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Genetic parameters estimation for yield and yield related traits in rice (*Oryza sativa* L.) with drought tolerance trait under stress condition

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ABSTRACT

Drought is a major abiotic stress that causes severe yield loss in rice, a staple food crop, affecting 20 per cent of the total rice growing area in Asia. Keeping these in view, the present investigation was carried out to assess the extent of genetic variability for yield and yield related traits and to estimate heritability and genetic advance in rice genotypes for drought tolerance. The genotypes exhibited high variability for the characters like number of grains per panicle and plant height under both condition. The traits like plant height, flag leaf area, chlorophyll content, leaf drying at vegetative stage, and seed yield per plant showed high heritability coupled with high genetic advance as per cent of mean under both stress and normal conditions. Hence, the direct selection of these characters may be useful for future improvement of genotypes under respective environment for improvement of drought tolerance and highergrain yield.

Keywords : DSI, Drought stress, Genetic Parameters, Rice and Canopy Temperature

Rice; *Oryza sativa* L. (Asian rice) is the most important food crop and a major food grain for more than a third of the world's population (Zhao *et al.*, 2011). A successful breeding program depends on the genetic diversity of a crop for achieving the goals of improving the crop and producing high yielding varieties (Padulosi, 1993). Drought is a major abiotic stress that causes severe yield loss in rice as a staple food crop affecting 20 per cent of the total rice growing area in Asia. Grain yield is a complex polygenic quantitative trait, greatly affected by environment and determined by the magnitude and nature of their genetic variability Genetic variability, which is due to the genetic differences among individuals within a population, is the core of plant breeding because proper management of diversity can produce permanent gain in the performance of plant and can buffer against seasonal fluctuations (Sharma, 1998) Genetic variability among traits is important for breeding and in selecting desirable types. The low heritability of grain yield characters made selection for high yielding varieties possible usually using various components traits associated with yield.

However, information on relationship of grain yield and yield contributing traits for upland rice of Ethiopian agro-ecology is not sufficiently available. In view of the above gaps, the present study was undertaken to investigate the genetic variability, heritability and genetic advance for yield related traits as a basis for selection of high yielding rice genotypes in upland ecology. Hence, the present study aims at the assessment of the extent of genetic variability for yield and yield related traits and estimation of heritability and genetic advance in upland rice genotypes.

MATERIALS AND METHODS

A set of 33 rice genotypes including four checks *viz*., Sahbhagidhan, Vandana, Rasi and APO were evaluated at vegetative and reproductive stage under drought stress conditions during *kharif* 2012 in RBD design at Research Farm of Rajendra Agricultural University, Pusa, Samastipur, Bihar with objectives to estimate genetic variability, Genetic Parameters, Heritability and Genetic Advance for Yield Related Traits in Rice (*Oryza sativa* L.). The following characteristics were taken in consideration: Days to 50 per cent flowering (DFF), Days to maturity(DM), Plant height (cm) (PH), Flag leaf Area (cm^2)(FLA), Chlorophyll content (SPAD) (CHL), Number of tillers plant^{-1} (TPP), Leaf rolling at vegetative stage(LR), Leaf drying at vegetative stage(LD), Recovery Percentage After Stress (%) (RWC), Panicle Length (cm) (PL), Canopy Temperature (0C) (CT), Recovery percentage after stress (RAS), DSI, Number of grains panicle^{-1} (GPP), 1000 Grains weight (TWG), Harvest Index (HI), and Seed Yield / Plant (SYP).

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant variation among the genotypes for all the characters under study in both conditions (stress and normal) (Table 1). The effects of water deficit on various agro-morphological and physiological traits associated with drought tolerance were also studied. Result revealed that significant yield decline was observed almost in all rice genotypes grown under water stress condition compared to normal irrigated situation. Out of these 33 rice genotypes, RAU-1428-31-5-4 (8.39*),RAU-1428-54-35-5-5 (8.38*) and 21284-BAU445-06 (8.38*) under

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stress condition and the genotypes namely RAU-1428-31-5-4-3-2-2-2 (14.82*), RAU-1428-31-5-4 (14.31*) and RAU-1451-66-1-1-5-2 (13.69*) under normal condition showed superior in terms of grain yield and yield attributes. Significant variation was also observed among the genotypes for drought susceptibility index, canopy temperature, relative water content, leaf rolling at vegetative stage, leaf drying at vegetative stage, chlorophyll content, days to fifty percent flowering, days to maturity, plant height and seed yield plant^{-1} under both conditions. The tolerant lines maintained high leaf water status and plant biomass under vegetative and reproductive stage drought condition. Based on yield and yield attributes results under drought and irrigated condition, rice genotypes RAU-1428-31-5-4 (8.39*), RAU-1428-54-35-5-5 (8.38*) and 21284-BAU445-06 (8.38*) under stress condition and the genotypes namely RAU-1428-31-5-4-3-2-2-2 (14.82*), RAU-1428-31-5-4 (14.31*) and RAU-1451-66-1-1-5-2 (13.69*) under normal condition were recommended for use in drought breeding programme as well as adoption in rainfed lowland ecosystem. Analysis of variance revealed highly significant variation among the genotypes for all the characters under study in both conditions. The variability study indicated moderate to high phenotypic and genotypic coefficient of variation accompanied by high heritability (moderate for leaf rolling) and genetic advance as per cent of mean for traits like plant height, flag leaf area, chlorophyll content, leaf drying at vegetative stage. Seed yield plant^{-1} had showed high heritability coupled with high genetic advance as per cent of mean under both conditions indicating their importance in selection for yield improvement under respective environments. This study indicates preponderance of additive gene effect, which will help to make selection in early segregating generation. The genetic advance as per cent mean suggesting that still there is scope for further improvement of genotypes for these characters under drought stress condition.

In the present investigation, thirty three rice genotypes were studied to assess their performance in terms of traits implicated in drought, yield and yield related traits. The analysis of variance or estimates of MSS clearly indicated that there was highly significant variation among the genotypes for all the traits studied under both the environments. This in turn indicated that there was sufficient variability in the material studied under both stress and normal conditions, which could be utilized in further breeding programme. In other words, further analysis of drought tolerance is meaningful as indicated by significant mean sum of squares under stress condition. Interestingly, the magnitude of MSS of many traits were more under stress condition than normal, which indicated directly that the amount of variation for these traits was more desirable under stress condition. More variation under stress condition is expected as different genotypes respond differentially under stress condition. Many earlier workers, Chen *et al.* (2001), Pantuwan *et al.* (2002), Muthuswamy and Kumar (2006), Ouk *et al.* (2006), Ganapathy *et al.* (2007), Allah (2009), Mina *et al.* (2011), Gomez *et al.* (2003) reported high variability for different traits in rice. Thus, it implied that there was reasonably sufficient variability in material used for the study, which provides ample scope for selecting superior genotypes by the plant breeder for further improvement.

The phenotypic variances for all the traits under study were higher than the genotypic variances (El-Kareem and El-Saidy, 2011).This may be due to the non-genetic factor which played an important role in the manifestation of these characters. Wide ranges of variance (phenotypic & genotypic) were observed in the experimental material for all the traits under investigation in both environments. The maximum phenotypic and genotypic variance was exhibited by the traits *viz*., number of grains per panicle and plant height under both environments. These findings were in accordance of Mina *et al.* (2011), Blum *et al.* (1999) and Manickavelu *et al.* (2006) who also observed high variance for yield and yield component traits among rice genotypes. The relative water content (RWC) and Chlorophyll content exhibited high genotypic and phenotypic variance in stress condition indicating importance of these characters in stress condition for further improvement. Similar results were obtained by Chen *et al.* (2001); Lonbani and Arzani (2011). Characters which had high to moderate range of variation with maximum range were Number of grains per panicle followed by Plant height, Relative water content, Harvest index, Days to physiological maturity, Days to fifty per cent flowering and Chlorophyll content are quantitative in nature and influenced by macro and micro-environmental conditions under both conditions.

The assessment of heritable and non-heritable components in the total variability observed is indispensable in adoption of suitable breeding procedure. The heritable portion of the overall observed variation can be ascertained by studying the components of variation such as GCV, PCV, heritability and genetic advance as per cent of mean.

In the present investigation, Leaf rolling at vegetative stage, leaf drying at vegetative stage and seed yield per plant depicted very high GCV and PCV in both conditions, whereas drought susceptibility index and recovery percentage after stress in stress condition exhibited very high GCV and PCV, indicating the importance of these traits in evaluation and selection of

Table 1: Analysis of Variance for different quantitative characters in Rice under stress and normal condition

No.	Characters	Mean sum of squares					
		Replication		Treatments		Error	
		Normal	Control (Stress)	Normal	Control (Stress)	Normal	Control (Stress)
1	Days to 50 % flowering	3.68	6.83	72.29**	53.06**	1.05	2.06
2	Days to maturity	8.68	1.12	63.22**	81.99**	4.24	8.43
3	Plant height (cm)	0.0078	1.30	224.77**	223.68**	0.41	1.45
4	Flag leaf Area (cm^2)	0.023	1.59	194.31**	69.55**	0.21	1.72
5	Chlorophyll content (SPAD)	0.09	0.01	79.96**	73.91**	0.15	0.07
6	Number of tillers per plant	4.48	2.21	5.39**	6.28**	2.67	1.58
7	Leaf rolling at vegetative stage	0.28	1.40	0.54**	8.27**	0.12	0.90
8	Leaf drying at vegetative stage	0.21	0.94	0.96**	7.47**	0.15	0.54
9	RWC (%)	1.95	3.32	41.89**	137.25**	1.12	2.38
10	Panicle Length(cm)	0.54	10.61	15.73**	10.13**	0.42	1.30
11	Canopy Temperature(^{0}C)	0.44	4.13	3.84**	6.59**	1.61	1.86
12	Recovery percentage after stress	-	148.48	-	653.79**	-	100.57
13	DSI	-	0.18	-	0.19**	-	0.07
14	Number of grains per panicle	546.19	16.94	3096.46**	394.16**	701.40	0.46
15	1000 Grains weight	0.47	0.06	11.75**	71.21**	3.08	1.53
16	Harvest Index	0.76	2.54	68.86**	104.93**	0.24	1.44
17	Seed Yield / Plant	1.05	2.16	18.15**	6.67**	1.81	1.04

***Significant @ 1% level of significance*

Table 2: Mean, range and coefficient of variance for various characters in rice under both conditions

No.	Genotypes	Mean		Range		CV	
		Control	Normal	Control	Normal	Control	Normal
1	Days to 50% Flowering	69.83	75.28	62.66 -79.00	67.00-88.00	2.05	1.36
2	Days to Physiological Maturity	96.39	103.23	83.33 – 103.66	95.33-110.66	3.012	1.99
3	Plant Height(cm)	83.36	85.35	66.19 – 103.40	69.19-105.30	1.44	0.74
4	Flag Leaf Area (cm^2)	29.61	33.82	20.76 - 39.33	19.57-47.40	4.43	1.36
5	Chlorophyll Content	32.74	35.42	22.90 - 39.43	21.47-42.62	0.81	1.10
6	Number of tillers per plant	5.24	9.54	3.33 - 8.66	7.33-12.33	23.95	17.12
7	Leaf Rolling at vegetative stage	2.31	0.26	0.33 -7.66	0.00-1.66	41.10	129.79
8	Leaf Drying at vegetative stage	1.60	0.36	0.00-5.66	0.00-2.33	45.90	106.37
9	Relative Water Content	77.72	85.28	62.70-87.67	77.16-92.66	1.98	1.24
10	Panicle Length (cm)	22.75	23.57	19.28-27.13	20.50-28.23	5.00	2.73
11	Canopy Temperature (^{0}C)	32.18	30.35	29.69-35.61	28.30-32.71	4.23	4.17
12	Recovery Percentage After Stress	55.45	-	30.00-80.00	-	18.08	-
13	DSI	0.90	-	0.31-1.41	-	28.25	-
14	Number of grains per panicle	79.12	186.80	62.66-105.66	108.73-234.66	0.85	14.17
15	1000 Grains Weight (g)	32.90	20.71	24.06-44.13	18.40-26.083	3.75	8.46
16	harvest Index	37.38	54.00	27.30-49.82	38.72-60.29	3.21	0.90
17	Seed Yield/ Plant (g)	5.59	10.38	3.36-8.39	6.31-14.81	18.19	12.95

Table 3: Genetic parameters of various characters in Rice under both conditions.

No.	Characters	σ_g^2		σ_p^2		GCV		PCV		h^2 (Broad sense) (%)		Genetic Advance of Mean as (%)	
		Normal	Drought	Normal	Drought	Normal	Drought	Normal	Drought	Normal	Drought	Normal	Drought
1	DFF	23.74	17.00	24.79	19.06	6.47	5.90	6.62	6.25	95.80	89.20	13.05	11.49
2	DM	23.74	24.51	23.89	32.95	4.30	5.14	4.74	5.96	82.30	74.40	8.03	9.13
3	PH (cm)	74.78	74.07	75.19	75.52	10.13	10.32	10.16	10.42	99.50	98.10	20.82	21.06
4	FLA (cm^2)	64.70	22.60	64.91	24.33	23.78	16.06	23.82	16.66	99.70	92.90	48.91	31.89
5	CHL (SPAD)	26.60	24.61	26.75	24.68	14.56	15.15	14.60	15.17	99.40	99.70	29.91	31.16
6	TPP	0.90	1.56	3.57	3.14	9.98	23.88	19.82	33.82	25.30	49.80	10.34	34.72
7	LR	0.14	2.45	0.25	3.35	23.83	67.74	29.77	79.24	54.70	73.10	21.14	42.43
8	LD	0.27	2.30	0.42	2.85	22.37	94.59	25.84	89.14	64.50	80.90	23.36	40.48
9	RWC (%)	13.59	44.95	14.70	47.33	4.32	8.63	4.50	8.85	92.40	95.00	8.56	17.32
10	PL (cm)	5.10	2.94	5.52	4.24	9.58	7.54	9.97	9.05	92.40	69.40	18.98	12.94
11	CT(^{0}C)	0.74	1.57	2.35	3.43	2.84	3.90	5.05	5.76	31.60	45.90	3.29	5.44
12	RAS	-	184.40	-	284.97	-	24.49	-	30.44	-	64.70	-	40.58
13	DSI (%)	-	0.04	-	0.10	-	22.58	-	36.17	-	39.00	-	29.04
14	GPP	798.35	131.23	1499.75	131.69	15.13	14.48	20.73	14.50	53.00	99.70	22.73	29.77
15	TWG	2.89	23.22	5.96	24.75	8.21	14.65	11.79	15.12	49.00	93.80	11.77	29.23
16	HI	22.87	34.49	23.11	35.93	8.86	15.71	8.90	16.04	99.00	96.00	18.15	31.71
17	SYP	5.44	1.87	7.25	2.91	22.47	24.49	25.94	30.51	75.00	64.40	40.09	40.49

superior genotypes. In this study, the phenotypic and genotypic coefficient of variance was found to be moderate for chlorophyll content and plant height under both environments (normal and stress condition). Similar results were reported by Roy *et al.* (1995), Sarvanan and Senthil (1997), Ganapathy *et al.* (2007) and Sharma *et al.* (2000). These findings were clearly indicated that selecting genotypes through these traits will be effective for drought tolerance. It is interesting to note that the differences between GCV and PCV values were minimum implying least influence of environment and preponderances of additive gene effects; indicating genotypes can be improved and selected for these characters under stress condition for improvement of drought tolerance. Study of per se performance of individual genotype suggests the importance of the materials under study and it becomes first-hand information for the breeders. The mean (Kour and Pradhan, 2016) of different quantitative characters including grain yield as performed by the available genotypes suggested that selection of desirable genotypes based on the traits from materials evaluated, can be effective.

In crop improvement programme, selection is practiced directly or indirectly. Selection parameters include the study of heritability and genetic advance (direct selection parameters) and correlation between yield and component traits and path coefficient analysis (indirect selection parameters).

In this study, heritability in broad sense for all the characters, namely days to fifty per cent flowering, days to physiological maturity, plant height, flag leaf area, chlorophyll content, leaf drying at vegetative stage, relative water content (RWC), Panicle length, harvest index and seed yield plant^{-1} were found to be high in both (stress and normal) environments. These findings are in agreement with the findings of Venkataramana and Hittalmani (1999) for seed yield plant^{-1}; Gomez *et al.* (2003) for plant height; Wu *et al.* (2004) for relative water content; Muthuswamy *et al.* (2006) for panicle length, number of tillers plant^{-1}, number of grains per panicle and seed yield plant^{-1}; Manickavelu *et al.* (2006) for leaf drying at vegetative stage, relative water content, harvest index and days to fifty per cent flowering; Gupta (2007) for days to physiological maturity and Tammam (2004) for days to fifty per cent flowering, number of grains per panicle and seed yield plant^{-1} also reported high heritability for relative water content, Allah (2009) also noticed high heritability value for days to fifty flowering, plant height, flag leaf area, number of grains per panicle, 1000 grains weight and seed yield plant^{-1}. Lin *et al.* (2009) also reported the high heritability for days to fifty per cent flowering, plant height, seed yield plant^{-1}, 1000 grain weight and number of grains per panicle.

In the present investigation the characters, namely plant height, flag leaf area, chlorophyll content, leaf drying at vegetative stage, and seed yield plant^{-1} had showed high heritability coupled with high genetic advance as per cent of mean under both stress and normal conditions. Hence, direct selection can be done through these characters for future improvement of genotypes under respective environment for improvement of drought tolerance and higher grain yield. Similar results were also reported by earlier workers *viz*., Muthuswamy *et al.* (2006) for panicle length; Manickavelu *et al.* (2006) for leaf drying at vegetative stage, for flag leaf area and grain yield and Gomez *et al.* (2003) for plant height.

The high heritability associated with high genetic advance indicated, the variation was mostly due to additive gene effects. It indicates that if these characters are subjected to any selection scheme for exploiting fixable genetic variance, a widely adopted genotype can be developed.

High heritability coupled with moderate genetic advance was observed for the traits, namely days to fifty per cent flowering and panicle length under both stress and normal conditions. Recovery percentage after stress depicted high heritability coupled with moderate genetic advance as per cent of mean under stress condition. This finding is in accordance of Manickavelu *et al.* (2006) for recovery percentage after stress. These traits indicated that there manifestation is governed by both additive and non-additive genetic effects and therefore, selection should be practiced in later segregating generations i.e. by hybridization programme to exploit hybridity.

Drought susceptibility index showed moderate heritability coupled with high genetic advance as per cent of mean under stress condition reveals that the character is governed by additive gene effects. The moderate heritability is being exhibited due to high environmental effects. Selection may be effective in such cases.

Leaf rolling at vegetative stage exhibited high heritability coupled with high genetic advance as per cent of mean under stress condition reveals that the character is governed by additive gene effects and selection may be rewarding. This finding is in agreement with the finding of Manickavelu *et al.* (2006). However, under normal condition leaf rolling at vegetative stage exhibited moderate heritability accompanied with high genetic advance as per cent of mean revealing that the character is governed by additive gene effects and selection may be effective.

The present studies suggested the existence of variation among the genotypes for grain yield and yield contributing morpho-physiological traits showed differential response to drought stress environment at vegetative and reproductive stage. Drought stress at reproductive stage caused significant reduction in plant height, grain yield, RWC (%) and increase in grain sterility percentage in rice genotypes; however, the responses varied among genotype. Further yield improvements in drought stress situation can be achieved by identifying morpho-physiological traits contributing for tolerance against water stress.

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