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Effectiveness of Traits for Direct Selection under Severe Drought Stress Condition in Rice

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Abstract:
Morphological and yield related traits of 76 rice genotypes were studied during dry seasons of 2012 and 2013 to estimate the genetic variability, heritability, correlation coefficients and path analysis among some drought related and morphological traits and contribution of these traits to the yield under drought stress directly and indirectly in rice. Highly significant variation was obtained for all the traits were studied such as days to 50% flowering, plant height, ear bearing tiller, panicle length, total dry matter production, harvest index, kernel length, kernel breadth and 1000-grain weight. Relatively high GCV, PCV, broad sense heritability and genetic advance obtained for ear bearing tiller, total dry matter production, harvest index and plot yield suggested these characters would be inherited to the progenies after hybridization and phenotypic based selection would be effective. Grain yield was found to be positively and significantly associated with panicle length, ear bearing tiller, total dry matter production and harvest index at genotypic level, indicating the importance of these traits for yield improvement in upland rice. Harvest index exhibited maximum positive direct effect on grain yield.

***Keywords**: Variability, broad sense heritability, genetic advance, correlation coefficients, path coefficients*

1. Introduction

Rice (*Oryza sativa* L.) is one of the predominant food crops of the world. It is hydrophilic crop, commonly grown under flooded condition. However, more than half of the world productivity comes from upland or rainfed conditions. Drought is a major abiotic stress affecting crop growth and yield stability under rainfed conditions. Breeding for drought tolerance is usually performed by selecting genotypes for high yield under water limited conditions (Kumar et al., 2008) This yield based selection has further lead to a narrow genetic variability for yield and component traits in recently developed cultivars (Araus et al., 2002).Therefore trait based breeding approach has been proposed to improve rice yields under water limited conditions (Reynolds et al., 2011). More emphasis has been diverted in recent days to improve several morphological traits which confer drought tolerance without much compromising with yield reduction. So developing drought resistant cultivars especially with good performance under reproductive drought stress is one of the major objectives in rice breeding programs (Pantuwan et al., 2002). Genetic variability among traits is essential 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 in which yield and related traits are associated among themselves. The relationship between rice yield and yield component traits has been studied widely at phenotypic level (Sadeghi, 2011). But no information is available for selection of traits under reproductive stage drought tolerance. Path coefficient analysis partitions the genetic correlation between yield and its component traits into direct and indirect effects and effectively been used in identifying useful traits as selection criteria to improve grain yield in rice. Heritability of a trait is important in determining its response to selection. It was found earlier that genetic improvement of plants for quantitative traits requires reliable estimates of heritability in order to plan an efficient breeding programme. The broad sense heritability is the relative magnitude of genotype and phenotypic variance for the traits and it gives an idea of the total variation accounted to genotypic effect.

The effective breeding to increase grain yield could be achieved, if the components traits are highly heritable and positively correlated with grain yield. However, it is very difficult to judge whether observed heritability is highly heritable or not. Moreover, knowledge of heritability is essential for selection based improvement as it indicates the extent of transmissibility of a character into future generations. Therefore, the present study was conducted to find out the effective traits are to be selected during reproductive drought stress for achieving high yield along with drought tolerance.

2. Materials Methods

In the present research work study, 76 rice genotypes were studied for morphological traits under simulated drought stress condition. Seventy six rice genotypes consisting of direct seeded landraces of upland and lowland ecology and some promising cultures were acquired from Central Rice Research Institute, Cuttack and International Rice Research Institute, Manila, Philippines. These genotypes were direct seeded in a randomized block design with two replications at Central Rice Research Institute during dry season, 2012 and 2013. Each genotype was direct seeded in 2.4 m long plot with a between-row spacing of 20 cm and within-row spacing of 15 cm, while the number of rows per plot and the number of analyzed plants per plot varied with genotype. Grain yield components traits namely the number ear bearing tiller (EBT), days to 50% flowering (DFF), plant height (PH), panicle length (PL), total dry matter production (TDM), harvest index (HI), sterility %, plot yield (gm), kernel length (mm), kernel breadth (mm) and 1000-grain weight (gm) were analyzed. Stress was realized by stopping irrigation at the time of flowering. The data collected for all the traits studied were subjected to analysis of variance for RBD using GENRES 3 (1994) version 7.01 and SAS (2003) version 9.1.

3. Results and Discussion

Analysis of variance revealed significant differences among genotypes for all traits studied (Table 1), indicating presence of considerable amount of genetic variation among the study materials. The magnitude of variation between genotypes was reflected by high values of mean for traits studied (Table 2). High genetic variability for different quantitative traits in rice was also reported earlier by Khan and Ashfaq (2009). The results (Table 2) revealed that the estimates of phenotypic coefficient of variation (PCV) were higher than those of genotypic coefficient of variation (GCV) for all the traits studied. The extent of the environment influence on traits is explained by the magnitude of the difference between GCV and PCV. Large differences between GCV and PCV values reflect high environmental influence on the expression of traits. The high GCV coupled with PCV were recorded for, EBT (24.67 and 31.64), HI (24.38 and 32.07), sterility (39.75 and 42.47), plot yield (68.88 and 71.82) respectively. Moderate GCV coupled with PCV were recorded for, DFF (14.57 and 19.18), TDM (15.94 and 20.53), 1000 grain weight (14.64 and 24.29) and kernel breadth (11.31 and 13.19) respectively. Low GCV coupled with moderate PCV were recorded for, plant height (9.82 and 18.95) and panicle length (8.58 and 12.09) respectively. A same result was recorded by Akinwale *et al*. (2011) for different quantitative traits in rice. High PCV and high CV of the traits revealed from the study will favour during selection of genotypes under drought stress.

The estimates of broad sense heritability varied from 26.8 to 94.8% (Table 2). In the present study, kernel breadth (73.5%), sterility (87.6%), plot yield (91.9%) and kernel length (94.8%) exhibited high heritability. High heritability suggests high component of heritable portion of variation that can be exploited by breeders in the selection of superior genotypes on the basis of phenotypic performance. Moderate heritability was recorded for DFF (57.6%), EBT (60.7%), PL (50.3%), TDM (60.2%), HI (57.8%) and 1000-grain weight (36.3%) which indicates the possibility of using for rice improvement program, but their expression can be influenced very much by the environment. The study revealed very low estimate of heritability for plant height (26.8). Very low heritability indicates greater role of environment on the expression of the trait. Therefore, direct selection for plant height will be ineffective. The estimates of genetic advance as percent of mean (Table 2) were high for DFF (22.79%), EBT (39.61%), TDM (25.49%), HI (38.18%), sterility (76.36%) and plot yield (73.51%). These results were supported by earlier findings (Kole et al., 2008).In this study, high to medium estimates of heritability and high genetic advance were obtained for ear bearing tiller, total dry matter production, harvest index and plot yield, which suggests these traits could be considered as favourable attributes for upland rice improvement through selection. Likewise, the high heritability combined with high genetic advance could be regarded as an indication of additive gene action and the consequent high expected genetic gain from selection for these characters. High heritability and high genetic advance were also reported earlier in rice for panicles per plant, plant height, grains per panicle and grain yield. High heritability estimates with low genetic advance observed for panicle length and kernel length indicates non-additive type of gene action and the genotype by environment interaction play a significant role in the expression of the trait. It is in agreement with the present findings relating to high heritability with low genetic advance was observed for panicle length (Ullah et al., 2011) and for spikelet fertility (Qamar et al., 2005). Relatively high GCV, PCV, broad sense heritability and genetic advance obtained for ear bearing tiller, total dry matter production, harvest index and plot yield suggested these characters could be transmitted to the progeny when hybridization would be conducted and phenotypic based selection would be effective.

The results of simple linear correlation coefficients between all pairs of traits as shown in Table 3, reveals grain yield had positive and significant association with harvest index (r =0.78**), total dry matter production (r = 0.71**), ear bearing tiller(r =0.58**), panicle length (r =0.37**), plant height (r= 0.36**) under reproductive stage drought condition. The results are in conformity with Hairmansis *et al*. (2010) for grains per panicle, spikelets per panicle and spikelet fertility. Grain yield had negative and non significant correlation with days to 50% flowering and sterility at genotypic level whereas it showed positive and non significant correlation with plant height and kernel breadth at genotypic level. Similar observations were reported for days to 50% flowering, plant height and tillers per plant (Wattoo et al., 2010). Genotypic correlation coefficients were partitioned by using method of path analysis to find out the direct and indirect effects of yield contributing traits towards the grain yield. From the path analysis (Table 4), it was revealed that harvest index exhibited maximum positive direct effect on grain yield

followed by plant height (1.64), sterility (0.31), ear bearing tiller (0.28) and kernel breadth (0.1).The direct effects of days to 50% flowering, panicle length, total dry matter production, kernel length and 1000-grain weight were negative. The indirect effect of harvest index through other traits indicated that direct selection using total dry matter production and ear bearing tiller to select high yielding genotypes will be effective. Harvest index showed the highest positive direct effect and genotypic correlation (r = 0.78) with grain yield. This strong genetic correlation resulted in high positive direct effect on grain yield. Much research works revealed similar findings under non stress condition. The highest positive direct effect has been reported by Agahi *et al*. (2007) for number of productive tillers, days to maturity, panicle number and chlorophyll content in rice.
The residual effect was 0.376 indicated that the other components such as soil fertility, moisture, weather etc. might have significant contribution on grain yield than the characters studied in the present experiment.

4. Conclusion

The present study results indicated that there is adequate genetic variability present in the materials studied under stress condition. The GCV, PCV, broad sense heritability and genetic advance suggested ear bearing tiller, total dry matter production, harvest index and plot yield were important yield attributing traits under drought stress condition. Harvest index had maximum positive direct effect and the highest genotypic correlation coefficient, followed by plant height, sterility, ear bearing tiller, panicle length, plant height, kernel length and kernel breadth had positive indirect effect on grain yield through grains per panicle. Harvest index is the most important trait which should be given due attention in making selection effective for high yielding genotypes which can be forwarded that for increasing rice grain yield under drought stress. Therefore, from the present study it can be forwarded that for increasing rice grain yield under drought stress, a genotype should possess high harvest index, ear bearing tiller, plot yield, and total dry matter production. .

Characters	Sources of variation		
	Rep (2)	Genotype (76)	Error
Days to 50% flowering	8.05	306.02*	82.09
Plant height (cm)	38.20	296.03*	170.71
Ear bearing tiller	0.50	10.80*	2.63
Panicle length (cm)	6.52	8.99*	2.97
Total dry matter production (gm)	3.52	550.17*	136.31
Harvest index	8.09	7.57*	2.02
Sterility %	0.28	573.45*	37.92
Plot yield (gm)	138.49	5250.27*	219.72
1000 grain weight (gm)	16.18	53.78*	25.10
Kernel length (mm)	2.90	0.73*	1.95
Kernel breadth (mm)	5.09	0.13*	1.98

Table 1: Analysis of variance for various morpho-physiological traits of 76 rice genotypes under reproductive stage drought stress (= Significant at 5% level of probability)*

Characters	Mean	CV(%)	ECV(%)	GCV(%)	PCV(%)	h2(Broad sense)	GA(%)as mean
Days to 50% flowering	72.63	12.47	12.47	14.57	19.18	0.57	22.79
Plant height (cm)	80.60	16.21	16.21	9.82	18.95	0.26	10.48
Ear bearing tiller	8.19	19.81	19.81	24.67	31.64	0.60	39.61
Panicle length (cm)	20.24	8.51	8.52	8.58	12.09	0.50	12.53
Total dry matter production (gm)	90.23	12.93	12.94	15.94	20.53	0.60	25.49
Harvest index	0.21	20.83	20.83	24.38	32.07	0.57	38.18
Sterility %	41.16	14.95	14.96	39.75	42.47	0.87	76.63
Plot yield (gm)	72.81	20.35	20.36	68.88	71.82	0.91	73.51
1000 grain weight (gm)	25.85	19.37	19.38	14.64	24.29	0.36	18.18
Kernel length (mm)	6.19	2.25	2.25	9.67	9.93	0.94	19.39
Kernel breadth (mm)	2.07	6.78	6.79	11.31	13.19	0.73	19.97

Table 2: Estimates of parameters of variability for eleven traits under drought stress in 76 rice genotypes

	DFF	PH	EBT	PL	TDM	HI	Ster	KL	KB	1000 grain wt	GY
DFF	1	-0.09	-0.34**	-0.29*	-0.32**	-0.47**	-0.47**	0.17	-0.09	0.01	-0.51**
PH		1	0.39**	0.68**	0.51**	0.29*	-0.46**	0.26*	0.26*	0.13	0.36**
EBT			1	0.63**	0.43**	0.56**	-0.48**	0.19	-0.07	-0.08	0.58**
PL				1	0.35**	0.51**	-0.3*	0.14	0.15	-0.19	0.37**
TDM					1	0.54**	-0.78**	-0.02	0.27*	0.03	0.71**
HI						1	-0.72**	0.11	0.12	0.48**	0.78**
St							1	-0.15	-0.2	-0.38**	-0.73**
KL								1	-0.05	0.05	0
KB									1	0.14	0.13
1000 grain wt										1	0.3*
GY											1

Table 3: Simple linear correlation coefficients for various drought tolerance traits at genotypic level
(= Significant at 5% level of probability, ** = Significant at 1% level of probability)*
DFF= days to 50% flowering; PH= plant height; EBT= Ear bearing tiller; PL= Panicle length; TDM= Total dry matter production; HI= Harvest index; Ster = Sterility %; KL= Kernel length; KB= kernel breadth; 1000 grain wt= 1000 grain weight; GY= grain yield

Characters	DFF	PH	EBT	PL	TDM	HI	Ster	KL	KB	1000 grain wt.
DFF	**-0.15**	0.01	0.05	0.05	0.05	0.07	-0.07	0.03	0.01	0
PH	-0.15	**1.64**	0.63	1.11	0.84	0.47	-0.76	0.42	0.42	0.22
EBT	-0.1	0.11	**0.28**	0.18	0.12	0.16	-0.14	0.05	-0.02	-0.02
PL	0.6	-1.4	-1.31	**-2.06**	-0.71	-1.06	0.61	-0.3	-0.3	0.4
TDM	0.18	-0.3	-0.25	-0.2	**-0.58**	-0.31	0.45	0.01	-0.16	-0.02
HI	-1.08	0.66	1.28	1.18	1.24	**2.3**	-1.65	0.24	0.28	1.1
Ster	0.15	-0.14	-0.15	-0.09	-0.24	-0.22	**0.31**	-0.05	-0.06	-0.12
KL	0.06	-0.09	-0.06	-0.05	0.01	-0.04	0.05	**-0.34**	0.02	-0.02
KB	-0.01	0.03	-0.01	0.02	0.03	0.01	-0.02	-0.01	**0.1**	0.01
1000-grain wt.	-0.02	-0.17	0.01	0.24	-0.04	-0.6	0.48	-0.07	-0.17	**-1.26**

Table 4: Direct and indirect effects of drought related traits on plot yield under drought stress
DFF= days to 50% flowering; PH= plant height; EBT= Ear bearing tiller; PL= Panicle length; TDM= Total dry matter production; HI= Harvest index; Ster = Sterility %; KL= Kernel length; KB= kernel breadth; 1000 grain wt= 1000 grain weight; GY= grain yield

5. References

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