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Genetic Parameters of Morpho-Physiological Traits under Water Stress Condition in Rice (*Oryza sativa L.*)

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Abstract

To estimate genetic variability, heritability and genetic advance a study was conducted on 10 diverse parents (six recipients and four donors) and 24 hybrids of rice. The results obtained from current study showed that adequate variability present among the parents and crosses for morpho-physiological components. The phenotypic co-efficient of variation (PCV) was higher than genotypic co-efficient of variation (GCV) for all nineteen traits studied indicating that the presence of environmental influence on the expression of these traits. The magnitude of difference between PCV and GCV observed was relatively low for days to 50% flowering, spikelet fertility percentage, test weight, relative water content, leaf rolling and specific leaf area indicating less environmental influence. Moderate to high PCV and GCV coupled with high heritability and high genetic advance was registered as per cent of mean for days to 50% flowering, tiller number per plant, filled grains per plant, test weight, grain yield per plant, harvest index, leaf rolling, Chlorophyll stability index and specific leaf area suggesting predominance of additive type of gene action. Therefore, the improvement of these traits through selection is the most important way to achieve the genetic gain generation after generation. High heritability was obtained for leaf rolling (100%) followed by days to 50% flowering (97%), specific leaf area (89%), test weight (87%), harvest index (78%), flag leaf area (72%), chlorophyll stability index (72%), relative water content (71%) and filled grains per panicle (66%) which indicates high heritable portion of variation. High heritability coupled with high genetic advance was obtained for days to 50% flowering, tiller number per plant, filled grains per panicle, harvest index, leaf rolling and specific leaf area indicating the role of additive gene action and a good scope of selection using their phenotypic performance. High heritability coupled with moderate genetic advance was obtained for plant height, relative water content and flag leaf area indicates the role of both additive and non additive gene action in its inheritance.

Key words: variability, heritability, genetic advance, rainfed rice.

Introduction

Rice (*Oryza sativa* L.) is the major food crop for more than half of the global population and will continue to occupy the pivotal place in global food and livelihood security systems. The productivity of rice has now stagnated. The present world rice area, production and productivity is 161.6 million ha, 480.7 million tons and 2.97 t/ha, respectively. In India, it is being grown in 44.00 million ha area with production of 106.0 million tons and productivity of 2.41 t/ha. It contributes 25% to agricultural GDP (USDA, Rice Outlook, 2014). But much of this important crop yield is affected by drought. Drought constrains productivity more than any other factor, the global reduction in rice production due to drought averages 18 Mt annually (Haider *et al.*, 2012). Out of the total of 20.4 million ha of rainfed rice area in India, approximately 7.3 million ha of low land area is drought prone (Pandey and Bhandari, 2008). In Asia, 17 million ha of irrigated rice areas may experience physical water scarcity and 22 million ha may have economic water scarcity by 2025. Scarcity of fresh water resources such as in the world leading rice producing countries like China and India has threatened the production of the flood irrigated rice crop (Singh *et al.*, 2006). Asia's food security depends largely on irrigated low land rice fields, which produce three- quarters of all rice harvested. However, the increasing scarcity of fresh water threatens the sustainability of the irrigated rice ecosystem. Thus increasing the yield under water stress condition is very important to meet the future demand of growing population. In the absence of scope of the expansion of area under rice and near plateauing of rice productivity under irrigated ecosystems, there is imperative need to enhance productivity levels of unexploited unfavorable rice growing situations like rainfed ecosystems, where the productivity is very low due to moisture stress. In plants a better understanding of the morphological and physiological basis of changes in water stress resistance could be used to develop new varieties of crops to obtain a better productivity under water stress conditions. Breeding for drought tolerance is usually performed by selecting genotypes for high yield under water limited conditions. In view of this, the present study was conducted to assess the genetic variability, heritability and genetic advance (GA) of morpho-physiological traits in 10 parents and 24 F_1 hybrids to assist the future breeding programs for yield improvement under water stress condition. Heritability and genetic advance are important selection parameters while selection is made based on yield contributing traits. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone (Paul *et al*., 2006).

Materials and methods

The experimental material comprised of six recipients and four donors crossed in LxT fashion to generate 24 F_1's. The parental material includes well adapted, commercially popular rice varieties *viz.,* Samba mahsuri (BPT 5204), Sona mahsuri (BPT 3291), Karimnagar samba (JGL 3855), Nellore mahsuri (NLR 34449), IR 64,Vijetha (MTU 1001) as lines and four donors *viz.*, Annada, Ramappa, Rajendra and JGL 17004 as testers. These parents were selected based on their attributes for grain quality, drought tolerance, reaction to pests and diseases and high yield. The experiment was conducted at Andhra Pradesh Rice Research Institute & Regional Agricultural Research Station, Maruteru, West Godavari District, Andhra Pradesh during *Rabi* 2011-2012. All F_1's, and parents were planted in randomized block design with two replications in 4 rows of 5.0 meter length at a spacing of 20 x 15cm between and within row respectively. All the recommended agronomic and cultural measures were taken up in conducting the experiment. Observations were recorded on 10 random plants from each of the parents and F_1's for 19 characters *viz.,* days to 50% flowering, plant height, number of tillers per plant, number of panicles per plant, panicle length, filled grains per panicle, sterile grains per panicle, total spikelets per panicle, spikelet fertility percentage, test weight, grain yield, SPAD chlorophyll meter reading, relative water content, harvest index, chlorophyll stability index, leaf rolling, flag leaf area, specific leaf area and specific leaf weight. Mean data was utilized for calculating following line x tester design (Kempthorne, 1957). Genotypic and phenotypic co-efficient of variations were estimated according to (Burton and Devane (1953). Heritability in broad sense (h^2_b) was estimated according to the formula suggested by Allard (1960). Estimation of genetic advance was done following the formula given by (Johnson *et al.,* 1955).

Results and discussion

The analysis of variance for different characters is furnished in Table 1. A wide range of variation was observed among ten parents and twenty four F_1's for nineteen characters. This suggested that there were inherent genetic differences among the genotypes for all the characters under study. The estimates of phenotypic coefficient of variation (PCV) was higher than those of genotypic coefficient for all the traits studied (Table 2) indicating that they all interacted with the environment to some extent but the magnitude of difference between PCV and GCV observed was relatively low for days to 50% flowering (11.63,11.44), spikelet fertility percentage (7.96, 6.42), test weight (16.56, 15.47), relative water content (7.39, 6.24), leaf rolling (43.77, 43.72) and specific leaf area (16.24, 15.34) indicating minimum environmental influence and consequently greater role of genetic factors on the expression of traits. Similar observations were reported earlier by Prajapati *et al*. (2011) in rice. Among all the characters under study leaf rolling and grain yield/plant showed higher estimates of PCV (43.77 & 38.1 respectively) and GCV (43.72 & 27.1 respectively) therefore simple selection can be practiced for further improvement of these characters. The estimates of PCV and GCV were moderate for days to 50% flowering (11.63, 11.44), filled grains per panicle (15.64, 12.66), total spikelets per panicle (13.51, 10.13), test weight (16.56, 15.47), harvest index (14.19, 12.56), flag leaf area (12.35, 10.47), chlorophyll stability index (13.36, 11.36), specific leaf area (16.24, 15.34) and specific leaf weight (14.59,10.29). The estimates of PCV and GCV were lowest for plant height (9.18, 7.21), spikelet fertility (%) (7.96, 6.42) and relative water content (7.39, 6.24). Akinwale *et al*. (2011) and Ullah *et al.* (2011) reported moderate to low GCV and PCV estimates for different quantitative traits in rice.

Although GCV is measure of genetic variation, the amount of heritable portion can only be determined with the help of heritability and genetic advance estimates. Broad sense heritability estimates varied from 50 (specific leaf weight) to 100 (leaf rolling). Among the traits, high heritability was observed for days to 50% flowering (97%), plant height (62%), number of tillers per plant (61%), filled grains per panicle (66%), test weight (87%), relative water content (71%), harvest index (78%) chlorophyll stability index (72%), leaf rolling (100%), flag leaf area (72%) and specific leaf area (89%). High heritability suggests high component of heritable portion of variation that can be exploited by breeders in selection of superior genotypes on the basis of phenotypic performance. These findings were in consonance with the reports made earlier in rice by Karthikeyan *et al.* (2009) for days to 50% flowering and test weight.

The genetic advance is a useful indicator of the progress that can be expected as a result of exercising selection on the pertinent population. Heritability in conjunction with genetic advance would give a more reliable index of selection value (Johnson *et al*., 1955). The estimated genetic advance as per cent of mean was highest for leaf rolling (89.97) followed by grain yield/plant (39.71).

High heritability coupled with moderate genetic advance was obtained for plant height, relative water content and flag leaf area indicating the role of both additive and non additive gene action in its inheritance. High heritability coupled with high genetic advance was obtained for days to 50% flowering, tiller number per plant, filled grains per panicle, harvest index, leaf rolling and specific leaf area indicating the role of additive gene action and a good scope of selection using their phenotypic performance.

Table 1: Analysis of variance for yield and physiological traits in Rice

Source	Replication	Treatments	Error
Degrees of freedom	**2-1**	**33**	**33**
Mean squares			
Days to 50% Flowering	1.47	231.31**	3.86
Plant height (cm)	0.42	102.85**	24.38
Tiller Number/ Plant	2.48	16.53**	3.97
Ear bearing tillers/ Plant	0.52	9.24**	2.59
Panicle Length (cm)	0.97	8.09**	3.92
Filled Grains/ Panicle	41.3	292.97**	61.0
Sterile Grains/ Panicle	3.76	87.09**	24.34
Total spikelets / Panicle	20.13	328.56**	91.95
Fertility %	12.11	66.7**	13.86
Test Weight (gm)	1.73	19.16**	1.3
Grain Yield/ Plant	2.52	49.19**	16.14
SPAD chlorophyll meter reading	10.02	38.3**	11.01
Relative Water Content	6.38	51.08**	8.69
Harvest Index %	14.48	60.8**	7.39
Flag Leaf Area	0.12	41.11**	6.71
Leaf Rolling	0.04	8.9**	0.01
Chlorophyll stability index	10.27	148.19**	23.84
Specific leaf area	328.46	2605.69**	145.62
Specific leaf weight	0.17	0.94**	0.31

* Significant at 1% level.

Table 2: Mean variability, heritability and genetic advance as per cent of mean for yield components and physiological traits under water stress condition in rice (*Oryza sativa* L.)

Character	Mean	Range		Coefficient of variation (%)		Heritability (broad sense)	Genetic advance as percent of mean (5%) level
		Min.	Max.	PCV	GCV		
Days to 50% Flowering	93.24	71.50	121.50	11.63	11.44	97	23.17
Plant height (cm)	86.87	17.82	98.40	9.18	7.21	62	11.66
Tiller Number/ Plant	1.51	6.70	20.50	25.58	20.02	61	32.29
Ear bearing tillers/ Plant	8.53	5.50	12.50	28.51	21.38	56	33.02
Panicle Length (cm)	20.73	16.05	24.55	11.83	10.97	35	8.45
Filled Grains/ Panicle (No.)	69.07	64.50	105.00	15.64	12.66	66	21.11
Sterile Grains/ Panicle (No.)	34.25	11.00	39.50	33.53	25.16	56	28.89
Total spikelets / Panicle (No.)	103.32	82.00	128.00	13.51	10.13	56	15.66

Spikelet fertility %	66.85	52.04	88.71	7.96	6.42	55	10.67
Test Weight (gm)	19.32	12.85	24.65	16.56	15.47	87	29.77
Grain Yield/ Plant (gm.)	15.00	6.88	24.42	38.10	27.10	61	39.71
SPAD chlorophyll meter reading	43.20	35.67	52.48	11.50	8.55	55	13.11
Relative Water Content	74.34	62.35	83.13	7.39	6.24	71	10.84
Harvest Index %	41.15	31.55	52.60	14.19	12.56	78	22.89
Flag Leaf Area	39.60	28.12	48.09	12.35	10.47	72	18.30
Leaf Rolling	4.82	1.00	9.00	43.77	43.72	100	89.97
Chlorophyll stability index	69.43	47.62	85.55	13.36	11.36	72	20.89
Specific leaf area	228.38	155.25	286.10	16.24	15.34	89	29.91
Specific leaf weight	5.43	4.25	4.25	14.59	10.29	50	14.96

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