**}	0.68^{**}							
	PCV	-0.16	0.26	-0.41^{*}	-0.18	-0.65^{**}	0.69^{**}							
TP	GCV	-0.24	-0.12	-0.24	-0.37^{*}	-0.72^{**}	0.17	0.46^{**}						
	PCV	-0.16	-0.07	-0.24	-0.32	-0.52^{**}	0.11	0.30						
PL	GCV	0.39^{*}	0.00	0.74^{**}	0.82^{**}	0.47^{**}	-0.16	-0.59^{**}	-0.44^{**}					
	PCV	0.38^{*}	0.01	0.69^{**}	0.74^{**}	0.45^{**}	-0.15	-0.55^{**}	-0.33^{*}					
FG	GCV	0.51^{**}	0.53^{**}	-0.24	0.25	0.03	0.26	-0.13	-0.08	0.36^{*}				
	PCV	0.50^{**}	0.50^{**}	-0.22	0.23	0.02	0.24	-0.14	-0.07	0.35^{*}				
SF	GCV	0.25	0.23	-0.23	-0.01	-0.63^{**}	0.61^{**}	0.54^{**}	0.57^{**}	-0.24	-0.13			
	PCV	0.24	0.21	-0.21	-0.00	-0.61^{**}	0.56^{**}	0.47^{**}	0.37^{*}	-0.22	-0.11			
TW	GCV	-0.20	-0.16	-0.04	-0.16	-0.66^{**}	0.19	0.43^{**}	0.55^{**}	-0.41^{*}	-0.62^{**}	0.76^{**}		
	PCV	-0.19	-0.14	-0.04	-0.14	-0.63^{**}	0.20	0.41^{*}	0.41^{*}	-0.40^{*}	-0.61^{**}	0.72^{**}		
YP	GCV	0.46^{**}	0.37^{*}	-0.03	0.35^{*}	-0.56^{**}	0.58^{**}	0.28	0.18	0.19	0.39^{*}	0.72^{**}	0.34^{*}	
	PCV	0.42^{*}	0.29	-0.03	0.25	-0.47^{**}	0.49^{**}	0.21	0.31	0.18	0.33^{*}	0.58^{**}	0.25	

PH: Plant Height (cm) **FLL:** Flag Leaf Length (cm) **FLB:** Flag Leaf Breadth (cm) **FLAn:** Flag Leaf Angle (^{0}) **RL:** Root Length (cm) **RSR:** Root to Shoot Ratio **T/P:** Number of Tillers/Plant **PL:** Panicle Length (cm) **FG:** Filled Grains/Panicle **TW:** Test Weigh **SF:** Spikelet Fertilty % **YP:** Yield/Plant (g) **NS:** Non Stress **S:** Stress

TABLE 6: Direct (diagonal values) & Indirect Effects of 13 Different Characters on Grain Yield at Genotypic Level under Both Hydrological Regimes

		PH	FLL	FLB	FLA	FLAn	RL	RSR	TP	PL	FG	SF	TW
PH	NS	**-0.93**	2.07	-1.70	-0.26	0.00	0.64	0.12	0.02	-0.05	0.21	0.02	0.13
	S	**-1.42**	0.54	-0.37	-0.36	0.01	1.53	0.34	-0.04	-0.12	0.20	0.09	0.02
FLL	NS	-0.59	**3.27**	-1.08	-1.86	0.04	0.46	0.06	-0.02	-0.06	0.07	0.03	0.02
	S	-1.04	**0.74**	-0.82	-0.31	0.08	1.91	-0.53	-0.02	0.00	0.20	0.07	0.01
FLB	NS	0.45	-1.01	**3.52**	-2.20	0.10	-0.15	-0.09	-0.07	-0.08	-0.14	-0.07	-0.09
	S	0.34	-0.40	**1.52**	-0.50	-0.14	-1.28	0.84	-0.05	-0.21	-0.08	-0.07	0.00
FLA	NS	-0.07	1.76	2.24	**-3.46**	0.12	0.24	-0.04	-0.08	-0.11	-0.06	-0.03	-0.07
	S	-0.60	0.27	0.88	**-0.86**	-0.07	0.45	0.36	-0.07	-0.23	0.09	0.00	0.01
FLAn	NS	0.01	0.57	1.35	-1.65	**0.26**	0.03	-0.01	0.07	-0.13	0.04	-0.19	0.08
	S	0.05	-0.21	0.71	-0.19	**-0.29**	-1.45	1.33	-0.12	-0.14	0.01	-0.22	0.05
RL	NS	-0.78	1.96	-0.67	-1.08	0.01	**0.77**	0.04	-0.03	-0.06	0.10	0.06	0.06
	S	-0.84	0.55	-0.75	-0.15	0.16	**2.58**	-1.41	0.03	0.05	0.10	0.20	-0.02
RSR	NS	0.69	-1.20	2.02	-0.78	0.02	-0.20	**-0.16**	-0.06	0.02	-0.24	0.03	-0.16
	S	0.23	0.19	-0.63	0.15	0.19	1.78	**-2.03**	0.07	0.17	-0.05	0.17	-0.03
TP	NS	0.05	0.25	0.78	-0.89	-0.05	0.06	-0.03	**-0.33**	0.05	-0.15	-0.01	-0.12
	S	0.23	-0.05	-0.36	0.27	0.15	0.29	-0.61	**0.23**	0.10	-0.03	0.13	-0.03
PL	NS	-0.27	1.05	1.49	-2.16	0.18	0.27	0.02	0.08	**-0.18**	0.15	-0.10	0.10
	S	-0.54	0.00	1.04	-0.63	-0.13	-0.38	1.12	-0.07	**-0.30**	0.14	-0.08	0.03
FG	NS	-0.59	0.75	-1.47	0.68	0.03	0.24	0.12	0.15	-0.08	**0.33**	-0.07	0.24
	S	-0.70	0.37	-0.33	-0.20	-0.01	0.63	0.28	-0.02	-0.11	**0.39**	-0.04	0.05
SF	NS	-0.04	0.22	-0.61	0.25	-0.12	0.12	-0.01	0.01	0.04	-0.05	**0.42**	-0.11
	S	-0.34	0.15	-0.31	0.00	0.18	1.44	-0.96	0.08	0.07	-0.04	**0.36**	-0.06
TW	NS	0.40	-0.22	1.05	-0.78	-0.07	-0.14	-0.08	-0.13	0.06	-0.26	0.15	**-0.30**
	S	0.27	-0.10	-0.05	0.12	0.19	0.51	-0.84	0.09	0.12	-0.24	0.26	**-0.08**

PH: Plant Height (cm) **FLL:** Flag Leaf Length (cm) **FLB:** Flag Leaf Breadth (cm) **FLAn:** Flag Leaf Angle (^{0}) **RL:** Root Length (cm) **RSR:** Root to Shoot Ratio **T/P:** Number of Tillers/Plant **PL:** Panicle Length (cm) **TW:** Test Weigh **FG:** Filled Grains/Panicle **SF:** Spikelet Fertilty % **YP:** Yield/Plant (g) **NS:** Non Stress **S:** Stress

Such influences can be estimated through path coefficient analysis which permits the separation of the correlation coefficient into components of direct and indirect effect on grain yield. In the present investigations yield/plant (g) was taken as a dependent or resultant variable and all the others characters, under study as independent or causal variables. Path analysis under optimum irrigated condition revealed that number of filled grains/panicle had high positive direct effect (0.33) and positive indirect effect through plant height (0.21), flag leaf length (2.07), and number of tillers/plant (0.02) which was followed by root to shoot ratio (0.12). Flag leaf length showed indirect effect via plant height (2.07) and number of filled grains/panicle (0.07). On the other hand, flag leaf angle, number of tillers/plant, panicle length and test weight showed negative direct effect on grain yield. However, under stress condition the traits exhibited direct influence on grain yield are flag leaf length (0.74), flag leaf breadth (1.52), root length (2.58), number of filled grains/panicle (0.39), number of tillers/plant (0.23) and spikelet fertility percentage (0.36). Plant height (-1.42), flag leaf area (-0.86), flag leaf angle (-0.29), root to shoot ratio (-2.03), panicle length (-0.30) and test weight (-0.08) showed negative direct effect on grain yield and some of the traits showed indirect positive effect via number of filled grains/panicle, spikelet fertility percentage, plant height, flag leaf length and number of tillers/plant. It can be concluded that, the number of filled grains/panicle, spikelet fertility percentage, plant height and leaf length could be considered for selection of lines adaptable to rainfed condition. Past workers identified the traits for selection in different ecosystem as: harvest index, plant height and panicle length (Mehetre *et al*., 1996) under low land stress, filled grains/panicle, spikelet fertility (Seyoum *et al.*, 2012) in upland condition and spikelet fertility, biomass and harvest index (Pandey *et al*., 2012) under irrigated condition. Thus, practical applicability of yield and yield attributing traits, such as plant height, tillers/plant, number of filled grains/panicle and spikelet fertility could be considered, as selection criteria for development of lines suitable for rainfed cultivation and the characters were enlighten with either high direct or indirect effect on grain yield. Root length and root to shoot ratio may also be emphasized for selection of such lines. Mehetre *et al.* (1994) reported that, number of filled grains/panicle, plant height and panicle length are the most important and effective traits on yield for breeding of upland rice.

CONCLUSION

Results from the study highlighted presence of adequate genetic variability within the collected germplasm under stress and irrigated condition. The characters number of filled grains/panicle, spikelet fertility percentage, plant height, flag leaf length and root length were correlated with yield and had either high direct or indirect effect and could be considered for selection of desirable lines. Genotypes that are capable of maintaining high spikelet fertility, more filled grains/panicle and root length could be considered suitable for improving the grain yield in rice breeding programs targeting development of lines adaptable to rainfed area maintaining high economic yield.

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