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Evaluation of genetic variability of rice genotypes in Terai agro-climatic zone

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Abstract
Rice is known as the "Global Grain" and considered as staple food due to its widespread production and consumption throughout the world. In order to assess the genetic diversity, the present experiment was conducted with 52 rice genotypes for eight morphological characters related to the yield in the Kharif season (2021). Statistical analysis was carried out for the estimation of the genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (BS), and genetic advance as percentage of mean for all the characters. Among all the characters, the highest GCV and PCV values were found in the character yield per plant (30.97% and 29.82%), harvest index (21.83% and 20.45%), number of effective tillers per plant (21.81% and 21.09%) and all the characters had the high heritability while the characters yield per plant (59.14%), the number of effective tillers per plant (42.04%), 1000 grain weight (40.10%), number of grains per panicle (39.62%), harvest index (39.47% had the highest genetic advance in percent mean coupled with high heritability. So, these characters were governed by additive gene action. Correlation studies showed that the character yield per plant had the significant positive correlation with days to 50% flowering (0.291), number of effective tillers per plant (0.373), number of grains per panicle (0.326) and harvest index (0.789). The path analysis revealed that the character harvest index (0.767) had the highest direct effect followed by the characters number of effective tillers per plant (0.305), days to 50% flowering (0.284), number of grains per panicle (0.125) and these characters were positively associated with yield per plant. So, these characters could be considered for selection.

Keywords: GCV, PCV, heritability, path analysis, direct effect, indirect effect, rice

Introduction
Rice is a self-pollinating crop that belongs to the Gramineae, or grass family. As, it is a staple food, more than half of the world's population relies on it. Due to its extensive global cultivation, it is referred to as a "Global Grain." In addition to being a staple food, rice is also utilized as a fuel source in the soap industry, a substantial component of cow fodder, and in cottage industries (rice straw) (Pode *et al.*, 2016) [19]. Due to rice genotypes' ability to adapt to various climatic conditions, different rice varieties with varied physical and agro-morphological characters have been developed (Bhattacharya, 2005) [3]. Characterizing genotypes using a number of agro-morphological characters is the main prerequisite for plant breeding programmes (Lin, 1991) [14]. The number of panicles per plant, the length of the panicle, and the weight of 1000 grains are the primary factors that affect rice yield (Yoshida,1983) [26]. Knowledge of the variable parameters, such as genotypic co-efficient of variation (GCV), phenotypic co-efficient of variation (PCV), heritability and genetic advance is crucial for the development of superior varieties with high-yielding ability. Grain yield is an illustration of the combined activity of several component characters, indicating that it has a complex character and is quantitative in nature. In light of this, it follows that if yield components are ignored, germplasm selection must not be particularly effective. In order to execute a successful breeding programme, the relationship between yield and its component characters as well as the direct and indirect impacts of different yield-influencing characters must be assessed. Several studies have documented a large range of variability in rice yield and its related features (Kaul and Kumar, 1982 [8]; De and Suriya Rao, 1988 [4]; Lokaprakash *et al.*, 1992) [15]. Evaluation of expected genetic advance is required to measure the efficiency of selection. Determining heritability in addition to genetic advancement would be more useful when predicting the expected improvement to be achieved through selection (Johnson *et al*. 1955) [7].

The highest levels of genetic advance, heritability, and variability were found for the character plant height, grain yield per plant, and grains per panicle (Govindarasu and Natarajan, 1995 [6]; Sawant and Patil,1995 [23]). The effectiveness of the characters' associations with one another is measured through correlation analysis. Moreover, the simultaneous selection of two or more characters using correlation analysis is effective. Genotypic correlations are mostly caused by genetic factors, specifically the pleiotropic effects of genes and/or linkage. As yield is a complex polygenic character that can be impacted by numerous environmental factors, so, direct selection is not a suitable strategy. It is crucial to learn about the additional component characters which can influence in the improvement of yield/plant. Path-coefficient, a standardised partial regression coefficient, assesses the relative significance of each component by quantifying the direct influence of one variable on the other and permits the splitting of the correlation coefficient into direct and indirect effects (Dewey and Lu, 1959) [5]. So, after considering the aforementioned factors, the current study was undertaken to obtain valuable information about rice.

Materials and Methods

Locations for the experiment: The present study was conducted with 52 rice genotypes in three replications at the Agricultural Instruction Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar district during Kharif season of 2021. When the seedling reached 4-6 weeks old, they were transplanted in the main field following the Randomized Block Design (RBD) at a spacing of 15 cm between the plants and 20 cm between the rows. All recommended cultural practices were followed. The observation for the character namely, days to 50% flowering was recorded from each genotype and each replication individually and separately. Other observations for morphological characters namely plant height and number of effective tillers per plant, were recorded from five individual randomly selected and tagged plants from each replication. The observation of panicle and seed-based characters such as panicle length and number of grains per panicle and grain yield per plant (g) and harvest index (%) were recorded from randomly selected and tagged 10 plants.

Results and Discussion

The agro-morphological analysis is one of the most helpful techniques for plant breeders to choose a good parent or genotype for the future breeding programme. It is emphasized yield and yield-attributing characters that have a direct impact on grain yield improvement.

Analysis of variance (ANOVA) Table 1 showed significant variations for all eight characters, namely plant height, days to 50% flowering, number of effective tillers per plant, panicle length, number of grains per panicle, 1000 grain weight, harvest index (%) and yield per plant (g) that had taken into consideration for agro-morphological characters in the present study. It showed that the characters had a significant level of variation, which indicated that there existeded lot of opportunity for bringing improvement by the selection of these characters.

Sivasubramanian and Madhavamenon (1973) [24] categorised GCV and PCV estimates as high (>20%), moderate (10%–20%), and low (less than 10%). The different characters in the kharif 2021 (Table 2) had lower GCV values compared to PCV values and the difference between PCV and GCV was minimal. This indicated that the environment had very less impact on the characters and selection based on the phenotypic value could be beneficial for the improvements of the characters. Similar findings were noticed by Sudeepthi *et al.* (2020) [25], Akshay *et al.* (2022) [1]. Among all the agro-morphological characters (Table 2) high PCV and GCV values were found in the characters yield per plant (30.97% and 29.82%), harvest index (21.83% and 20.45%), number of effective tillers per plant (21.81% and 21.09%). Moderate PCV and GCV values were found in the characters number of grains per panicle (19.68% and 19.45%), 1000 grain weight (19.58 and 19.53) and lowest PCV and GCV values were found in the characters panicle length (9.42 and 9.01), plant height (8.65 and 8.54) and days to 50% flowering (8.28 and 8.15). Similar findings were observed by Kumar *et al.* (2018) [11], Pathak *et al*. (2022) [17], Babar *et al.* (2009) [2]. According to Robinson (1966) [21], the heritability can be divided into three categories: high (> 70%), intermediate (50–70%), and low (50%). Table 2 showed that high heritability was found in the all the characters such as 1000 grain weight (99.40%), grains per panicle (97.73%), plant height (97.59%), days to 50% flowering (96.89%), number of effective tillers per plant (93.58%), yield per plant (92.68%), panicle length (91.44%) and harvest index (87.77%). Similar results were also reported by Kumar *et al*. (2011) [12], Prakash *et al.* (2018) [18]. Johnson (1955) [7] divided genetic advance as percent of mean into three categories: high (>20%), moderate (10–20%), and low (10%). Among all the eight characters highest genetic advance in percent mean was found in yield per plant (59.14%) followed by number of effective tillers per plant (42.04%), 1000 grain weight (40.10%), number of grains per panicle (39.62%), harvest index (39.47%). Moderate genetic advance in percent mean was found in the characters panicle length (17.74%), plant height (17.39%) and days to 50% flowering (16.54%). No character was found in low genetic advance in percent mean. Hence, the characters number of effective tillers per plant, 1000 grain weight, yield per plant, number of grains per panicle, harvest index had high heritability coupled with high genetic advance in percent mean. This indicated that these characters are governed by additive genes and as these characters would respond to selection, therefore selection would be successful for these characters. Similar study was also observed by Prakash *et al.* (2018) [18], Khare *et al.* (2014) [9].

The genotypic correlation coefficient among eight characters is presented in Table 3. Correlation studies among eight characters showed genotypic association between characters. Plant height exhibited significant positive correlation with days to 50% flowering (0.376). Days to 50% flowering showed significant positive correlation with yield per plant (0.291). Number of effective tillers per plant showed significant positive correlation with yield per plant (0.373). Panicle length exhibited significant positive correlation with number of grains per panicle (0.486) and harvest index (0.300). Number of grains per panicle showed significant positive correlation with yield per plant (0.326) and harvest index (0.315). Number of grains per panicle showed significant negative correlation with 1000 Grain Weight (-0.483). Harvest index exhibited highly significant positive correlation with yield per plant (0.789). Similar results were shown by Lalitha *et al.* (2019) [13], Khare *et al.* (2014) [9].

The direct and indirect effect for eight characters on the yield per plant is shown in Table 4. The residual effect was low (0.1531) indicating that the number of characters selected for the study was enough for determining rice yield. The path analysis (Table 4) revealed that the character harvest index had the highest direct effect (0.767) followed by number of effective tillers per plant (0.305), days to 50% flowering (0.284), number of grains per panicle (0.125) and plant height (0.123) respectively. Among these characters, harvest index, number of effective tillers per plant, days to 50% flowering, number of grains per panicle were positively associated with yield per plant and coupled with the positive direct effect of these characters. Therefore, these characters could effectively be utilized for yield improvement in rice. Similar results were also observed by Roy *et al.* (2020) [22], Kumar *et al.* (2018) [10], Ratna *et al.* (2015) [20], Nandan *et al.* (2010) [16].

Table 1: Analysis of variance (ANOVA) for different characters of 52 genotypes of rice (Kharif 2021)

Source of Variation	Degrees of Freedom	Plant Height	Days to 50% flowering	No. of effective tillers per plant	Panicle Length	No. of grains per panicle	1000 Grain Weight	Harvest Index (%)	Yield Per Plant (g)
Replication	2	3.06	0.97	0.22	0.90	23.40	0.17	34.63	8.29
Genotype	51	418.09**	233.58**	17.22**	17.44**	3227.30**	55.20**	119.12**	98.46**
Error	102	3.42	2.47	0.38	0.53	24.80	0.11	5.29	2.52

Table 2: Genetic parameters for different Characters of 52 Rice genotypes (Kharif 2021)

Characters	Mean	Range		CV (%)	PCV (%)	GCV (%)	Heritability (broad sense) (%)	Genetic Advance as % of mean
		Min	Max					
Plant Height (cm)	137.59	106.93	150.60	1.34	8.65	8.54	97.59	17.39
Days to 50% flowering	107.63	75.33	118.67	1.46	8.28	8.15	96.89	16.54
Number of effective tillers per plant	11.23	7.53	16.40	5.52	21.81	21.09	93.58	42.04
Panicle Length	26.36	21.07	31.80	2.75	9.42	9.01	91.44	17.74
Number of grains per panicle	167.95	86.33	242.00	2.96	19.68	19.45	97.73	39.62
1000 Grain Weight	21.95	11.03	30.90	1.51	19.58	19.53	99.40	40.10
Harvest Index (%)	30.12	18.12	44.23	7.63	21.83	20.45	87.77	39.47
Yield per plant (g)	18.96	9.57	31.27	8.37	30.97	29.82	92.68	59.14

Table 3: Genotypic Correlation between yield and its attributing characters in Rice (Kharif 2021)

Characters	Plant Height	Days to 50% flowering	No. of effective tillers per plant	Panicle Length	Number of grains per panicle	1000 Grain Weight	Harvest Index
Days to 50% flowering	0.376**						
No. of effective tillers per plant	-0.096	-0.028					
Panicle Length	0.045	-0.149	0.024				
Number of grains per panicle	0.121	0.198	-0.213	0.486**			
1000 Grain Weight	0.087	-0.019	0.230	-0.212	-0.483**		
Harvest Index	-0.202	-0.078	0.133	0.300*	0.315*	-0.012	
Yield per plant	0.065	0.291*	0.373**	0.213	0.326*	0.075	0.789**

*Significant at 5% probability level, **Significant at 1% probability level

Table 4: Direct (diagonal) and indirect (off-diagonal) effects of different characters on Rice (Kharif 2021)

Characters	Plant Height	Days to 50% flowering	Number of effective tillers per plant	Panicle Length	Number of grains per panicle	1000 Grain Weight	Harvest Index	Correlation with yield per plant
Plant Height	0.123	0.107	-0.029	-0.002	0.015	0.005	-0.155	0.065
Days to 50% flowering	0.046	0.284	-0.009	0.005	0.025	-0.001	-0.060	0.291*
Number of effective tillers per plant	-0.012	-0.008	0.305	-0.001	-0.027	0.014	0.102	0.373**
Panicle Length	0.005	-0.043	0.007	-0.036	0.061	-0.013	0.230	0.213
Number of grains per panicle	0.015	0.056	-0.065	-0.017	0.125	-0.030	0.242	0.326*
1000 Grain Weight	0.011	-0.006	0.070	0.008	-0.060	0.062	-0.009	0.075
Harvest Index	-0.025	-0.022	0.040	-0.011	0.039	-0.001	0.767	0.789**

*Significant at 5% probability level, **Significant at 1% probability level, Residual effect 0.1531

Conclusion

It can be concluded that in the present study, the residual effect was 0.1531 which appeared quite low which indicated that the sufficient number of characters had been chosen and taken into consideration. The direct and indirect effect showed that the maximum direct effect was found in the characters harvest index followed by the characters number of effective tillers per plant, days to 50% flowering, number of grains per panicle, plant height had the highest direct effect. Although the characters, harvest index, number of effective tillers per plant, days to 50% flowering, number of grains per panicle were positively associated with yield per plant coupled with maximum direct effect. Therefore, selection utilizing these characters would be successful to produce high-yielding genotypes in subsequent breeding programme.

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