PAPER NAME

2021 BIODIVERSITAS Agronomic characters, genetic and phenotypic diversity coefficients, and heritabi

AUTHOR

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WORD COUNT

6056 Words

CHARACTER COUNT

28766 Characters

PAGE COUNT

7 Pages

FILE SIZE

565.2KB

SUBMISSION DATE

Jan 1, 2023 5:15 PM GMT+7

REPORT DATE

Jan 1, 2023 5:15 PM GMT+7

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Agronomic characters, genetic and phenotypic diversity coefficients, and heritability of 12 genotypes of rice

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Abstract. *Kartahadimaja J, Utomo SD, Yuliadi E, Salam AK, Warsono, Wahyudi A. 2021. Agronomic characters, genetic and phenotypic diversity coefficients, and heritability of 12 genotypes of rice. Biodiversitas 22: 1091-1097.* The achievement of national rice production is always below the target. One of the causes is the low productivity of the varieties grown due to the stagnant genetic capacity of these varieties. The assembly of new lines through breeding is one solution that can increase the genetic capacity of new varieties. Genetic diversity is one of the factors that influence the success of plant breeding. Ten new F9 rice lines were successfully assembled showing various phenotypes. The identification of the specific advantages of each of these new rice lines was based largely on the phenotypic response. The research objective was to identify the genetic advantages of each line through the analysis approach of genetic diversity coefficient (GDC), Phenotific Diversity Coefficient (PDC), and broad-sense heritability. The research was designed on a randomized completely block design (RCBD) with ten new F_9 rice lines and two comparison varieties as treatments, repeated three times. The variables observed were plant height, maximum number of tillers, number of productive tillers, flowering time, harvesting time, panicle length, number of grain per panicle, number of filled grains per panicle, number of empty grain per panicle, grain length, grain width, grain thickness, and grain yield per hectare. The data were analyzed using Analysis of Variance (ANOVA), if there was a difference between the mean values, it was continued with a 5% LSD test. The results showed that (i) the genotypes tested showed wide genetic and phenotypic diversity, (ii) based on the analysis of GDC, PDC, and broad sense heritability, the appearance of phenotypes of several agronomic characters was controlled by genetic factors.

Keywords: Agronomic characters, genetic diversity, heritability, phenotypic diversity, rice production

Abbreviations: GDC: diversity coefficient; PDC: phenotypic diversity coefficient

INTRODUCTION

Rice is one of the most important crops in the world because it can feed 50% of the world's population (Zhang et al. 2011; Kumar et al. 2018). In Indonesia, rice is the staple food ingredient for most of the population (Irawan 2015). The achievement of national rice production is always below the target. In order to maintain a balance between demand and production, almost all rice-producing countries have attempted to stabilize the rate of production through increasing crop productivity. Many factors cause the production below the target such as decrease in harvested area, pests and diseases, and low productivity of the varieties used (Central Bureau of Statistics of Riau Islands Province 2015). The low productivity of cultivated varieties is due to stagnant genetic capacity (Sobir 2013). The assembly of new lines through plant breeding is one of the solutions that can increase the genetic capacity of new varieties.. Plant breeding is an activity that aims to improve or increase the genetic potential of plants, in order to obtain new varieties that are better than the two parents (Purwati

2009). Genetic diversity is one of the factors that greatly contributes the success of plant breeding. The existence of genetic diversity in a population are variations in genotype values among individuals in the population (Sofiari and Kirana 2009).

Ten new rice lines of the F_9 generation were successfully assembled showing various phenotypic appearances. The germplasm used as parents of the crosses comes from several national superior varieties, namely Gilirang, IR64, Cigeulis, and Ciherang which have different genetic diversity crossed with local superior varieties Mentik Wangi or Pandan Wangi which has high yield potential, and good quality rice showed by a fragrant rice aroma. Zuriates from the crosses starting from the 2nd generation (F2) were selected using the pedigreed method. Currently, there are 10 expected 9th generation (F9) lines that have a superior phenotypic appearance. The identification of the specific advantages each of these new rice lines was primarily based on the phenotypic response. To increase the value of precision in increasing the genetic diversity of each line, it is necessary to identify the genetic

advantages of each line through the analysis of the genetic diversity coefficient (GDC) approach, the coefficient of phenotypic diversity (PDC) and the estimated heritability value. Broad genetic diversity will affect the success of selection, and the success of selection is also influenced by the heritability level of the characters to be selected. The heritability prediction value shows whether a character is controlled by genetic factors or environmental factors, so that it can be seen to what extent the character can be passed on to the next offspring. The research objective was to identify the genetic superiority of each line through the analysis approach of the Genetic Diversity Coefficient (GDC), the Phenotific Diversity Coefficient (PDC), and the estimated heritability value.

MATERIALS AND METHODS

Plant materials

The germplasms used as the parent for the crossing were IR64, Gilirang, Cigeulis and Ciherang from national superior varieties which have different genetic diversity, and the local superior varieties, i.e., Mentik Wangi which have high yield potential and good quality in term of a rice fragrant aroma.

F_9 generation selection

Zuriates of the crossing starting from the 2nd (F_2) to the 6th (F_6) generation were selected using the pedigree method to produce a segregating population that will be selected as new line candidates. Currently, 10 selected lines from the F_9 generation have been produced and showed superior agronomic characters. The lines of hope show superior agronomic characters. The 10 lines are coded B2, B3, B4, B7, F2, F3, F4, H1, H4, and L2.

Experiment design and analysis

Ten new F_9 rice lines and 2 commercial varieties were planted in the field using a randomized complete block design (RCBD). The varieties were used and treatment and each treatment was repeated three times. The maximum plant height, maximum number of tillers, number of productive tillers, 50% age of flowering plants, length of panicles, number of grains per panicle, number of filled grains per panicle, number of empty grain per panicle, grain yield per clump, and grain yield per hectare was observed. The data were analyzed using Analysis of Variance (ANOVA), if there was a difference between the mean values, the LSD at 5% level was employed. To determine whether the phenotypic performance is influenced by genetic factors or environmental factors, analysis of Genetic Diversity Coefficient (GDC), the Phenotific Diversity Coefficient (PDC), and the estimated heritability value was applied for each observed variable. Genotypic diversity and phenotypic diversity (δ^2_g, δ^2_p) were used to estimate the Genetic Diversity Coefficient (GDC) and the Phenotific Diversity Coefficient (PDC) using the following formula:

$$GDC = \frac{\sqrt{\delta^2_g}}{\bar{x}} \times 100\%$$

$$PDC = \frac{\sqrt{\delta^2_p}}{\bar{x}} \times 100\%$$

Where:
GDC : Genetic Diversity Coefficient
PDC : Phenotific Diversity Coefficient
δ^2_p : Phenotific variance
δ^2_g : Genotific variance
$\bar{x}$: General average

Broad sense heritability was calculated according to the method of Singh and Chaudhary (1985); Fehr (1987).

$$H^2_B = \frac{\delta^2_g}{\delta^2_p}$$

Where:
δ^2_p : Phenotypic variance;
δ^2_g : Genotypic variance;

RESULTS AND DISCUSSION

Growth variables

The results of statistical analysis showed that the plant height, maximum number of tillers, number of productive tillers, width of flag leaves, length of flag leaves, and angles of flag leaves of 12 genotypes (10 lines and 2 varieties) varied among the genotypes (Table 1).

The plant height characters of 12 rice genotypes (10 lines and 2 varieties) showed significant variation. The F4 line showed the highest plant height about145.98 cm. Two lines, H4 and H1, as well as IR64 variety, showed lower than the other varieties. The twelve rice genotypes tested, if grouped based on plant height characters, can be grouped into three groups, i.e., (i) short plant, namely B4, F3, H1, H4 lines; (ii) medium plant, namely IR64 and Ciherang, B7, L2 lines, and; (iii) high plant, i.e., B2, B3, F2, and F4 (International Rice Research Institute 2002 and Yoshida 1981). The structure of rice plants is mainly determined by the condition of plant height, stem strength, number of tillers, leaf morphology and panicle (Kushwaha et al. 2015). Short and stiff rice stems are desirable traits in the development of superior rice varieties, because the plants become resistant to falling.

The capacity to produce maximum and productive tillers of the 12 rice genotypes tested showed character variation (Table 1). The H4 line shows the capacity to produce the maximum number of tillers a productive tillers. Based on the character of the ability to produce tillers, the 12 rice genotypes tested were categorized as the many tiller-producing rice. The capacity of the tillers is one of the important characteristics in high yielding varieties. The ability to produce tillers is a quantitative trait that contributes positively to rice productivity or yields (Constantino et al. 2015). Many tillers are expected to have a positive impact on the number of productive tillers.

Table 1. The growth variables of 12 rice genotype observed

Genotype	Plant height (cm)	Maximum number of tillers (tiller)	Maximum number of tillers (tiller)	Flag leaf width (cm)	Flag leaf length (cm)	Flag leaf angle (º)
B2(line)	130.43 b	32.40 bc	26.20 abcd	1.82 b	34.88 bc	20.68 ab
B3 (line)	132.96 b	25.60 e	22.33 d	2.14 a	37.75 b	24.64 a
B4 (line)	106.12 fg	27.87 cde	24.73 abcd	1.88 b	28.53 gh	17.61 bc
B7 (line)	114.07 d	26.53 de	24.00 abcd	1.87 b	27.57 h	15.89 bcd
F2 (line)	133.73 b	31.13 bcd	26.07 abcd	1.88 b	30.34 efgh	22.67 a
F3 (line)	109.15 ef	26.47 de	23.33 cd	1.86 b	33.17 cdef	17.22 bc
F4 (line)	145.98 a	28.73 cde	24.00 abcd	2.25 a	42.53 a	14.64 cd
H1 (line)	103.54 gh	27.87 cde	23.60 bcd	1.90 b	31.14 defg	15.11 cd
H4 (line)	100.51 h	39.13 a	28.73 a	1.82 b	29.80 fgh	13,91 cd
L2 (line)	122.36 c	27.87 ab	28.27 ab	1.82 b	31.25 defg	12.20 d
Var. IR-64	103.88 gh	31.13 cde	22.20 d	1.77 b	34.01 cd	15.93 bcd
Var. Ciherang	111.25 de	31.73 bc	27.27 abc	1.82 b	33.36 cde	14.00 cd
LSD	4.45	4.86	4.78	0.23	3.38	4.90

Note: The numbers followed by the same letter in the same column are not significantly different according to the 5% LSD test

Productive tillers are tillers that produce panicles where the seeds or grains are located. The number of productive tillers per clump or per unit area determines the number of panicles as a yield component which will have a direct effect on the high and low potential yield of grain. Cultivars with the ability to produce large numbers of tillers have been the main objective of breeding programs since the 18th century for high yields (Liu et al. 2013). Many tiller types are suitable for a wide variety of spacing. The ability to produce many tillers will have an impact on the yield potential of a variety or line.

The characters of flag leaf length, flag leaf width, and flag leaf angle of the 12 rice genotypes tested showed differences (Table 1). Flag leaf is the top leaf that looks different in position and size from other leaves. The F4 and B3 lines are the two lines that have the widest flag leaf about 2.14-2.25 cm, and B4, F2 and H4 lines have the shortest flag leaf ranging from 27.57-30.34 cm.

The leaf angles of the lines observed ranging from 12.20o-24.64o. A flag leaf angle of less than 45º is an upright leaf plant category. The flag leaves act as an assimilate producer during the seed filling process. The ideal morphological characters of flag leaf include 50 cm length, 2 cm width, 5º leaf angle, and narrow leaf to form the letter V (Peng et al. 2008). The desired characteristics of the leaves of the superior rice varieties are those that grow upright, thick, small and short. The effect of plant type on yield is highly dependent on the structure of the leaf canopy (Lu et al. 2010). Agronomically, the characters of rice varieties or lines with upright leaves are favored by farmers. In rice fields, which have an upright flag leaf character, are not favored by plant-disturbing organisms, especially birds, while those whose flag leaves are drooping, are preferred by birds because these pests will more easily perch at the base of the flag leaves and eat the grains.

Yield component and yield variables

The characters of flowering time, harvesting time, panicle length, filled grain of each panicle, empty grain of each panicle, and the total number of grains per panicle of the12 rice genotypes varied widely (Table 2). Strains B2, B4, H1 and IR 64 are genotypes that are faster flowering and harvesting than the other lines. There are three genotypes, namely the B3, F4 and L2 lines which are slower flowering and harvesting. Based on the harvesting time, rice was categorized as aged > 151 days after sowing (DAS); medium age (125-150) DAS; early age 105 – 124 DAS; very early age 90 90-104 DAS; and ultra-early < 90 DAS (Indonesian Center for Rice Research 2016). Based on the age group categories, the 12 rice genotypes studied were categorized as early maturity, which ranged from 106.60 to115.93 days.

Observations on panicle length for the 12 rice genotypes (Table 2) showed variation/differences. The F4 line has a longer panicle length than the other genotypes, while the B4, H1, and H4 lines are three genotypes with shorter panicle lengths. The range of panicle length was 23.68 cm-29.90 cm and classified as the medium panicle length category (Diptaningsari 2013).

Rice plant panicles support the grain which is a sink that needs to be filled with photosynthate from various sources in the plant. Panicle achieves high yield when the number of grains per m^2 is high, the percentage of filled grains is high, and the weight of 1000 filled grains is high. There are two genotypes that have the character of producing a higher total number of grain per panicle and filled grains of each panicle, namely the B3 and F4 lines. Although the length of the panicle is not too long in B3 line, it has capability to produce the highest number of total grain per panicle. This is the advantage of the B3 line because the location of the seeds or grain in the panicles is very tight, while other lines and varieties are rather rare.

Table 2. Yield characteristics and components of 12 rice genotypes observed in this study

Genotype	Flowering time (days)	Harvest time (days)	Panicle length (cm)	Filled grain panicle^{-1} (grains)	Empty grain panicle^{-1} (grains)	Total grain panicle^{-1} (grains)
B2(line)	62.60 fgh	106.60 d	25,59 de	86.64 e	64.98 a	147.02 cd
B3 (line)	69.00 ab	115.93 a	26,31 cd	185.49 a	30.38 ab	209.55 a
B4 (line)	62.93 efgh	107.33 d	23,68 g	136.28 cd	38.63 ab	175.03 bc
B7 (line)	64.00 def	113.00 b	26,23 d	145.03 bcd	21.17 b	166.28 bcd
F2 (line)	65.67 c	110.53 c	27,01 c	119.31 d	30.03 ab	148.12 cd
F3 (line)	64.20 de	106.47 d	24,86 ef	140.13 bcd	23.24 b	162.97 bcd
F4 (line)	70.20 a	115.67 a	29,90 a	171.47 ab	45.64 ab	218.29 a
H1 (line)	62.53 h	107.53 d	23,68 g	126.77 d	31.92 ab	158.27 bcde
H4 (line)	64.00 def	107.00 d	24,44 fg	143.00 bcd	11.60 b	150.91 cde
L2 (line)	68.67 b	115.33 a	28,60 b	137.42 cd	24.78 b	163.31 bcde
Var. IR-64	60.73 i	106.87 d	25,99 d	116.39 de	32.24 ab	139.36 d
Var. Ciherang	64.47 cd	111.40 c	25,19 ef	160.16 abc	18.54 b	176.44 b
BNT	1.45	1.23	0,76	32.38	38.82	24.79

Note: The numbers followed by the same letter in the same column are not significantly different according to the 5% LSD test

Grain quality is one of the selection parameters in rice plant breeding. The number of filled grains per panicle determines plant productivity. If the panicles produce a lot of dense grains, the productivity of rice plants is high. A large number of filled grains in each panicle and the small number of empty grains will determine the high quality of the plant (Mulyaningsih et al. 2016).

The grain size of the 12 genotypes studied varied in length, width and thickness (Table 3). The B3 line is one of the new rice lines which has the shortest grain length character of 8.30 mm (classified as the medium-grain length category), but it has the widest grain width character, while the other nine lines are ranging from 9.04-10.31 mm and including as the long grain category. Other lines, such as B2, B4, B7, F2, F3, F4, H1, H4, L2, and two varieties IR 64 and Ciherang, have a long grain length with a narrower grain. IR 64 is the smallest (narrow) grain rice that has only 2.55 mm width.

The weight of 1000 filled grains of the 12 rice genotypes tested was different (Table 3). The F4 line has the weighest 1000 filled grains, i.e., 33.40 g compared to other genotypes. The F3, H4, and Ciherang varieties are three genotypes that have lower 1000 grains weight of filled grain. The weight of the 12 rice genotypes tested was ranging from 26.79 to 33.40 g. The 1000 grains weight of most paddy fields is about 25 g.. The weight of 1,000 filled grains is more dominated by plant genetic factors (Kartina et al. 2017). The yield components do not work independently, in general, they are interrelated with each other which ultimately produces the grain. Most characters of yield components are inherited and some of them are not (Hasanuzzaman et al. 2010).

Grain shape characters

Qualitatively, the grain characters of the 12 rice genotypes studied (10 lines and 2 varieties) were observed and they had different characters (Figure 1). The three genotypes such as B2, F4, and H4 strains have hairy or tail

tips, in which the F4 line at the end of the tail is longer than the B2, and H4 lines. Other genotypes are hairless (Figure 1).

Thus, the 12 rice genotypes tested are grouped into two characters, namely the hairy and hairless rice. The hairy rice is included in the *Javanica* cultivar group, while the hairless rice are included in the *Indica* cultivar group.

Rice shape characters

The grain was then peeled off and the husk was removed to becomes cracked rice (Figure 2) and then the length, width and length/width ratio were measured. The measurements and characterization were carried out according to the Ministry of Environment and Forests Government of India (2011).

The results of characterization, of the 12 rice genotypes tested, there were two characters of rice shape, i.e., medium and (lean/slender character. Four genotypes (B2, B3, F2, and H1) lines are classified as medium rice shape which has a length/width ratio between 2.4-3.0 mm. The other eight genotypes, i.e., B4, B7, F3, F4, H4, L2, IR64, and Ciherang, are grouped into slender grain shape characters because they have a length/width ratio> 3.0 mm) (Table 4).

Genotypic diversity coefficient (GDC), phenotypic diversity coefficient (PDC), and heritability

The genetic variability criterion is determined by comparing genetic variability with its standard deviation. The observed variable has a wide genetic variability value if the value of genetic variability is equal to or greater than twice the standard deviation of genetic variance ($\sigma^2g > 2.\text{Sd } \sigma^2g$) and the phenotypic variability is referred to as broad genetic variability if the value of the phenotypic variance is equal to or greater than twice the standard deviation of the variance ($\sigma^2f > 2.\text{Sd } \sigma^2f$) (Qosim at al. 2013).

Table 3. Characteristics of grain size, weight of 1000 filled grains, and yield potential of 12 rice genotypes

Genotype	Grain length (mm)	Grain width (mm)	Grain thickness (mm)	Weight of 1000 grains of filled grain (g)	Grain yield per hecta (ton)
B2(line)	10.05 abc	3.13 bc	2.10 a	31,56 b	11.56 ab
B3 (line)	8.30 f	3.37 a	2.05 abc	30,10 c	12.00 a
B4 (line)	10.00 bcd	2.86 d	2.06 abc	28,88 cdef	10.19 cde
B7 (line)	9.96 bcd	2.76 de	2.03 abc	28,57 def	10.81 bc
F2 (line)	9.01 e	3.05 c	2.06 abc	28,33 defg	7.86 f
F3 (line)	9.70 cd	2.77 de	1.98 c	28,09 fgh	10.44 cd
F4 (line)	10.31 ab	2.77 b	2.04 abc	33,40 a	11.72 ab
H1 (line)	9.04 e	3.05 c	2.08 ab	29,89 cd	7.71 f
H4 (line)	9.64 d	2.79 de	2.01 bc	27,13 gh	9.66 de
L2 (line)	10.41 a	2.84 de	2.07 abc	29,53 cde	10.70 bcd
Var. IR-64	9.64 ab	2.55 f	2.06 abc	26.79 h	8.03 f
Var. Ciherang	9.79 cd	2.74 e	2.05 abc	28.49 defg	9.26 e
LSD	0.40	0.12	0.09	1.41	1.11

Note: The numbers followed by the same letter in the same column are not significantly different according to the 5% LSD test
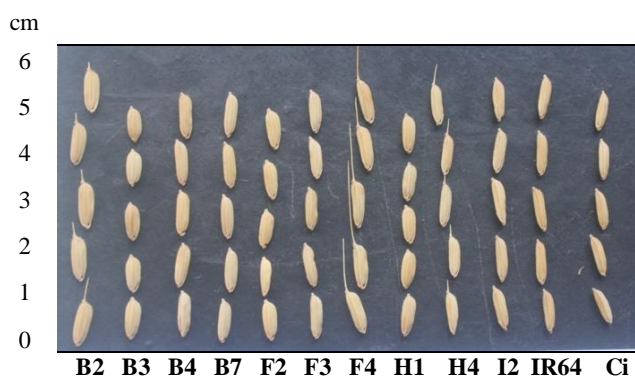
Figure 1. Grain characteristics of 12 rice genotypes. Ci: Ciherang
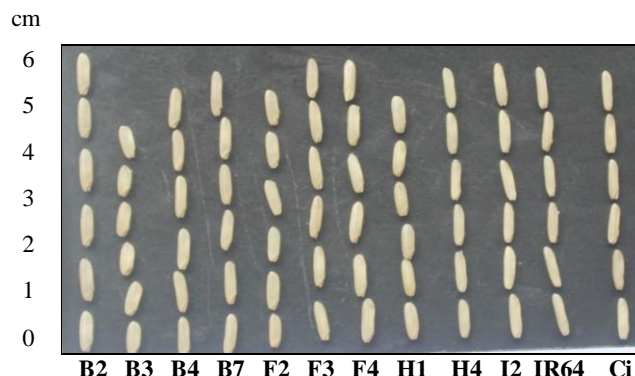
Figure 2. Rice shape characters of 12 rice genotypes. Ci: Ciherang

Table 4. Size and shape characters of 12 genotypes of rice

Genotype	Rice length (mm)	Rice width (mm)	length/width ratio (mm)	Character of rice shape
B2(line)	7.52	2.55	2.97	Medium
B3 (line)	6.43	2.78	2,31	Medium
B4 (line)	7.38	2.36	3.12	Slim
B7 (line)	7.45	2.30	3.24	Slim
F2 (line)	6.24	2.45	2.55	Medium
F3 (line)	7.63	2.12	3.60	Slim
F4 (line)	7.51	2.49	3.02	Slim
H1 (line)	6.43	2.56	2.51	Medium
H4 (line)	7.12	2.19	3.25	Slim
L2 (line)	7.97	2.32	3.44	Slim
Var. IR-64	7.35	1.96	3.75	Slim
Var. Ciherang	7.30	2.09	3.49	Slim

Note: Slim shape (length/width ratio > 3mm); Medium form (length/width ratio 2.4-3.0) (Ministry of Environment and Forests Government of India, 2011)

The results of statistical analysis, genetic and phenotypic variability for the characters of maximum plant height, number of tillers, flag leaf length, flag leaf angle, flowering time, harvesting time, panicle length, filled grain per panicle, total grain per panicle, grain length, grain width, weight 1000 grains of filled grain, and grain yield per hectare have wide genetic and phenotypic variability values. This can be seen from the magnitude of the value of genetic variance and phenotype variety which is greater than twice the standard deviation of genetic variance and phenotypic variety (Table 5). This shows that the agronomic characters between genotypes are very diverse. Genetic and phenotypic diversity is one of the factors that greatly influence the success of plant breeding efforts. The presence of genetic and phenotypic diversity in a population means that there are variations in genotype and phenotype values between individuals in the population (Sofiari et al. 2009). The wide diversity of characters will provide good opportunities in the selection process because the process of improving plant character is as expected.

Table 5. Values of environmental variety, genetic variety, phenotypic variety, heritability, GDC and PDC 12 rice genotypes

Observation variable	$\sigma^2 e$	$\sigma^2 g$	$\sigma^2 p$	2x sd $\sigma^2 g$	GDC	PDC	Heritability $(h^2)_{BS}$
Plant height	6.91	217.89	220.20	172.74	12.53	12.59	0.99
Maximum number of tillers	8.25	13.21	15.97	12.63	12.11	13.31	0.47
Number of productive tillers	7.98	2.25	4.91	4.15	5.99	8.84	0.46
Flag leaf width	0.02	0.01	0.02	0.02	6.19	7.47	0.69
Flag leaf length	3.98	16.06	17.39	13.66	12.20	12.69	0.92
Flag leaf angle	8.37	11.53	14.31	11.34	19.92	22.20	0.81
Flowering time	0.73	8.31	8.55	6.71	4.44	4.51	0.97
Harvest time	0.52	14.55	14.72	11.55	3.46	3.48	0.99
Panicle long	0,20	3,43	3,50	2,74	7,14	7,21	0,98
Grain fill each panicle	365.71	561.40	683.30	540.63	17.05	18.80	0.82
Empty grain every panicle	525.68	20.96	196.19	184.18	14.72	45.04	0.11
Total grain of each panicle	214.37	516.58	588.03	463.13	13.53	14.44	0.88
Grain length	0.06	0.37	0.39	0.31	6.27	6.43	0.95
Grain width	0.005	0.06	0.06	0.04	8.06	8.17	0.97
Grain thickness	0.003	0.00	0.001	0.001	0.47	1.50	0.10
The weight of 1000 grains of filled grain	0.69	3.19	3.42	2.69	6.11	6.33	0.93
Grain yield per hectare	0.43	2.14	2.29	1.80	14.65	15.13	0.94

Genotypic Diversity Coefficient (GDC) and Phenotypic Diversity Coefficient (PDC) values for plant height, flag leaf length, flag leaf angle, flowering time, harvesting time, panicle length, number of filled grains per panicle, total number of grain per panicle, grain length, grain width, weight of 1000 filled grains, and grain yield per hectare are almost equal (coincide), while the characters of the maximum tillers, the number of productive tillers, the number of empty grains per panicle, and the grain thickness, have a PDC value that is higher than the value GDC (Table 5).

The criteria for the value of the GDC and PDC scores are low (0-25%), rather low (25-50%), quite high (50-75%), high (75-100%) (Moedjiono and Mejaya 1994). The GDC and PDC scores of the 15 characters observed are low. This gives an indication that the characters that appear from each genotype show uniform and stable conditions. The low values of the Genotypic Diversity Coefficient (GDC) and the Phenotypic Diversity Coefficient (PDC) for the character of plant height, flag leaf length, flag leaf angle, flowering time, harvesting time, panicle length, number of filled grains per panicle, total number of grain per panicle, length Grain, grain width, weight of 1000 filled grains, and grain yield per hectare which are almost equal or coincide, indicate that the diversity of a character is more due to genetic factors (Hapsari et al. 2010). Thus, if the 12 rice genotypes tested were planted in another place with a different environment, the possibility of character changes was very low.

According to Jalata et al. (2011), the PDC value that is higher than the GDC indicates that the selection can be made based on the diversity of these characters. PDC which is higher than GDC also shows that the diversity seen in these characters is more influenced by environmental factors than genotypic factors. The GDC value which is close to or almost the same as the PDC indicates that environmental factors have little effect on the diversity that occurs in the characters tested, so that selection can be effectively carried out on these characters based on their performance (Yasinda et al 2015).

Heritability values for the characters of plant height, flag leaf width, flag leaf length, flag leaf angle, flowering time, harvesting time, panicle length, filled grain per panicle, total grain per panicle, grain length, grain width, weight of 1000 filled grains, and grain yield per hectare showed broad sense heritability values (h^2_{BS}) ranging from 0.69 to 0.99 (Table 5). This shows that all the characters observed have high heritability values. The characters of the maximum number of tillers and the number of productive tillers produced by the 12 genotypes had a heritability value between 4.6-4.7 which was in the moderate category, and the character of the number of empty grains per panicle and grain thickness character had low heritability, i.e., 0.10-0.11.

Heritability is a genetic parameter used to measure the level of inheritance of a character in a plant population or an estimate that measures the extent to which the variability of a character's appearance in the population is caused by the role of genetic factors. If a character has a high heritability value, the appearance of that character is more controlled by genetic factors, so that the character can be referred to as a character that is easily inherited. Genetic factors play a more important role in controlling a trait than environmental factors (Barmawi 2013; Hermanto et al. 2017). In order to release a line as a new high-yielding variety, one of the conditions that must be fulfilled by the line concerned is its population in a uniform line.

the Politeknik Negeri Lampung Research and Community Service Unit (RCSU) that helped to carry out this research.

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