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Genetic Variability for Growth and Yield Traits in Rice

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Abstract

Genetic variability is necessary for any crop breeding program to develop superior varieties. The objective was to estimate the genetic variability for growth and yield traits. The experiment was carried out at Baijanath-4, Banke district, Province no. 5 Nepal during June to November, 2019. Eleven rice genotypes were evaluated in a randomized complete block design with three replications. Days to flowering, days to maturity, panicle length, plant height, number of panicle per hill, number of tiller per hill, grain yield and thousand grain weights were found significant. Moreover, number of panicle per hill having high heritability (79%) have maximum genotypic coefficient of variation (29.03). Further, thousand grain weight, grain yield, plant height need to be considered as effective traits for breeding material selection. PB 1509 was declared superior genotype among aromatic genotype and also found as effective genotype with short height, more thousand grain weight, higher yield potential than compare to check HH1. Thus, the exploitation of PB1509 in further yield trial will contribute to National Rice Breeding Programs of Nepal.

***Keywords*:** rice, heritability, variation, yield

Introduction

Rice (*Oryza sativa* L), is one of the decisive (basic) staple cereal crops feeding more than 3.5 billion people worldwide, belonging to family Poaceae with chromosome number 24. In terms of production, rice ranks third most staple crops after maize and wheat in world. Rice occupies first position among the cereals and contributes significantly in the Nepalese agriculture and directly related to food security and

livelihood of majority of people in the Asia region. Ranging from east to west and lowland Terai (50-300 msl) to hills (>300-1500 msl) and mountains (1500-3050 msl) according to Sapkota et al., (2010). Nepal has plentiful agro-biodiversity that includes rice adaptation and cultivation.

In Nepal, rice is grown in major three agro-ecological regions and with irrigated, rain-fed lowland and upland production system. Agricultural growth rate (1.8) is still below with the population growth rate (2.3%) per annum (Tiwari & Pokharel, 2021). The rice occupies 58% of total cultivated land throughout Nepal and provides 50% of the calories requirement of Nepalese people (CDD, 2015).

Characterization of individuals in the germplasm is the primary goal to provide information for plant breeding programs for broadening the prevailing genetic base in Rice. Many studies have been carried out for germplasm utilization in rice for breeding purposes. Further, analyzing genetic and morphological differentiation, distinguishing diversity, assessing variability in agronomic characters among rice variety, evaluating genetic relationships and characterizing rice genotypes which are adapted to specific environment conditions are also important aspects in the field of evolutionary, functional and ecological biology. Different genetic variability parameters, such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, and genetic advance for yield attributing traits, are major concerns for any plant breeder and crop improvement program. Furthermore, Heritability (h^2) of a trait is vital for selection and determination of genotype. The study of relationship of Rice yield with plant height, panicle per hill, tiller per panicle, days to maturity and thousand grain weights in genotypic and phenotypic level makes effective evaluation on varieties.

Since 1966 IRRI has provided improved germplasm to Nepal contributing to nearly 70% of high yielding inbred rice varieties developed and released in Nepal (Tiwari & pokharel, 2021). Kirkegaard and Hunt (2010) explained use of high yielding varieties and location specific genotype is one vital option for the increasing productivity of the agricultural system. The present study was carried out to understand the genetic background and agro-morphological traits of rice genotype. The study was conducted to identify suitable genetic materials and assist to increase rice productivity through determining the high yielding rice genotype.

Materials and Methods

Experimental Location and Planting Materials

The experimental was conducted in Baijanath-4, Banke district, Lumbini Province, mid-western Nepal during June 2019 to November, 2019. The research was

conducted in Gorkha Polytechnic College and Research Centre Research farm and geographically situated at 28°14'09.6"N latitude and 81°39'44.1"E longitude with an elevation of 170-meter average sea level (m asl). The average annual rainfall is 1312 mm. The highest precipitation occurs in July which is about 406 mm and the least rainfall occurs in November. The highest temperature is in May which is around 38˚C and minimum temperature is around 12˚C in November (MFD, 2019).

The plant materials used in research were the genotypes provided by IRRI project in Nepal and NRRP, Hardinath (NARC). Eleven longer slender rice varieties are Sarbati, Pusa basmati-1, Bahuguni-1, Dejgora, Hardinath Hybrid-1 (HH1) (check variety), NR973, Pantdhan2, PB1509, PusaSugandha-5, PB1121 and Rajendra Bhagwati.

Experimental Design, Treatment Details and Cultural Practices

Experiment was carried out in Randomized Complete Block Design with 3 replications. The total area of plot is 540 m^2 with individual plot size was 5×2 m^2. The 22 days old 2-3 seedlings were transplanted in a line with spacing 20 × 20 cm^2. The space between each replication is 1m and distance between two test plots and from outer border is 0.5m.

The research field was ploughed with tractor to make suitable depth for transplanting (15-20 cm) and *Sesbania spps* (dhaincha) incorporated into the soil for green manuring. Finally, leveling was done. The chemical fertilizer was applied at the rate of 100:60:40NPK kg/hectare (Marahatta, 2017). The standard agronomical practices were adopted for healthy crop development.

Data Collection

Five plants were randomly selected from each plot and their average value used for statistical analysis. Days of 50% flowering, days of 85% flowering, plant height, lodging, panicle length, number of panicle per hill, tillers per hill, thousand grain weight, grain yield (t ha^{-1}) and aroma were recorded.

Rice Aroma

Scent (aroma) in rice evaluated by score 0, 1 and 2. Scent (aroma): Scent detected at flowering time as organoleptic. Three classes are recognized: (0) non-scented, (1) lightly scented and (2) scented.

Lodging Effect

Lodging in rice was score from 1 to 7. Lodging score: 1 indicate no lodging (plants are vertically upright), 3 indicate only few <10% plants fall in ground, 5 indicate Half to majority of the plants fallen in ground and 7 indicate plant in whole plot in horizontal stage.

Statistical Analysis

Analysis for mean and standard deviation was done by using Gene Stat (15th Ed). Analysis of Variance (ANOVA) was used to assess genotypic effect and check if the mean of two or more treatments significantly different from each other by the least significant difference (LSD) test at 5% level of significance.

Estimation of Genetic Parameters

The genetic parameters; phenotypic coefficient off variation (PCV) and genotypic coefficient of variation (PCV) were derived using the formula, suggested by Burton and Devane (1953).

PCV and GCV values were categorized slow, moderate and high indicated by Subramanian & Menon, (1973) as follows:

0–10% regarded as Low, 10–20% regarded as Moderate and >20% as High.

Broad Sense Heritability (hbs^2)

Broad sense heritability was derived for characters using variance components as explained by DeLacy *et al.,* (1996). The heritability estimate was categorized as low, moderate and high as followed by Robinson *et al.,* (1949), which is given as 0–30% Low, 30–60% Moderate and >60% High.

Genetic Advance (GA)

The extent of genetic advance to be expected by selecting about five percent of the genotypes was calculated by using the following formula given by Robinson *et al.*, (1949).

Genetic Advance as Percent of Means (GAM)

The GA as percent of mean was categorized as low, moderate and high as suggested by Johnson *et al.,* (1955) as 0-10% is Low, 10-20% is Moderate and >20% is High.

Results and Discussion

Days to 50% of Flowering

The results indicated that there is highly significant variation for days to 50% flowering. The average mean days to 50% flowering was found to be 63.82. The check variety HH1 significantly had lower number of flowering days followed by NR 973. PB1121 was recorded highest for days to 50% flowering which was statistically at par with Pusa Basmati 1. (Table1) Puri et al. (2021) also reported highly significant differences for days to flowering with HH1 among different eight genotypes of rice in the research conducted at Baniyani, Jhapa.

Days to 85 % Grain Maturity

Highly significance variation was found for Days to 85% grain maturity. The mean day to 85% grain maturity found to be 95.24 days. The check variety Hardinath hybrid-1 matures in 91days. HH1 significantly mature at lower number of days followed by Rajendra Bhagawati while PusaBasmati-1was found to mature on delay followed by PB 1121 (98.67 days) and Bahuguni 1 (98.33 days) as mentioned in Table 1

Similar trend on Chaudhary et al. (2012) found maturity on 95 to 108 days to local varieties at Nepalgunj climatic condition.

Panicle Length and Plant Height

The variety NR 973 was found significantly to be highest panicle length with 31.37 cm which was statistically *at par* with variety HH1, Pant dhan-2 and Pusa Sugandha-5 with 30.4 cm, 30.07 cm and 29.57cm respectively. The average mean of length of panicle was found to be 27.62cm. Similarly, Maximum height was found on NR 973 and PB1509 produced statistically less height 122.5cm. (Table 1) From this supporting research Ghasal et al. (2015), they found that the longer panicles in 'Pusa Rice Hybrid 10' and 'Pusa Sugandh 5' led to produce significantly more panicle weight and grain weight/panicle than the other varieties. Similarly, this result was supported by Ghasal et al. (2015) research where at maturity, 'Pusa Basmati1121'with height 108.1cm had the tallest plants, being at par with 'Pusa Rice Hybrid 10' (103.4 cm), 'Pusa Sugandh 5'(102.2) and 'Pusa Basmati 1401'(101.8cm) remained significantly taller than 'Pusa Basmati 1509'(94.7cm) and 'Pusa Basmati 1460'(98.6cm).

Number of Panicle/Hills

The statistical result shows that varieties had significantly influenced in the number of panicles per hill. The average mean of number of panicles/hills was found to be 12.43 per hill. The variety PB 1121 is suitable for producing more panicle (15.73 per hill) followed by Pusa Basmati-1(14 per hill). The lowest number of panicles per hill was recorded on Pant dhan-2 (7.73 per hill). This shows number of panicles/hill is influenced by genotypes and have effect on yield.(Table 1) Highly significant difference was obtained in number of panicle per hill by Simten and Aydin (2010). Similarly, Khan et al. (2006) conducted research with four varieties of rice and he obtained 9.2 to 18 panicles per plant in his study.

Number of Tillers/Hills

Statistically highly significant difference was found. The average mean of Number of tillers was found to be 13.95 per hill. The genotype PB1121 significantly found to have maximum number of tillers (16.87 per hill) followed by Pusa Basmati-1 (16.07 per hill). The genotype Pant dhan-2 was found to have a smaller number of

tillers (10.27 per hill). The check variety was found to have 13.97 tillers per hill as mentioned in Table 1.

Islam et al. (2017) found significant difference among the rice varieties regarding number of tillers per hill in three varieties BINA dhan7, BRRI dhan56 and BRRI dhan62 in which BRRI dhan 56 have maximum number of tillers per hill followed by BRRI dhan 62 and BINA dhan 7 *at par*. Differences in the production of total tillers and effective tillers hill^{-1} might be due to variation on genetic, physiological functions and growth characters of the cultivars under study. Similarly, Sohel et al. (2009) and Howladar et al. (2017) also reported that all the yield and yield contributing characters differed significantly due to varietal differences.

Grain Yield (t ha^{-1})

Yield is one of the most important traits in rice. It is regulated by quantitative trait loci genes and influenced by external environmental factors (Zhang et al., 2008). The statistical result revealed that the effect of different rice varieties had significant ($p<0.05$) influenced on the grain yield. The average mean yield was found to be 5.03 t ha^{-1}. The maximum grain yield was found on genotype Bhahuguni-1(6.989 t ha^{-1}) followed by PB 1509 (6.533 t ha^{-1}) in compare to check HH1 (6.496 t ha^{-1}) and minimum was found on genotype NR 973 (3.290 t ha^{-1}) which was statistically at par with Rajendra Bhagwati (3.628 t ha^{-1}). When the yield of different long grain Rice genotypes was compared, similar result was found on grain yield of Hardinath3, Cerhrang Sub1, Bahuguni 1, Bahuguni 2 and Radha 4 in two district Kailali and Kanchanpur under on farm Varietal demonstration, they found highest yield in Bahuguni 2 (5.1 t ha^{-1} in Kailali and 4.94 t ha^{-1} in Kanchanpur) (Beshir, 2019). Grain yield (6.215 t ha^{-1}) of Hardinath hybrid-1 was obtained at Jhapa (Puri et al., 2021). According to Jadhav et al. (2019), G x E interaction effect shows that genotypes perform differently to the variation in environmental condition and most of traits were contributed mainly due to genotype followed by environment and their interaction. The variation in biological yield was also found due to the variation in grain and straw yield according to Hossain et al. (2014b). This statement also supports observation.

Thousand Grain Weight and Sterility Percentage

The maximum thousand grain weight was found on genotype PB 1509 (31.89g) due to large size grain which was statistically at par with PusaBasmati-1 (31.51g). The minimum thousand grain weight was found on Sarbati (19.86 g). The average mean thousand grain weight was found to be 28.41g (Table 1). Islam et al. (2013) stated that significant variation in thousand grain weight due to the variation in genetic makeup of the variety. Similarly, PusaBasmati1509 rice showed the highest fertility percentage (87.6g), and the lowest chaffy grains/panicle, followed by 'Pusa Basmati 1121' and

'Pusa Sugandh5' (Ghasal et al. 2015). The maximum unfilled grains decreased the final yield as well as minimum unfilled grains increases the grain yield.

Table 1

Yield Attributes of 11 Rice Genotype in Study Site

Rice genotypes	50F	85M	PL (cm)	PH (cm)	PPH	TILL	Yd (t ha^{-1})	TGW (g)	S(%)
Sarbati	63.33cde	93.00de	24.57c	139.2bc	10.80bc	13.47bcd	3.781bc	19.86 d	23.02
Pusa Sugandha-5	61.00def	93.67 bcde	29.57a	126.2ef	11.60b	12.20de	4.201 bc	30.65ab	29.33
Rajendra Bhagawati	61.00cdef	92.67 de	27.10b	128.4def	10.53bc	12.07 de	3.628 c	28.23abc	27.58
Pusa Basmati-1	68.67a	99.67 a	26.40bc	141.6bc	14.00ab	16.07 ab	5.975abc	31.51 a	32.28
PB 1121	69.33a	98.67ab	27.53b	137.7bcd	15.73 a	16.87a	5.751abc	30.63ab	29.50
Dejgora	65.67abc	96.00abcde	25.77bc	146.8ab	13.80ab	15.80ab	4.473abc	24.01 cd	25.20
Pant dhan-2	63.67cd	97.33abcd	30.07a	144.5ab	7.73 c	10.27 e	4.178bc	28.93 ab	39.51
NR 973	59.00ef	93.33 cde	31.37a	153.9a	12.80ab	12.53 cde	3.290 c	26.05 bc	29.57
Bahuguni-1	68.33ab	98.33abc	26.40bc	127.5ef	12.87ab	14.00abcd	6.989a	30.43 ab	23.79
HH1 (Check)	58.00f	91.00 e	30.40a	133.8cde	13.97ab	15.47abc	6.496ab	30.30ab	31.73
PB1509	64.00bcd	94.00 bcde	24.63c	122.5 f	12.87ab	14.77abcd	6.533 ab	31.89 a	27.76
Grand Mean	63.82	95.24	27.62	136.55	12.43	13.95	5.03	28.41	29
Sem(±)	2.018	2.198	0.953	4.41	1.492	1.296	1.167	2.054	7.75
LSD(0.05)	4.21	4.585	1.987	9.199	3.113	2.704	2.435	4.284	_
F-test	**	**	**	**	*	**	*	**	Ns
CV (%)	3.9	2.8	4.2	4	14.7	11.4	28.4	8.9	_

Note. ** =significant at P <0.01. *=significant at P <0.05. Indicate significantly different at 1% and 5% respectively, Different letters represent significant differences based on LSD test at p<5%, CV: Coefficient of variation, LSD: Least significant difference. NS: Non-significance Indicators, 50F= days to 50% flowering, 85M= Days to 85% maturity, PH= plant height (cm), PL = Panicle length (cm), TILL= number of tillers per hill, PPH= number of panicles per hill, TGW = thousand grain weight (g), Yd= yield (t ha-1) and S(%) =sterility(%)

Correlation Coefficient Analysis

In Table 2, the result shows positive correlation between grain yield and traits such as days to 50% flowering, thousand grain weight, number of panicles per hill, number of tillers per hill and Days to 85% maturity whereas negative correlation

between grain yield and traits such as panicle length, plant height and sterility were observed. The number of panicles per hill contribute approximately 28.87% (R^2=0.2887) on grain yield. Similarly, approximately 38.22% (R^2=0.3822) contribution was given by Number of tillers per hill on grain yield. Again, thousand grain weight input about 40.64% (R^2=0.4064) share on grain yield and left over 59.36% increase in grain yield was due to other variables except thousand grain weight. There was positive correlation of thousand grain weight and number of tillers per hill with grain yield. Chakraborty et al. (2010) reported highly positive correlation of thousand grain weight with grain yield. With increase in number of tillers per hill, thousand grain weight increment, Number of panicles per hill, grain yield also has increment. Similarly, grain yield had positive correlation with Days to 50% flowering (R^2=0.2043) and days to 85% maturity (R^2 = 0.1213). In relation with days to 50% flowering Madhavilatha et al. (2005) reported similar results.

Table 2

Correlation Coefficient between Traits under Selection

	50F	85M	PH	PL	TILL	PPH	HPP	TGW	Yd
50F	1								
85M	.909**	1							
PH	-0.030	0.178	1						
PL	-0.574	-0.232	0.346	1					
TILL	0.493	0.291	-0.025	-0.408	1				
PPH	0.342	0.206	0.000	-0.156	.919**	1			
HPP	-0.026	-0.004	0.509	0.004	-0.397	-0.372	1		
TGW	0.191	0.314	-0.495	0.222	0.167	0.255	-.711*	1	
Yd	0.502	0.407	-0.350	-0.263	0.445	0.373	-0.041	0.410	1

Note. **. Correlation is significant at the 0.01 level (2-tailed).

* .Correlation is significant at the 0.05 level (2-tailed).

50F= days to 50% flowering, 85M= Days to 85% maturity, PH= plant height (cm), PL = Panicle length (cm), TILL= number of tillers per hill, PPH= number of panicles per hill, HPP = hills per plot, TGW = thousand grain weight (g), Yd= yield (t ha-1)

Negative correlation was found on grain yield with panicle length and plant height and concludes that grain yield is reducing due to tall trait in rice. This may due to extension of vegetative growth stage than that of reproductive stage so selection can be done for semi dwarf genotypes. Also, Genotypes taking more days for 50% flowering

and variety require more days for maturity have ultimately maximum grain yield (Hairmansis et al. 2010). Thus, for better crop improvement and breeding programs traits such as days to 50% flowering, number of tillers per hill, number of panicles per hill, thousand grain weight is to be considered in selecting genotypes having highly positive and significant correlation coefficient.

Phenotypic and Genotypic Coefficient of Variation

The highest variability for both GCV and PCV was estimated for grain yield (43.10 and 51.62). Traits like days to 50% flowering and days to 85% grain maturity had low value of both GCV and PCV. The difference between GCV and PCV ranged from 0.59 to 8.52. The result of present study closely agreed with previous report where, GCV and PCV high for effective tillers per m^2, thousand grain weights, grain yield, harvest index (Gyawali et al*.,* 2018). In general, PCV is higher than GCV for all the traits. There is maximum difference between PCV and GCV in grain yield, moderate difference in traits tiller per hill and panicle per hill and other traits have small difference between PCV and GCV. The genetic variation showed that phenotypic coefficient of variation was relatively higher than genotypic coefficient of variation results, it revealed that the influence of environment on phenotypic expression of each traits (Adhikari et al*.,* 2018).

Heritability

The considerable differences in differences in heritability value for different characters were observed. Among observed characters under study, panicle length (92%) had highest value of heritability followed by plant height (90%). Traits like days to 50% flowering (87%), thousand grain weight (86%), tiller per hill (82%), panicle per hill (79%) and days to 85% maturity (75%) shows high heritability estimates. The heritability of grain yield (69%) exhibits the lowest one among observed traits. Similar result showed on report of Kishore *et al.,* (2015**)** where highest heritability found on plant height, panicle length and moderate heritability on tiller per hill.

Genetic Advance as Percentage of Mean

The genetic advance as percentage of mean at 5% selection intensity reveled remarkable differences among the traits under study. Yield per hectare shows the highest genetic advances as per percentage of mean (74.12%) among the entire traits. Similarly, panicle per hill (53.36%) and tiller per hill (45.81%) exhibits high genetic advance as percentage of mean. Likewise, genetic advances as percentage of mean were found to be moderate for thousand grain weight (42.13%), panicle length (29.10%), and plant height (24.01%). Genetic advance as per percentage of mean was found lowest for days to 50% flowering followed by days to 85% grain maturity (8.92%).

These findings agreed with Sharma et al. (2015) where genetic advance as percentage of mean was found higher in trait yield per hectare followed by thousand grain weight, days to 50% flowering and days to 85% grain maturity.

Table 3

Heritability of 8 Characters of 11 Genotypes

Variables	GCV	PCV	h²bs	GA	GAM
50F	10.30	11.00	0.87	12.68	19.87
85M	4.98	5.72	0.75	8.50	8.92
PH	12.25	12.87	0.90	32.79	24.01
PL	14.70	15.29	0.92	8.03	29.10
TILL	24.51	27.03	0.82	6.39	45.81
PPH	29.03	32.54	0.79	6.63	53.36
TGW	22.04	23.75	0.86	11.96	42.13
Grain yield (t ha^{-1})	43.10	51.62	0.69	3.72	74.12

Note. h^2_{bs} – heritability in the broad sense, GCV – genotypic coefficient of variation, PCV – phenotypic coefficient of variation, GA – genetic advance at 5% intensity of selection, GAM – genetic advance as per cent of mean. 50F= days to 50% flowering, 85M= Days to 85% maturity, PH= plant height (cm), PL = Panicle length (cm), TILL= number of tillers per hill, PPH= number of panicles per hill and TGW = thousand grain weight (g)

Lodging Effects

In this research on Banke district, Sarbati and Dejgora have maximum lodging effect. Other was not found on lodging condition in any growing stages. However, losses were not heavy due to lodging effects on these genotypes.

Rice Aroma

PB 1509 and Rajendra Bhagawati were found scented. The lightly scented genotypes were Sarbati, Pusasugandha5, NR973 and PusaBasmati1. Non-scented genotypes were Bahuguni-1, HH1, Dejgora, PB 1121 and Pant dhan. Rice with more aroma is preference in recent trend. Thus, PB 1509 is indispensable in further research program.

Conclusion

The genotype Bahuguni-1 and PB 1509 yielded high for their *per se* performance. Thousand grain weights and number of panicle per hill were also higher for these two

genotypes and these characters were highly associated with grain yield. Genotypic coefficient of variation and genetic advance as percentage of mean estimation also supported the utilization of thousand grain weights and number of panicle per hill in rice breeding program through indirect selection in addition to direct selection for grain yield. Thus, exploitation of PB1509 in further yield trial will contribute to national rice breeding programs of Nepal.

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