Characteristic of panicle in M4 red rice mutants

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Abstract. The need for rice is always increasing every year in line with population growth making rice commodities have a very important role. Red rice which has been known for a long time, needs to be given priority in research to overcome the problem of food and nutrition shortages. Rice panicle, a crucial organ that has economic values, is an important yield component to improve. This study aimed to obtain information on relationship within the panicle characters on rice production. The experiment was conducted within 6 month using 10 red rice mutant lines M4 and 2 non-mutant lines as controls. Data from yield components used were number of grains per panicle, panicle density, percentage of filled grain per panicle, grain length, grain width, and grain thick. Based on the results of the path analysis on these characters, it is known that four characters that have a total positive and significant direct effect on the weight of grain per panicle were the number of grains per panicle, panicle density, panicle length and percentage of filled grain per panicle. Hence, these characters are important and effective to be used as a selection component in increasing grain production in red rice plants. Tests of several M4 generation red rice mutants based on grain characterization show very significant differences in grain length and grain width characters. The longest grain is GK2 strain (10.33 mm) and the widest grain is G9 strain (3.29 mm).

1. Introduction
Rice (Oryza sativa L.) is the main food of most of Indonesia's population [1]. Almost all residents in this country consume rice every day. The need for rice to meet food needs always increases every year in line with population growth. In terms of increasing and strengthening food security in Indonesia, rice commodity has a very important and strategic role [2,3].

Intensification of national superior rice has been done but it has not been able to meet food needs. On the other hand, there are available local rice that has not been used and cultivated intensively. Local rice varieties planted by farmers are varieties that have been planted for decades and are selected by nature. Local rice planting is favoured by farmers because some have good adaptability to the sub-optimal environment including peat land ecology, delicious rice taste, fragrant aroma, proven resistance to pests and good quality rice. New varieties are partly undesirable by farmers because they require intensive maintenance and optimal environment optimal [4,5].
Local rice that is widely known by the community in general is red rice. In addition to containing carbohydrate, fat, protein, fiber and minerals, red rice also contains anthocyanin and is widely consumed as a healthy food [6]. Local red rice generally has the characteristics of a long life, long panicles, little tillers and a fairly high posture [7]. According to Okasa et al. [7], another characteristic of local rice is that it has strong and deep roots but is not responsive to the application of fertilizer, deep age, high stems so that it easily fell and low production. However the quality of rice is comparable to the national rice varieties.

Rice production is determined by one of its main organs, namely rice panicles. Various components of the yield continue to be improved, one of which is an important organ of economic value, namely rice panicle. Lack information on genetic studies and morphology of the local rice panicles encourages in-depth study of morphological characters of the rice panicles to produce varieties with panicle ideotypes that can increase yield potential. Rice panicles consist of complex branches and grains found along branches [9]. The contribution of these two components will determine the yield of rice in addition to the number of productive tillers. The yield on rice plants is determined by the characters associated with the yield components, especially panicle characters [10], hence this research needs to be done to determine the direct effect of panicle characters on production yields.

2. Materials and Methods
This research was carried out in the Paddy Field in Tana Toraja Regency, Gandang Batu Sillanan District, Buntu Limbung Village and continued at the Laboratory of Plant Breeding and Seed Sciences, Faculty of Agriculture, Universitas Hasanuddin. The research took place in December to July 2019. The experiment was arranged based on a Randomized Block Design (RBD) with two replications. The treatments were 10 M4 generation mutant lines and 2 non-mutant lines as controls.

Land management was carried out using a tractor until the land is clean and ready for planting. The seedlings were planted in a 1 m x 1 m nursery bed. After the seeds are 3 weeks old, the seeds were transferred to the prepared land. Planting was conducted manually. The spacing of 30 cm x 30 cm was used with one seed per planting hole. The soil condition at the time of planting was muddy. Weeding was done 2 times at 7 days after planting (DAP) and 15 DAP. Fertilizing was carried out 2 times, namely at 2 weeks after planting (WAP) for the first fertilization and 8 WAP for the second fertilization. Pests control was conducted by spraying the infected plants based on the types of pests that attack. Harvesting was marked if the rice grain has yellowed according to harvest criteria. Harvesting was conducted manually.

Observations were made on each of the 12 samples from each treatment line and control line. Characteristics of yield components observed for panicle characteristics were number of grains per panicle, panicle density, panicle length, percentage of filled grain per panicle, weight of 100 seeds and grain yield per panicle. Panicle density data was obtained from the division between the number of grains per panicle and panicle length. Data were tabulated using MS Excel 2010. Path coefficient analysis was performed using SPSS version 16. Characteristics of yield components observed for grain characteristics were grain length, grain width, and grain color. The observational data obtained were analyzed using analysis of variance and if there was a significant effect on treatment data analysis was continued with the Least Significance Differences (LSD) test.

3. Results and Discussion
3.1. Panicle characteristics
Path analysis is used to determine the direct and indirect effects of characters that contribute to grain yield. The characters tested using cross analysis were the characters that have a significant correlation coefficient value with the grain weight per panicle character [10]. The results of the path analysis of red rice panicle characters are shown in Table 1. The results show that all characters (the number of grains per panicle, panicle density, panicle length, percentage of filled grain per panicle and weight of
100 seeds) had a positive correlation coefficient on production per panicle with values of 0.095, 0.0592, 0.244, 0.249, 0.163, respectively.

| Characters of panicle components | Direct effects | Indirect effects | Total effects |
|----------------------------------|----------------|-----------------|--------------|
| X1                               | 0.095          | -0.182          | -0.112       | -0.484       | 0.501          | 0.0131**       |
| X2                               | 0.592          | 0.572           | 0.928**      | 0.741**      | -0.224         | 0.3591**       |
| X3                               | 0.244          | 0.729           | 0.006        | 0.002        | -0.083         | 0.3744**       |
| X4                               | 0.249          | 0.111           | 0.002        | -0.119       | -0.0030ns      |
| X5                               | 0.163          | 0.097           | 0.483        | 0.714        | -              | 0.3105**       |

X1 = number of grain per panicle, X2 = Density of panicle, X3 = panicle length, X4 =Percentage of grain content per panicle, X5 = Weight of 100 seeds, ** = significant at the 0.01 level, ns = non-significant.

Characters in these conditions have a direct influence that tends to be uniform among characters. Characters with the highest direct effect on grain weight per panicle was the panicle density (0.592). The direct effect is a reflection of the magnitude of the correlation coefficient. Jumin [12] stated that the nature of each genetic and the environment in which the variety grows will affect the grain density of each panicle. Lower grain density can also be caused by non-genetic factors, such as pests and diseases.

The character with the smallest direct effect was found in the number of grains per panicle (0.095). According to Singh and Chaudary [13] significant value of the correlation coefficient between characters show direct influence, then the correlation value shows the actual relationship between the two characters. If the correlation coefficient value is significant while the direct effect is negative or very small, then the indirect effect causes the correlation coefficient value to be significant.

In this study four characters found to have a total positive and significant direct effect on grain weight per panicle, namely the number of grains per panicle, panicle density, panicle length and percentage of filled grain per panicle with a total value of direct influence of 0.0131, 0.3591, 0.3744, and 0.3105, respectively. The character that has the highest total direct influence was the panicle length (0.3744), hence can be used as a selection criterion for selecting superior mutant line of red rice with high grain yield per panicle and only one character has a negative and insignificant total direct effect value to the production of grain per panicle that is the weight of 100 seeds (-0.0030). This is consistent with the opinion of Puji [14] which states that panicle length is a parameter that determines the high and low productivity of a strain / variety and panicle length components are the main supporting factors for yield potential because the longer the panicle the greater the chance of the number of grain in one rice plant.

The diagram shows that the number of grains per panicle, panicle density, panicle length, percentage of filled grains per panicle, and the weight of 100 seeds has a positive correlation coefficient on grain production per panicle ie 0.095, 0.592, 0.244, 0.249, 0.163 (Figure 1).
3.2. Characteristics of grain

The grain characters observed in this study were grain length and grain width (Table 2). Table 2 shows that the average grain length of some mutant rice lines showed significant differences. The longest grain length was obtained in the GK2 strain (10.33 mm), while the shortest grain length was obtained in the G8 strain (7.68 mm). The table also shows that the grain width in some mutant rice lines shows very significant differences. The widest grain width was obtained in the G9 strain (3.29 mm), while the narrowest grain width was obtained in the GK2 strain (2.32 mm).

| Lines | Grain Length | Grain Width |
|-------|--------------|-------------|
| GK1   | 7.77 cd      | 2.64 g      |
| GK2   | 10.33 a      | 2.32 h      |
| G1    | 7.87 bcd     | 2.90 e      |
| G2    | 8.19 bcd     | 2.94 d      |
| G3    | 8.27 bc      | 2.83 f      |
| G4    | 8.16 bcd     | 2.90 e      |
| G5    | 8.36 b       | 2.99 bc     |
| G6    | 8.07 bcd     | 2.95 cd     |
| G7    | 8.34 b       | 3.01 b      |
| G8    | 7.68 d       | 2.86 ef     |
| G9    | 7.90 bcd     | 3.29 a      |
| G10   | 7.97 bcd     | 2.78 g      |

Values in each average column followed by different letters for each treatment showed significant differences according to LSD 5%.

The length and width of the grain were varied significantly between the lines tested. The difference is caused by genetic differences that cause each cultivar to have special characteristics and that are different from each other. This is consistent with the statement of Fitri [15] which stated that the genetic makeup is one of the factors causing diversity in plant appearance. Conservation effort and breeding programs are among the urgent activities needed to prevent extinction [16-18]. Genetic characteristics of the species and population is needed as basic consideration in formulating appropriate conservation strategy for the species [19]. The genetic program will be expressed on a
variety of plant traits which include the shape and function of plants that produce different plant growth diversity.

4. Conclusions
   a) Based on the results of this path analysis there are four characters that have a total positive and significant direct effect on the weight of grain per panicle, namely the number of grains per panicle, panicle density, panicle length and percentage of filled grain per panicle with the total value of each direct effect 0.0131, 0.3591, 0.3744, and 0.3105, so these characters are important and effective to be used as a selection component in increasing grain production in red rice plants.
   b) Tests of several M4 generation red rice mutants based on grain characterization showed very significant differences in grain length and grain width characters. Where the one who has the longest grain is the GK2 strain (10.33 mm) and the one who has the widest grain is the G9 strain (3.29 mm) which can support grain production in red rice plants.

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