

# Heritability and path coefficient analysis for important characters of yield component related to grain yield in M4 red rice mutant

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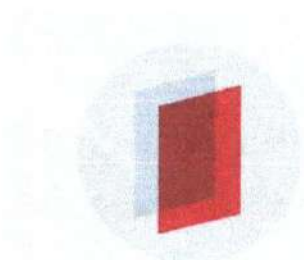
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## Heritability and path coefficient analysis for important characters of yield component related to grain yield in M4 red rice mutant

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**Abstract.** Formation of new red rice cultivar through mutation breeding is reported in this study. Mutant lines of fourth generation have been planted and analysed. The purpose of the experiment were to determine the value of heritability and the direct and indirect effects of the characters of yield components on the grain. The experiments were prepared based on a randomized block design. Seven red rice mutant lines of fourth generation and one non-mutant origin as control were used as treatments. Data from yield components used were the number of productive tillers per hill, the number of grains per panicle, the panicle density, and grain weight per hill. Results showed that the characters of the productive tillers number per hill, the number of grains per panicle, the panicle density, and the grain weight per hill gave all high heritability values, *i.e.* 0.83, 0.83, 0.62, and 0.52, respectively. Based on the path coefficient analysis against these characters, that there were only two very important character and effective for screening in increasing grain yield per hectare of red rice cultivars, *i.e.*: the character of productive tillers number per hill and grain weight per hill.

### 1. Introduction

Rice (*Oryza sativa* L.) is one of the most important staple food crops, as a source of food for more than half of the world's population. It is estimated that the world should produce 60% more rice by 2030 than it produced in 1995 [1]. In Indonesia, rice is the main food for most Indonesians. The average rice consumption in rural households were higher than the average consumption of rice in urban households. For rural households, there were a tendency that higher incomes, spending on rice consumption were greater. The opposite occurred in urban households [2].

South Sulawesi Province is one of the provinces in Indonesia known as the national rice barn. Rice cultivation has become part of the life and cultural tradition of the community for generations. In some districts in the province of South Sulawesi is still cultivated several types of local rice. One of the local rice species found and still cultivated in some districts is red rice. According to Saxena [3], the red rice has a red pigment, ranging from light to dark red in the pericarp and testa or husk. The portion is



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recognized to contain phenols and anthocyanins and has antioxidant. The results of Muntana and Prasong [4] found that the antioxidant activity of all rice bran extracts from white rice, brown rice and black rice Thailand showed high antioxidant efficiency in the following order: brown rice > black rice > white rice.

Now, red rice becoming more popular and demand for that rice is expected to increase in the future along with the increasing level of people's welfare and awareness of the importance of healthy food. According to Rohman *et al.* [5], public awareness to consume brown rice is generally still associated with diabetes (diabetes mellitus) because of its high glycemic index. Based on the function of red rice which is very important for health, efforts are needed to promote and expand its cultivation area. However, on the other hand, there is still a weakness of the red rice, which is long-lived and the production is still low compared to the national superior rice production, resulting in the interest of farmers to cultivate it is still low [6]. The establishment of a new red rice cultivars, which is short-live and high-yielding through mutation breeding activity has been done and in this research has been done planting of mutant lines of fourth generation (M4).

Grain yield is the main criterion always used by rice plant breeders in producing new varieties with high yield potential. However, when selecting for very varied characters such as grain yields, the direct selection is not always efficient because the grain yield is a polygenic character that is strongly influenced by the environment. In the grain yield improvement program, information about the interrelationships between characters, the direct and indirect effects contributed by each character to the grain yield will be an additional advantage in assisting the selection process. Path coefficient analysis can be used to determine the direct and indirect effects of the those characters to the grain yield, thus providing a clear understanding of the relationship of the characters of grain yield components with the grain yield. Ultimately, such an analysis can help breeders design a selection strategy to improve grain yield. The aim of this research is to determine heritability and path coefficient values of the important characters of yield components to the grain yield per hectare and to formulate selection criteria of red rice cultivar with high grain yield per hectare.

## 2. Materials and method

The experiment was conducted in irrigated rice field located in Aengae Village, Bantimuring District, Maros Regency, South Sulawesi Province at altitude  $\pm 25$  m above sea level with Alluvial soil type. The study took place from May to September 2016. The experiment was prepared based on a Randomized Block Design with three replications. The treatments were seven mutant red rice mutant lines at fourth generation and one origin (not mutant) line as a control. Seeds of all lines used are first seeded.

Soil preparation is done by hand tractor until sludge structure is formed. Layout of experimental plots measuring 3 m x 2 m was done using a hoe and completed before the seedlings ready for transplanted. After the seedlings are 15 days old, the seedlings are transplanted on the prepared fields. Planting is done manually. Spacing used is 25 cm x 25 cm with one seedling per planting hole. The condition of the land at the time of planting is muddy. Weeding done twice. The first weeding is done after the plants are 15 days after transplanting and the second weeding is done after the plants are 30 days old. Fertilization is done three times. The first fertilization with 1/3 dose Urea (100 kg/ha), SP-36 (200 kg/ha), and KCl (100 kg/ha) is done at age 7 days after planting. The second fertilization using 1/3 dose of Urea (100 kg/ha) was done at age 45 days after planting and third fertilization using 1/3 dose of Urea (100 kg/ha) done at flowering age 50%. Pest control using Furadan 3 G according to recommended dosage, done before planting by way of sprinkling on the surface of the soil. Harvest is done after 2/3 part of the panicle has yellowed. Harvesting is done manually.

Observations were made on each of 12 plant samples from all treatments and replications. The characters of yield components observed were number of productive tillers per hill, number of grains per panicle, panicle density (grains cm<sup>-3</sup>), grain weight per hill (g), and grain yield per hectare (t). The panicle density data was obtained from the division between the number of grains per panicle with panicle length, while the grain yield data per hectare was obtained from converting grain yield (g) per

plot at 12% moisture grain of all treatments and replications. Data were tabulated using MS Excel 2007. The analysis of variance, correlation coefficient and path coefficient analysis were performed using SPSS version 22 program. The analysis of variance was used to calculate heritability value.

### 3. Results and discussion

The results from analysis of variance on the characters of yield components and grain yield per hectare are presented in table 1. In table 1, it shows that there are significantly different between red rice mutant lines in terms of the characters of yield components, i.e. the number of productive tillers per hill, the number of grains per panicle, the panicle density, and grain weight per hill. The existence of differences between mutant lines, illustrates the great diversity among the mutant lines, so that selection activities can be performed to determine the superior mutant lines based on those characters.

Based on the analysis of variance can be determined the genotypic variance ( $V_g$ ), phenotypic variance ( $V_p$ ), genotypic coefficient variation (GCV), phenotypic coefficient variation (PCV) and heritability value ( $h^2$ ) presented in table 2. Phenotypic variance ( $V_p$ ) separated into two distinct components, namely the genotypic variance ( $V_g$ ) and the variance of environments ( $V_e$ ) used to clarify the understanding of the variation patterns of the observed characters. The values of the phenotypic coefficient variation (PCV) were slightly higher than the genotypic coefficient variation (GCV) for all observed characters, indicating an environmental influence to some degree of phenotypic expression of the characters. The coefficient variation of phenotypic values (PCV) obtained for all characters ranged from 21.02% to 54.86%, whereas the coefficient variation of genotypic values (GCV) for all characters ranged from 16.50% to 51.50%. According to Akinwale *et al.* [7], Konate *et al.* [8] and Sumanth *et al.* [9], the values of the phenotypic coefficient variation (PCV) and the genotypic coefficient variation (GCV) greater than 20% are categorized as high and those characters can be used as selection criteria in the improvement of mutant lines.

**Table 1.** Analysis of variance of the yield components characters and grain yield per hectare from 8 red rice mutant lines at fourth generation (M4).

Source of variation	Degree of freedom	Characters				
		Number of productive tillers per hill	Number of grains per panicle	Panicle density	Grain weight per hill	Grain yield per hectare
Replications	2	3,617ns	227,391ns	4,059*	1,602ns	0,681ns
Mutant lines	7	82,815**	3212,531**	3,119*	4,006*	3,131**
Error	14	5,401	205,573	0,536	0,956	0,135
CV (%)		14,02	9,91	13,02	19,50	18,90

ns= not significant, \*= significant at 5% level; \*\*= significant at 1% level

The values of heritability are the ratio between the genotypic variance value to the phenotypic variance value can help to determine whether the variation of all observed characters are more controlled by genetic factors or more controlled by environmental factors. The heritability values obtained from the observed characters, i.e. the number of productive tillers per hill, the number of grains per panicle, the panicle density, and the grain weight per hill are all 0.83, 0.83, 0.62, and 0.52. Those means indicate that all of the observed characters are greater controlled by genetic factors than environmental factors and the selection made of these characters can be achieved through the phenotypic of those characters. This is in line with the opinion of Akinwale *et al.* [7], Naseem *et al.* [10] and Konate *et al.* [8] that characters with high heritability values are more controlled by genetic factors and those characters can be used as selection criteria for selecting superior lines based on the phenotypic characters.

**Table 2.** Genotypic variance ( $V_g$ ), phenotypic variance ( $V_p$ ), genotypic coefficient variation (GCV), phenotypic coefficient variation (PCV) and heritability values ( $h^2$ ) of the yield components characters and grain yield per hectares from 8 red rice mutant lines at fourth generation (M4)

Characters	Minimum	Average	Maximum	$V_g$	$V_p$	GCV (%)	PCV (%)	$h^2$
X1	8,08	16,57	23,06	25,80	31,21	30,65	33,71	0,83
X2	115,22	144,61	214,14	1002,32	1207,89	21,89	24,03	0,83
X3	4,53	5,62	7,98	0,86	1,40	16,50	21,02	0,62
X4	14,54	28,17	41,46	1,02	1,97	28,94	48,96	0,52
Y	0,44	1,94	3,41	1,00	1,13	51,50	54,86	0,88

X1= Number of productive tillers per hill; X2= Number of grains per panicle; X3= Panicle density ( $\text{gram.cm}^{-3}$ ); X4= Grain weight per hill (g); and Y= Grain yield per hectare (t).

The result of path analysis is presented in Table 3, showed that the number of productive tillers per hill, the number of grains per panicle, and the grain weight per hill were the characters that have significant positive direct effects on the grain yield per hectare with the values of direct effects (C) were 0.729\*, 0.916\*, and 0.637\* respectively, whereas the panicle density was a character that has a non significant negative direct effect on the grain yield per hectare with the value of direct effect - 0.497<sup>ns</sup> on the grain yield per hectare. These means that, increasing of the characters that have significant positive direct effects will increase the grain yield per hectare, whereas for the character that have a negative direct effect will decrease the grain yield per hectare. Similar result were associated with a significant positive direct effect of the number of productive tillers per hill on the grain yield per hectare reported by Badri *et al.* [11], whereas the results of other studies related to the significant positive direct effects of the number of productive tillers per plant on the grain yield per plant are reported by Vanisree *et al.* [12], Ashok *et al.* [13] and Kalyan *et al.* [14]. The results of the research showed that there were two important characters of yield components were considered to be effective as selection criteria in increasing grain yield per hectare at fourth generation (M4) of red rice mutant lines, i.e. the number of productive tillers per hill and the grain weight per hill.

**Table 3.** Direct, indirect and total effects of the characters of yield components to the grain yield per hectare

Characters of yield components	Direct effects	Indirect effects through				Total effects
		X1	X2	X3	X4	
X1	0,729*	-	-0,594	0,214	0,438	0,786**
X2	0,916*	-0,473	-	-0,375	-0,261	-0,193 <sup>ns</sup>
X3	-0,497 <sup>ns</sup>	-0,314	0,691	-	-0,032	-0,152 <sup>ns</sup>
X4	0,637*	0,501	-0,376	0,025	-	0,787**

X1 = Number of productive tillers per hill; X2 = Number of grains per panicle; X3 = Panicle density; X4 = Grain weight per hill; ns = not significant; \* = significant at level 5%.

In this study, the number of grains per panicle has a significant positive direct effect on the grain yield per hectare, but because the indirect effects were all negative and cause the total effect becomes negative, causing the character cannot be used as selection criteria to choose the superior red rice mutant lines at fourth generation (M4) with high grain yield per hectare. The panicle density is a representation of the ratio between the number of grains per panicle to the length of panicle has a non significant negative direct effect on the grain yield per hectare, so it also cannot be used as selection criteria to choose the superior red rice mutant lines with high grain yield per hectare. The magnitude of the panicle density does not necessarily represent a large number of grains and the long panicle length, because the same value of the panicle density can be obtained from less number of grains with shorter panicles.

#### 4. Conclusion

The heritability values of the yield components characters observed, i.e. the number of productive tillers per hill, the number of grains per panicle, the panicle density, and the grain weight per hill were all high with the heritability values are 0.83, 0.83, 0.62 and 0.52. Based on the path coefficient analysis toward characters of yield components on the grains yield per hectare obtained three characters which showed direct positive effects to grains yield per hectare, that is the number of productive tillers per hill, the number of grains per panicle and the grain weight per hill with path coefficient values were 0.729, 0.916 and 0.637, respectively, but the number of grains per panicle showed negative effect (-0.497) with grain yield per hectare. This indicates that there are only two very important and effective characters for selection in increasing the grain yield per hectare in red rice cultivar of fourth generations (M4), i.e. the number of productive tillers per hill and the grain weight per hill.

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