The Pharma Innovation Journal 2022; 11(2): 2520-2524

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(2): 2520-2524

www.thepharmajournal.com
Received: 01-12-2021
Accepted: 06-01-2022

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Genetic variability, heritability and genetic advance for yield and its related traits in rainfed upland rice (*Oryza sativa* L.) genotypes

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Abstract
The present study consists of 32 rice genotypes and three check verities that were evaluated at Crop Research Station Masodha under the supervision ANDUAT, Ayodhya from July to November 2019 to estimate genetic variability, heritability and genetic advance for grain yield and 12 yield associated traits. The estimates of genotypic and phenotypic variances for the characters like plant height, effective tillers per plant, number of grains per panicle, grain yield per plant, harvest index and 1000 grain weight, genotypic variance contributed larger in phenotypic variance. The combined analysis of variance revealed statistically significant differences ($p < 0.05$) indicating the existence of genetic variability among the 32 genotypes for all the traits studied. Higher PCV and GCV values were exhibited by L/B ratio, number of tillers per plant, length of panicle and test weight which was suggests the possibility of improving this trait through selection. The highest heritability was recorded for days to 50 percent flowering followed by number of seed per panicle, plant height, days to maturity and seed yield per plant. High to medium heritability coupled with high GCV and high genetic advance as percentage of means were exhibited for plant height, number of tillers per plant, length of panicle and test weight.

Keywords: Genetic advance, genetic variability, heritability, rice (*Oryza sativa* L.), test weight, genotypic coefficient of variation

Introduction
Rice (*Oryza sativa* L., 2n= 24) is a self-pollinated crop belonging to the family of grasses, Poaceae (Gramineae). The genus *Oryza* includes a total of 25 recognized species out of which 23 are wild and two, *Oryza sativa* and *Oryza glaberrima* are cultivated species (Brar and Khus, 2003). Genetic evidence has shown that rice originates from a single domestication 8,200–13,500 years ago in the Pearl River valley region of China. Previously, archaeological evidence had suggested that rice was domesticated in the Yangtze River valley region in China. Rice was spread from East Asia to South east and South Asia. Rice was introduced to Europe through Western Asia, and to the Americas through European colonization. Rice is the seed of the grass species *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice). The *Oryza sativa* is divided into three sub-species, *viz. Indica* (cultivated in Indian condition), *Japonica* (cultivated in Japan condition) and *Javanica* (cultivated in Indonesian condition).
Rice crop needs a hot and humid climate. It is best suited to region which has high humidity, prolonged sunshine and an assured supply of water. The average temperature required throughout the life period of the crop ranges from 21 to 37 °C. At the time of tillering the crop requires a high temperature for growth. Temperature requirement for blooming ranges from 26.5 to 29.5 °C. At the time of ripening the temperature should be between 20 to 25 °C. Photo periodically rice is a short day plant. However, there are varieties which are non-sensitive to photo periodic condition. Rice is grown under different agro-climatic conditions and production system, by submerged in water, is the most common method used worldwide. Rice is the only the cereal that can be grown successfully in standing water. It has been estimated that about 57 per cent of rice is grown on irrigated land; 25 per cent on rain fed low land; 10 percent on the upland 60 percent in deep water and 2 per cent in tidal wet land. In India, it stretches from 8^0N latitude to 34^0N latitude. Rice is also grown even in areas below the sea-level, as in the Kuttanand region of Kerala to high altitudes above 1979 m, as in parts of Jammu and Kashmir. It is cultivated as a purely rain-fed upland crop in West Bengal, Bihar and Uttar Pradesh where, the monsoon is precarious and its distribution is often erratic.

Rice occupies a pivotal role in Indian agriculture. It is staple food for more than 70 percent Indians and source of livelihood for 120-150 million rural households. India is the second largest rice producing country the world next to China; as it is grown in almost all the state of India. From the total cultivable million ha area of 143 million ha nearly 43.79 million ha is utilized for rice cultivation with a production of 115.60 million tonnes and average productivity of 2578 kg/ha (Anonymous, 2018) [1, 2]. However in world, it was grown on 163.43 million ha with production of 498.95 million metric tonnes and productivity of 45.60 q ha^{-1} in the world in 2018 (Anonymous, 2018) [1, 2].

Uttar Pradesh lies between $23^{0}52$’ and $30^{0}16$’ N latitude and $77^{0}84$’ and $84^{0}38$ E longitude surrounded by Nepal in North. Thus, it has been divided into Gangetic plain and Southern plateau. Rice is the major crop in Uttar Pradesh and is grown over an area of about 5.87 million hectares with production of 12.51 million tonnes and productivity of 2131 kg per hectare (Anonymous 2018) [1, 2] covering five major ecological conditions including favourable irrigated; unfavourable rain-fed upland; rain-fed lowland; deep water and flood prone and inland salinity condition which comprises of 13.5% of total rice in India. Uttar Pradesh has favourable and suitable climate, vast areas of fertile soils, sunshine and adequate water resources.

Rice is therefore, on the frontline in the fight against world’s hunger and poverty. Rice is also a symbol of both cultural identity and unity. For all these reasons, “Rice is life” and therefore, the United Nations General Assembly (UNGA) during its 57th session on 16th December 2002 declared 2004 as the International Year of Rice. This dedication of an International Year of Rice, for rice as a single crop, is unique precedence in the UNGA’s history. It reflects the fact that rice is not only a fundamental commodity and primary food source for more than half of the world’s population, but also a focus within a complex rice-based ecosystem that influences issues of global concern such as food security, poverty alleviation, presentation of cultural heritage and sustainable development.

The success of any crop breeding programme depends upon the nature and amount of genetic variability available. Germplasm serves as valuable nature reservoir in providing needed attributes for developing successful variety. The germplasm resources will be little value unless these are properly evaluated, because evaluation provides an estimate of its potential value. In order to launch a sound breeding strategy, it is essential to have an idea of the nature and magnitude of variability, heritability and genetic advance in respect to breeding materials at hand. The genetic variability is heritable one and hence important in any selection programme.

The success of any breeding programme depends on the exploitation of existing variability and therefore it is desirable to collect, evaluate and utilize the available diversity for crop improvement to suit specific need with regards to specific ecosystem. Genetic improvement mainly depends upon the amount of genetic variability present in the population. In any crop, the germplasm serves as a valuable source of base population and provides scope for wide variability. Information on the nature and degree of genetic diversity would help the plant breeder in choosing the right parents for breeding programme (Vivekanandan and Subramanian, 1993) [4]. Genetic diversity among the parents is very important because a cross involving genetically diverse parents is likely to produce high heterotic effect and also more variability could be expected in segregating generations (Khush, 1974). Estimates of genotypic coefficients of variation (GCV), phenotypic coefficients of variation (PCV), heritability and genetic advance will play an important role in exploiting future research projection of rice improvement. In rice improvement program, it is the germplasm, which virtually determine the success and nature of end product. The development of superior rice population involved the intelligent use of available genetic variability, both indigenous as well exogenous, to cater the need of various farming situations of rice. The grain yield is the primary targeted for improvement of rice productivity in both favorable and unfavorable environments from its present level. The data recorded for all the characters were subjected to analysis of variance with the formula suggested by Panse and Sukhatme (1978). Further, Different components of variance *viz.*, phenotypic, genotypic and environmental variance were estimated and genetic parameters like genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and heritability in broad sense and genetic advance as percent of mean were worked out following appropriate statistical procedure.

Materials and Methods

The experimental material comprised of thirty two selected genetically diverse true breeding genotypes of rice (*Oryza sativa* L.) obtained from different geographical regions and 3 check varieties of Rice under study. All the genotypes were grown in randomized block design with 3 replications under Rainfed conditions in the *Kharif* season of year 2019. Each genotype was grown in 5.0 m x 3.0 m plot with 30 x 10 cm spacing at the CRS Masodha under the supervision of Acharya Narendra Deva University of Agriculture and Tecnology, Kumarganj, Ayodhya. Standard agronomic practices and plant protection measures were followed.

Replication-wise data on the basis of five randomly taken competitive plants were recorded on following traits: Days to 50 per cent flowering (DFF), Days to maturity, Plant height, Number of tillers per plant, Number of seeds per panicle, Panicle bearing tillers per plant, length of panicle (cm), seed yield per plant (g), Test weight (g), L: B ratio and Grain type.

The data recorded for all the characters were subjected to analysis of variance with the formula suggested by Panse and Sukhatme (1978). Further, Different components of variance *viz.*, phenotypic, genotypic and environmental variance were estimated and genetic parameters like genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and heritability in broad sense and genetic advance as percent of mean were worked out following appropriate statistical procedure.

Results and Discussion

The analysis of variance for the Randomized Block Design, accommodating 32 genotypes of rice and three checks, was done for different characters and presented in Table. The variance analysis showed that genotypes differ significantly among themselves for all character under study, indicating the presence of adequate variability.

Table 1: Analysis of variance for different characters in rice genotypes

S.N.	Characters	Mean sum of squares		
		Replication	Treatment	Error
	Degree of freedom	2	34	68
1.	Days to 50% flowering	3.68	155.87**	4.97
2.	Days to maturity	5.89	161.49**	7.73
3.	Plant height (cm)	24.71	476.92**	6.78
4.	Number of tillers per plant	1.63	5.89**	2.92
5.	Panicle bearing tillers per plant	1.26	4.96**	2.51
6.	Number of seed per panicle	144.29	812.87**	162.84
7.	Length of panicle	2.42	6.95**	1.47
8.	Test Weight (g)	0.01	113.50**	7.81
9.	L:B ratio	0.00	0.39*	0.002
10.	Seed yield per plant (g)	11.10	102.65**	7.76

*and** Significant at 5% and 1% probability levels, respectively.

Analysis of variance revealed significant differences among the different genotypes for all the 10 characters like days to 50 per cent flowering (DFF), Days to maturity, plant height (cm), effective number of tillers per plant, Panicle bearing tillers per plant, Number of seed per panicle, Length of panicle Test Weight (g), grain breadth and grain L/B ratio, Seed yield per plant (g). (Table 1), which clearly suggested the existence of sufficient amount of variability in the experimental material. The estimates of genotypic and phenotypic variances revealed that for the characters like plant height, effective tillers per plant, number of grains per panicle, grain yield per plant, straw yield per plant, harvest index and 1000 grain weight, genotypic variance contributed larger in phenotypic variance, which indicated less influence of environmental factors on the expression of these characters. The success of selection in improving plant characters depends on presence of substantial genetic variability and nature of heritability and gene action. The genetic variability is the raw material of plant breeding programme on which selection acts to evolve superior genotypes. The phenotypic and genotypic coefficients of variation can be used for assessing and comparing the nature and magnitude of variability existing for different characters in the breeding materials. Heritability in broad sense quantifies the proportion of heritable genetic variance to phenotypic variance, while heritability in narrow sense represents the ratio of fixable additive genetic variance to total phenotypic variance. Estimates of heritability help in estimating expected progress through selection. The genetic advance in per cent of mean provides indication of expected selection response by taking into account the existing genetic variability and heritability of the character. The estimates of direct selection parameters, coefficients of variation, heritability and genetic advance in per cent of means were computed for 10 characters of 32 genotypic.

The highest estimates of phenotypic (PCV) and as well as genotypic (GCV) coefficient of variation were observed for seed yield per plant (PCV=23.05%, GCV=21.84) followed by number of panicle bearing tillers per plant (PCV = 22.36%, GCV=21.08%). Thus, below mentioned (table-2) two characters were characterized by high estimates (>15%) of PCV as well as GCV. The existence of high variability for above characters in rice has also been reported earlier by Saxena *et al.* (2005) [5]; Sharma and Sharma (2007); Kard and Paul (2008) [7]; Raut (2009) [8]; Sarangi *et al.* (2009) [9]; Anjaneyulu *et al*. (2010) [10]; Jayasudha and Sharma (2011); Jahn *et al.* (2011) [12]; Paswan *et al.* (2014) [13]; Manjunatha *et al.* (2017) [17]; Adhikari *et al.* (2018) [15]; Tiwari *et al.* (2019) [18] and Kumari and Parmar (2020) [16].

Moderate estimates (> 10% to < 20%) PCV as well as GCV were recorded for no. of tillers per plant (PCV=18.67%, GCV=18.36%) followed by number of seed per panicle (PCV=16.43%, GCV=12.41%), plant height (cm) (PCV=13.12%, GCV=12.85%), test weight (gm) (PCV=12.24%, GCV=10.86%) and L/B ratio (PCV=11.84%, GCV=11.83%). Remaining three traits, lowest estimates of PCV and GCV were observed for days to maturity (PCV=6.21%, GCV= 5.71%) followed by days of 50% flowering (PCV=7.50%, GCV=7.16%) and length of panicle (cm) (PCV=8.75%, GCV=6.51%).

The results of the presented study in respect of genotypic and phenotypic coefficient of variation are broadly in the findings of earlier workers Suman *et al.* (2005) [20] Seyoum *et al.* (2012); Rai *et al.* (2014) [21]; Kalyan *et al.* (2017) [23]; Iqbal *et al.* (2018) [22] and Longjam and Singh (2019) [24].

Genetic variability is the raw material on which selection acts to bring improvement in genetic architecture of plants. The important direct selection parameters, heritability in broad sense and genetic advance in per cent of mean, provide index of transmissibility of traits which gives indication about the effectiveness of selection in improving the characters. The high order of heritability coupled with moderate genetic advance in per cent of mean was observed for L/B ratio, plant height (cm), days to 50% flowering, days to maturity, seed yield per plant (gm), test weight, number of seed per panicle and length of panicle (cm) while in lower heritability in case of number of panicle bearing tillers per plant (Table 2). Above mentioned characters, exhibiting very high Ḡa and high h^2 also showed high and medium GCV and PCV values, which indicated that these would be ideal traits for improvement through selection owing to their high transmissibility and variability. Thus, the germplasm lines evaluated and segregating generations derived from them may provide very high response to selection for the characters exhibiting high heritability along with very high genetic advance in per cent of mean The high estimates of heritability and genetic advance observed in present study are in agreement with available literature in rice Chaudhary and Motiramani (2003) [26]; Islam *et al*. (2004) [28]; Sarma *et al.* (2015) [6, 27]; Tripathi *et al.* (2018) [29]; Bagudam *et al.* (2018); Bhinda *et al.* (2017) [30].

On the basis of all the above findings, it can be concluded that, while imposing selection for genetic improvement of grain yield in rice under aerobic condition, due weightage should be given to effective tillers per plant, plant height, number of grains per panicle, grain yield per plant, 1000 grain weight, harvest index and straw yield per plant. Presence of sufficient variability in the characters studied offer possibilities to explore the material for further genetic improvement program to widen the genetic background of various rice genotypes. Considering the overall result it is apparent that certain information obtained here will help in future for developments of new varieties.

Table 2: Estimates of general mean, range, phenotypic (PCV) and genotypic (GCV) coefficient of variation, heritability in broad sense (h^2b) and genetic advance in per cent of mean for 10 characters in rice

Characters		General mean	Range		PCV	GCV	h^2	Genetic advance	
			Lowest	Highest				at 1%	in% of mean at 5%
1.	Days of 50% flowering	99.05	78.00	109.66	7.50	7.16	91.00	18.03	14.06
2.	Days of maturity	123.61	104.00	134.33	6.21	5.71	86.90	14.25	11.12
3.	Plant height (cm)	97.41	80.26	117.50	13.12	12.85	95.90	33.21	25.91
4.	No. of tillers per plant	10.58	8.00	12.66	18.67	18.36	25.20	12.40	9.67
5.	No. of panicle bearing tillers per plant	8.16	6.33	9.33	22.36	21.08	24.60	14.51	11.32
6.	No. of seed per panicle	118.56	80.66	140.33	16.43	12.41	57.10	24.76	19.32
7.	Length of panicle (cm)	20.74	17.40	23.00	8.75	6.51	55.40	12.80	9.99
8.	Test weight (gm)	20.42	16.63	25.93	12.24	10.86	78.70	25.44	19.85
9.	L/B ratio	3.08	2.33	3.64	11.84	11.83	99.80	31.19	24.34
10.	Seed yield per plant (gm)	31.41	23.06	40.64	23.05	21.84	80.30	42.35	33.04

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