

# Agronomic Appearance, Genetic Parameters of Red and Black Rice (*Oryza sativa* L.) in Different Environments Dry Land

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**Abstract.** Increasing yield and adaptability of brown and black rice in functional sub-optimal environments begins with increasing genetic diversity through conventional crosses between diverse germplasm. This study aims to determine the yield, genetic diversity, heritability, and interactions between rice genotypes in two different growing environments. The study was conducted in April-August 2021. The study was designed using a two-factor Randomized Block Design (RAK) with three replications. The first factor genotype consisted of 15 treatments, namely: 6 brown rice lines (G1-G6), five black rice lines (G7-G11), three the parents are Baas Selem (G13), Situpatenggang (G14), and GH Padi red rice (the elder of the brown rice line) and one comparison variety Inpago Unram 1 (G15). The second factor consists of two locations: Tampak Siring Village, Batukliang District (379 m a.s.l.) and Mujur Village, Praya Timur District (103 m a.s.l.) Central Lombok Regency. The results showed that the yield of Inpago Unram 1 (G15) was higher than other genotypes, namely 7.10 t/ha. The lines with the exact yield as the GH of red rice (brown rice strain parent) and Situ Patenggang (black rice parent) were G6 and G10 with a value of 5.21 t/ha and 5.35 t/ha, respectively. High heritability values were indicated by plant height and grain yield, while the other traits were classified as low to moderate with a range below 0.20 to 0.45. The coefficient of genetic diversity in the number of productive tillers was relatively high, namely 51.27%. Slightly low values were obtained for plant height and number of non-productive tillers with values of 38.63% and 48.26%, respectively. Developing G6 and G10 genotypes are recommended because they have higher yields. All tested genotypes were able to adapt to two different growing environments.

**Keywords:** genotype; diversity; heritability; interaction.

## INTRODUCTION

Red and black rice are starting to be in great demand, considering that excessive consumption of white rice is a health problem [1]. On the other hand, the functional rice productivity of red and black rice is still very low. Therefore, it is necessary to improve genetic traits to obtain red and black rice varieties with high yields and early maturity. Breeding activities through crossing techniques produced genotypes of red and black rice [2-4].

The genotypes produced from red and black rice still need to be observed on the adaptability to different growing environments and the genetic parameters of their agronomic characteristics, such as the ability to inherit from the parents. Inheritance ability can be calculated through

broad-meaning heritability values to facilitate the following selection process. If the heritability value is high, it shows that genetic factors play a more role in controlling a trait than environmental factors and vice versa [2-4]. Another genetic parameter that needs to be observed is the coefficient of genetic diversity. This parameter is important because it can determine the uniformity of a character in a population. Therefore, studying red and black rice genotypes in two different growing environments is necessary.

## MATERIALS AND METHODS

The research was carried out from April to August 2021 in two locations, namely in Jeranjang Hamlet, Tampak Siring Village (379 m a.s.l.) Batukliang District, Central Lombok Regency and in

Mujur Village (103 m a.s.l.) Praya Timur District, Central Lombok Regency.

The experiment consisted of two factors, namely genotype and location. Investigations at each site were designed using a Randomized Block Design (RAK), three replications. The genotype factor consisted of 15 genotypes, namely: 6 brown rice lines (G1–G6) and five black rice lines (G7–G11). Three parents are GH Padi Red Rice (G12) Baas Selem (G13), and Situpatenggang (G14), a comparison variety Inpago Unram 1 (G15). The second factor consists of two locations. Each plot measured 2×3 m with a spacing of 25×25 cm, and each planting hole was filled with two seeds and thinned to 1 grain per planting hole. Thinning was done on seeds that grew two plants in each planting hole and cultivated into one plant per planting hole. Thinning was done at the age of 14 days after planting. The difference test between treatments was carried out using the Duncan Multiple Range Test (DMRT) at a level of 5% [5]. Statistical analysis was performed using SAS software, while heritability analysis was based on [6], and the GFC value was based on [7].

## RESULTS AND DISCUSSION

Rice plants can grow optimally at an altitude of 0–1500 m above sea level, a temperature of 23 °C, requiring rainfall between 1500–2000 mm/year. The measurement of a place affects the air temperature of a home. The higher the area, the lower the air temperature or the colder it gets. Conversely, the lower a place is, the hotter the air temperature.

The average rainfall in the two study locations, namely the East Praya sub-district and the Batukliang sub-district, respectively, was 75.55 mm<sup>3</sup> per month and 98.33 mm<sup>3</sup> per month [8]. According to [9], the threshold values used to determine the intensity of rain (mm/day) are 0 including cloudy, 0.5–20 including light rain, 20–50 including moderate rain, 50–100 includes heavy rain, 100–150 includes very heavy rain, and > 150 includes extreme rain. Based on the threshold value for determining the intensity of precipitation set by BMKG, the study location in East Praya District is classified as light rain intensity. In contrast, Batukliang District is classified as moderate rain. The height of the place was measured using an altimeter and google earth. It was found that the altitude for Mujur Village, East Praya Subdistrict, was 103 m above sea level

with a temperature of 23–28 °C and Tampak Siring Village, Batukliang District, 379 m above sea level with a temperature of 23–26 °C. The altitude of 103 m above sea level is classified as lowland, and 379 m above sea level is classified as medium plain. Medium plains have an elevation (elevation) of 300–700 m above sea level [10], while the lowlands have an altitude below 200 m above sea level. Both locations are central for upland rice cultivation in Central Lombok Regency's dry land.

In general, based on the analysis of variance, the environmental location factor had a significant effect on several variables, and there was no interaction between genotypes and location, as described in Table 1.

Table 1 – Summary of results of analysis of variance (ANOVA) on all parameters of rice plants as the effect of Genotype (G), Location (L) and Interaction between G×L

Observation Variable	Single factor		Interaction G×L
	Genotype (G)	Location (L)	
Plant height	*	*	Ns
Number of productive tillers	*	Ns	Ns
Number of non-productive tillers	*	Ns	Ns
Flowering age	*	Ns	Ns
Harvest age	*	*	Ns
Panicle length	*	*	Ns
Total Grain Fill/panicle	*	*	Ns
Number of empty grain/panicle	*	*	Ns
Grain weight/clump	*	*	Ns
Weight 100 seeds	*	Ns	Ns
Grain Yield t/ha	*	Ns	Ns

Notes: \* – significant; Ns – non-significant

Based on Table 1, the genotype factors were significantly different for all observed variables. Location factors with different heights showed significant differences in plant height, harvest age, panicle length, number of filled grains per panicle, number of empty grains per panicle, and grain weight per clump. The difference was not significant for the location, indicated by the number of productive tillers, some non-productive tillers, age of flowering, the weight of 100 seeds, and grain yield. There was no significant differ-

ence for all variables in genotype interaction (G)×Location (L). This means that location does not affect plant growth in all tested genotypes.

Average agronomic variables per genotype are described in Table 2.

Table 2 – Average Agronomic Variables per Genotype

Treatment	ST	AP	ANP	UB	UP	PM	GI	GH	BGR	100 B	G t/ha
G1	100,703 fg	12,167 abcde	1.8333 a	82,667 cbde	114,167 a	21.2017 bc	103,785 bcd	25,463 ab	23,887 e	2,875 bcd	4.6260 dc
G2	117,993 ab	12,500 abcde	1000 abc	79,833 edition	111,500 ab	23,8250 a	110,020 bc	24,547 ab	35,525 bcd	3,101 a	3.7708 ed
G3	103,548 def	15,833 ab	1000 abc	83.333 abcde	111.333 ab	22.3533 abc	106,565 bc	24,907 ab	32,073 cde	2,871 bcd	4.7620 c
G4	109,830 dce	11,667 cde	1.5000 ab	83,500 abcde	111.333 ab	21.8883 abc	119,675 ab	24,842 ab	33,427 bcd	3,070 ab	5.0442 bc
G5	104,440 def	16,667 a	0.3333 c	79,333 de	113.333 ab	22,5600 abc	104,360 bcd	28,353 ab	35,228 bcd	2,920 abc	3.6368 e
G6	111,337 bcd	17,000 a	0.3333 c	84,167 abcde	111.333 ab	23.4617 a	119,010 ab	26,725 ab	44,532 a	2,941 abc	5.2115 bc
G7	103,718 def	10,000 e	0.6667 bc	85,167 abcd	114,167 a	20,3600 c	115,372 abc	20,722 bc	29,108 cde	2,738 cd	4.8230 c
G8	107,482 dcef	10,667 de	1.1667 abc	89,000 a	110,500 ab	20.5717 bc	119,862 ab	21,537 abc	26,690 de	2,678 d	4.7110 dc
G9	94,585 g	15,333 abc	0.1667 c	86,833 ab	108,333 ab	20.5533 bc	84,677 d	25,808 ab	33,047 bcd	2,908 abc	4.3760 cde
G10	111,278 bcd	12,667 abcde	0.3333 c	87,167 ab	109,333 ab	21.1600 bc	116,657 abc	20,880 bc	36,840 abc	2,718 cd	5.3562 bc
G11	107,580 cdef	17,333 a	0.6667 bc	84,000 abcde	108,667 ab	21.1083 bc	104,908 bcd	28,760 a	38,153 abc	2,876 bcd	4.7130 cd
G12	113,025 abc	16,000 ab	0.6667 bc	80,667 cde	107,167 b	21.8133 abc	121,528 ab	24,020 ab	33,762 bcd	2,833 cd	5.8162 b
G13	102.422 ef	14,333 abcd	0.0000 c	86,167 abc	109,667 ab	22.0783 abc	95,788 cd	27,527 ab	31,370 cde	2,771 cd	4.6087 cd
G14	106,162 cdef	18,167 a	0.0000 c	83,667 abcde	110,833 ab	22.7383 ab	115,573 abc	24,740 ab	38,300 abc	2,790 cd	5.3235 cb
G15	119,278 a	18,167 a	1.1667 abc	78,667 e	106,833 b	22.7867 ab	136,012 a	16,075 c	48.36 a	3,098 a	7.1020 a
Average	107.558	14.567	0.5000	83.611	109,644	20,381	104.919	24,327	31,842	2,879	4,925

Notes: TT – plant height (cm); AP – number of productive tillers per clump (stem); ANP – number of non-productive tillers per clump (stem); UB – flowering age (day); UP – harvest age (day); PM – panicle length (cm); GI – number of filled grains per panicle (grain); GH – number of empty grains per panicle (grain); BGR – weight of grain per clump (grams); 100 B – weight of 100 filled grains (grams); G t/ha: grain yield (t/ha).

\*Numbers followed by the same letter in the same column are not significantly different according to the DMRT test at the 5% level.

Plant height between brown and black rice lines and parental and comparison varieties varied significantly between genotypes. The lowest plant is indicated by G9, with a value of 94.5 cm. G2 indicates the tallest plant with a value of 117 cm. This value was higher than the expected line, its parents and the same as the comparison variety Inpago Unram 1 with a value of 119 cm. Plant height in all lines ranged from 94 to 117 cm. The growth indicator or growth parameter

used to measure the effect of the environment on the applied treatment is plant height. The most easily observed growth measure is plant height. Plant height in several genotypes has a high diversity and will affect the yield. This is in line with the opinion [11] that the size of the plant stem is a trait or characteristic that affects the outcome. One of the causes of the diversity in the appearance of plant height is the difference in their genetic composition. This is by the opinion

of [12] that the variation in plant height between varieties is caused by each genotype having different genetic factors and characteristics.

The number of productive tillers for each genotype, red and black rice showed identical three genotypes with the parent G14 and the comparison variety, the genotypes were G5, G6, and G11 and the lowest number of tillers was indicated by G7. The number of productive tillers ranged from 10 to 17 stems per clump. According to [13], one of the causes of differences in the number of tillers that occur is genetic factors.

The number of non-productive tillers in each genotype of brown rice was G1 (two tillers), G2 (one tiller), G3 (one tiller), G4 (two tillers), G8 (one tiller), and G15 (one tiller). The range of the number of non-productive tillers tested was zero to two tillers.

The flowering age of each brown and black rice genotype is quite diverse. The flowering period of genotypes G2 and G5 was not significantly different, but flowering was faster than the other genotypes, namely 79 DAP. These genotypes flowered faster than all of their parents, but the same as the comparison variety - flowering age range from 79 to 87 DAP.

The G1 and G7 lines showed a more profound harvesting age than the GH red rice (107 DAP) and the comparison varieties (107 DAP). Harvesting age ranged from 109–111 DAP. The harvest age of the plant is related to genetic factors, so each genotype tested has a different period. This was revealed by [14] plant phenotypes will show physiological maturity, generally caused by genetic factors. Meanwhile, according to [15], the appearance that appears on plants results from the interaction between environmental and genetic factors.

The panicle length of the G2 and G7 lines was the same as that of the parents, and the comparison variety, with a panicle length of 24 cm. The number of filled grain per panicle of G4 (119.675 cm), G6 (119 cm), G7 (115.372 cm), G8 (119.862 cm), and G10 (116.657 cm) lines was the same as the parents and the comparison variety. The G13 line had a low number of filled grains per panicle with a value of 22.1 cm. Grain weight per clump of G6 (44.532 g), G10 (36.840 g), and G11 (38.153 g) lines were the same as Situ Patenggang parents and the comparison variety Inpago Unram 1. G6 line showed higher grain weight per

clump than parents Baas Selem with a value of 31.370 g.

The weight of 100 grains in lines G2 (3.101 g), G4 (3.070 g), G5 (2.920 g), G6 (2.941 g), and G9 (2.908 g) was the same as the comparison variety Inpago Unram 1. G2 line showed a weight of 100 grains higher than the elder. This indicates that there are genetic differences between genotypes. The results of this study are by [16], which states that differences in production can be caused by the genetic composition of each rice cultivar. The grain yield of red and black rice lines showed lower yields compared to the comparison variety Inpago Unram 1. The G4 (5,044 t/ha), G6 (5,211 t/ha), and G10 (5,356 t/ha) lines showed lower yields the same as its parents, and the comparison variety Inpago Unram 1.

Table 3 – Average of rice genotype agronomic variables per location

Variable	Location	
	Look Siring (L1)	Lucky (L2)
Plant height (cm)	109.30 a	105.81 b
The amount will be produced per clump (stem)	14.95 a	14.17 a
Amount of non-productive per clump (stem)	0.64 a	0800 a
Flowering age (hst)	84.53 a	82.68 a
Harvest age (hst)	108.28 b	111.00 a
Panicle length (cm)	22.33 a	21.46 b
Number of grain containing per panicle (grain)	115.72 a	107.44 b
Number of empty grains per panicle (grain)	30.04 a	18.60 b
Grain weight per clump (g)	36.30 a	32.18 b
Weight of 100 grains of grain contains (g)	2.91 a	2.84 a
Grain yield (t/ha)	5.04 a	4.80 a

Notes: Numbers followed by the same letter in the row are not significantly different according to the DMRT test at the 5% level.

Variables of plant height, harvest age, panicle length, number of filled grains per panicle, number of empty grains per panicle, and grain weight per clump, differed between the two locations. This shows that environmental factors influence the observed variables. At the same time, the variable number of productive tillers per clump, number of non-productive tillers per clump, age

of flowering, the weight of 100 grains of unhulled grain, and grain yields showed that there was no significant difference. This shows that environmental factors at two different locations do not influence the agronomic variables. The same research has been submitted by [3], which states the higher a place is, the temperature in that place will be lower, and the humidity will be higher. Every 100 meters above sea level, the temperature will decrease by 0.6 °C. However, the study's results were not the same as the statement of [3], where the plant height in the highlands had higher yields than in the lowlands. This is due to the different factors of rainfall and soil fertility in the two study locations, resulting in different results. According to [9], the threshold value used to determine the intensity of rain, the study location in Tampak Siring Village is classified as moderate rain with an intensity of 20-50 mm/day, and L2 is classified as light rain with an intensity of 0.5-20 mm/day. At the time of the study, L1 (Batukliang) was in rainy conditions while L2 (Fortunately) was almost no rain. This causes vegetative growth to develop rapidly at L1. Plant height growth at L1 was followed by other variables and affected the yield. In addition to rainfall, different soil fertility can also affect growth and yield. The results of laboratory tests of soil samples at two locations showed higher N, P, and K content at location L1. The test results at location L1 showed: N 0.09%, P 0.07%, and K 0.13% while at L2: N 0.08%, P 0.02%, and K 0.10% (Soil Laboratory, BPTP NTB in 2021). Plant height growth at L1 was followed by other variables and affected the yield. In addition to rainfall, different soil fertility can also affect growth and yield. The results of laboratory tests of soil samples at two locations showed higher N, P, and K content at location L1. The test results at location L1 showed: N 0.09%, P 0.07%, and K 0.13% while at L2: N 0.08%, P 0.02%, and K 0.10% [17].

Genetic factors also affect plant growth, besides being influenced by environmental factors, based on observations about plant height. This is evidenced by calculating the heritability value. The

following is explained further in Table 4 about the value of heritability on the observed agronomic characters.

Table 4 – The value of heritability on the observed agronomic characters

Agronomic character	Variety component		Broad heritability	Notes
	genotypic variance	phenotypic variance		
Plant Height	41.556	77.237	0.538	Tall
Number of productive tillers	7.469	16.513	0.452	Currently
Number of non-productive tillers	0.241	0.966	0.250	Currently
Flower age	8.678	29.027	0.299	Currently
Harvest age	3.349	26.519	0.126	Low
Panicle length	1.047	27.859	0.038	Low
Total Grain Fill / Panicle	13.353	275.087	0.049	Low
Number of Void Grain / Panicle	2.988	33.762	0.089	Low
Grain Weight Per Clump	27.512	47.695	0.026	Low
Weight 100 grains	0.013	0.041	0.317	Currently
Grain Yield	0.612	1.134	0.540	Tall

The range of heritability values is between 0–1. The heritability value is said to be high if it is close to 1 with a range of  $0.5 \leq H^2 \leq 1.00$ . The heritability value is said to be moderate if it is in the range of  $0.20 \leq H^2 \leq 0.50$  and is said to be low if it is close to 0 with a range of  $0.00 \leq H^2 \leq 0.20$  [18].

The results of research that has been carried out using fifteen genotypes in two different environments show that the heritability values for all variables are classified as low, medium, to high. High heritability values were indicated by two variables, namely plant height and grain yield (t/ha), with values of 0.538 and 0.540, respectively. High heritability values told that genetic factors played more roles than environmental factors in plant appearance. Productive tillers, non-productive tillers, and flowering age had moderate heritability values of 0.452, 0.250, and 0.299, respectively. Most of the other variables have low heritability estimates. The above shows that there are variations in the heritability esti-

mate value. The heritability expressed by [19] that characters included in the category of moderate to high heritability, meaning that environmental factors do not play a significant role in the appearance of these characters. Further stated by [20], a character with a high heritability predictive value indicates the influence of genetic factors is more significant than environmental factors.

In line with the opinion [11], heritability with a value of 0 means that phenotype diversity is caused by environmental factors, while a value of 1 means that genetic factors cause phenotype diversity. If the heritability value is high, the selection can be carried out in the early generations using mass selection methods or pure genotype selection. Meanwhile, suppose the heritability value is low. In that case, the choice is carried out in the next generation using the pedigree method, singlet seed descent, and progeny test to obtain new superior varieties. According to [21], high heritability values provide an essential role in the following selection process.

One of the successes in improving a plant's character is highly dependent on genetic diversity. A comprehensive genetic variety of research material is needed so breeders can choose research materials suitable for breeding purposes. It is further explained in Table 5 below.

Table 5 – GFC values for all rice genotype variables

Agronomic character	Coefficient of Genetic Diversity (KKG), %	Notes
Plant Height	38,636	A bit low
Number of productive tillers	51,271	A bit high
Number of non-productive tillers	48,267	A bit low
Flower age	10,379	Low
Harvest age	3,055	Low
Panicle length	5,137	Low
Total Grain Fill/panicle	12,727	Low
Number of Void Grain / Panicle	12,284	Low
Grain Weight Per Clump	3,826	Low
Weight 100 grains	0,452	Low
Grain Yield	12,420	Low

The grouping of genetic diversity according to [22], namely, KKG 0-25% belongs to the category of low genetic diversity, relative KKG 25-50% belongs to rather low genetic diversity, KKG 50-75% belongs to the category of low genetic diversity in rather high genetic diversity, and KKG 75-100% belong to high genetic diversity.

The observations of the tested genotypes on all quantitative variables showed that the coefficient of genetic diversity was relatively low, low, and rather high. The range of KKG values for characters with low and relatively low values is between 0.159–12.420 %. The low weight was indicated by the number of non-productive tillers, with a value of 48.267%. The variables of flowering age, harvest age, panicle length, number of filled grains per panicle, number of empty grains per panicle, grain weight per clump, 100-grain weight, grain weight per plot, and grain yield had low or narrow genetic diversity values. The character of the number of productive tillers showed a relatively high coefficient of genetic diversity with a value of 51.271%. Authors [23] stated that the coefficient of low to moderate variety could be categorized as narrow diversity.

## CONCLUSIONS

The yield of Inpago Unram 1 (G15) variety was higher than other genotypes, namely 7.10 t/ha. The lines with the exact yield as GH Padi brown rice (the parent of the brown rice line) and Situ Patenggang (the elder of the black rice) were G6 and G10, with values of 5.21 t/ha and 5.35 t/ha, respectively. High heritability values were indicated by plant height and grain yield, while the other traits were classified as low to moderate, with a range below 0.20 to 0.45. The coefficient of genetic diversity in the number of productive tillers was quite high, 51.27%. Slightly low values were obtained for plant height and number of non-productive tillers with discounts of 38.63% and 48.26%, respectively. There isn't any interaction between Genotype (G)×Location (L); all tested genotypes were able to adapt to two different growing environments.

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