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Morphological Characters of Several Black and Aromatic Rice (*Oryza sativa* L.) in Indonesia

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Abstract. Indonesia has a high level of rice germplasm, both black rice and aromatic rice. To produce a new variety that is superior in terms of production and benefits, one of the information needed is agronomic and morphological character knowledge, which is very necessary to determine the kinship between varieties used as a basis for determining the parent in plant breeding. This research aimed to find out the morphological character of black rice and aromatic rice. The research findings discussed morphological characteristics using parameters including plant height (cm), number of productive tillers, flowering period (HSS), harvesting period (HSS), weight of 100 grains (grams), grain shape, grain colour, and rice colour where each of these characters was used as a distinctive feature in each variety for a cluster analysis. The grouping results showed that at the similarity level of 37.8%, 3 groups of black and aromatic rice varieties were obtained.

INTRODUCTION

Rice is one of the staple food sources of 62.8% of the world's population and is the main food of 29.3% of the Asian population [1]. It is one of the strategic agricultural commodities to be continuously developed and increased for both its quality and quantity. The effort of assembling rice varieties is one way to increase rice production. The potential for the germplasm abundance available in Indonesia, both black and aromatic rice, is one of the opportunities for the availability of one of the basic ingredients for assembling superior varieties [2]. Due to the increasing number of people and their prosperity, quality rice products are increasingly in demand. It is also seen in the increased value of food pattern expectations or consumption food quality indicators, as seen in 2015 to 2017 of 84.1, 86.2, and 88.4 [3], respectively. The important components taken into account from rice, in addition to high production, are the quality and benefits. As we know that black rice has a high anthocyanin content benefit that can be an antidote to free radicals or a high anti-oxidant and is useful for several chronic diabetes and cancer treatment [4]. The superiority of aromatic rice is its aroma that is better than regular rice due to its 2 acetyl 1- Pyrroline (2AP) volatile compounds [5]. Therefore, it is important to note that the observation of the morphological characteristics of black and aromatic rice can be used as basic information for rice breeding preparation.

Morphological observation is the taxonomy-based observation to find out the plant properties. Furthermore, the use of morphological characters is an easy and fast method, which can be used directly on plant populations. Then, the data obtained can be used as a plant description, plant properties improvement, and plant development plan [6]. Morphological observations commonly used as rice differentiators are plant height, number of productive tillers, leaf colour, stem colour, flowering character, and number of grains per 1000 grains [7]. The results of the morphological observations show the similarities and differences of each of these varieties as a reference to determine the relationship of kinship between the rice varieties observed.

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This research aimed to find out the morphological characters of black and aromatic rice and their kinship based on their similarities and differences in morphology. Thus, they can play a role in the new variety development in plant breeding.

EXPERIMENTAL DETAILS

Observation Samples

The research materials were 25 rice varieties consisting of 10 black rice varieties (Black Purwokerto (V1), Black Banjarnegara (V2), Black Purbalingga (V3), Black Bantul (V4), Black Paddy (V5), Black Melik (V6), Here Lahok (V7), Black Lumajang (V8), Black Blitar (V9) Black Toraja (V10)), 14 aromatic rice varieties (Mentik Wangi Pakuncen (V21), Mentik Wangi Banjarnegara (V12), Mapan 05 Banjarnegara (V20), White Radah (V15), Situ Patenggang (V19), PPM (V13), Batang Gadis (V24), Milky Rice (V16), Celebes (V17), Rojo Lele Delanggu (V11), Pendok (V18), Gilirang (V22), Kurik Kusut (V23), Genjah Arum (V25), and 1 non-aromatic rice variety Situ Bagendit (V14).

Observation Variables

The research procedures start with planting, fertilizing, maintaining (weeding, irrigation, and pest control), and harvesting. The observation variables observed were plant height (cm), number of productive tillers (stems), the weight of 1000 grains (grams), grain colour, rice colours, flowering age, and harvesting.

Statistical Analysis

This research used a Randomized Block Design (RBD) with 3 repetitions. The phenotypic data from 25 varieties arranged in an average form was analysed using ANOVA (Analysis of Variance) with the SPSS program. The observation data were then valued in the form of multistate data, the number of which varies between characters. The data were standardized with the STAND program in the NTSYS-pc program, which is the observation value of each character minus the average value of the character divided by the standard deviation [8]. The data obtained were then analysed with the SIMMINT (Similarity for Interval Data) function based on the DIST (taxonomic distance, hereinafter called the distance coefficient) coefficient in the NTSYS-pc program. The analysis results were represented in the form of a dendrogram.

RESULTS AND DISCUSSION

Plant Height

The plant height parameter is one aspect that can be used to determine the morphological property characteristics of rice. Rice plants belong to determinate plants. Stages of plant height measurements were carried out once as each variety has entered the generative phase. Based on the characterisation and evaluation of rice plant manual from IRRI [9], plant postures based on its height can be classified into short (<90 cm), medium (90-125 cm), and high (> 125cm) plants. The observation results show various values among 25 rice varieties. The lowest value is shown in the Situ Bagendit variety (V14) with a high average of 61.33 cm and the highest value is shown in Pendok variety (V18) with an average plant height of 160.57 cm.

Figure 1 shows 25 black and aromatic rice varieties can be classified into high plant postures including Pendok V18, PPM V13, and Genjah Arum V25. Medium plants include Rojolele Delanggu V11, White Radah V15, Gilirang V22, Mapan 05 V20, and other varieties classified as short plants. According to Bannet *et al*. [10], plant height is one of the criteria for the rice plant selection, but the high rice plant posture does not necessarily guarantee the production level. High rice plants tend to fall easily, while short plants tend to be difficult to harvest. High plant postures enable the occurrence of plant lodging which can cause inhibition of nutrients, minerals, and photosynthate as a result of damage to xylem and phloem vessels so that it is necessary to select the right posture of rice plants for the assembly of black and aromatic rice.

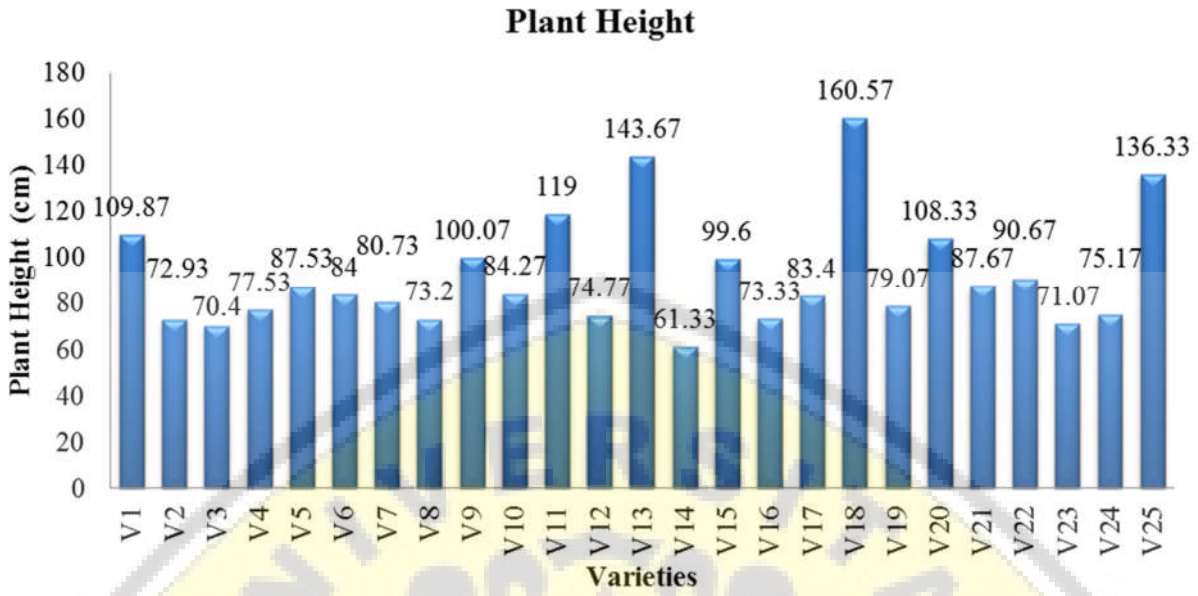

FIGURE 1. Plant height average value from 25 black and aromatic rice varieties

Number of Productive Tillers

According to IRRI [9], the tiller growth ability can be classified into several types including very high (>25 tillers per plant), high (20-25 tillers per plant), medium (10-19 tillers per plant), low (5-9 tillers per plant), and very low (<5 tillers per plant). This classification includes the entire tillers produced by plants. This research only calculates the number of tillers that produce productive panicles. The variable of the number of productive tillers includes the plant's ability to generate productive tillers. The productive tiller observation aimed to determine the productive ability potential of a variety by calculating the total tillers that produce panicles/rice grains.

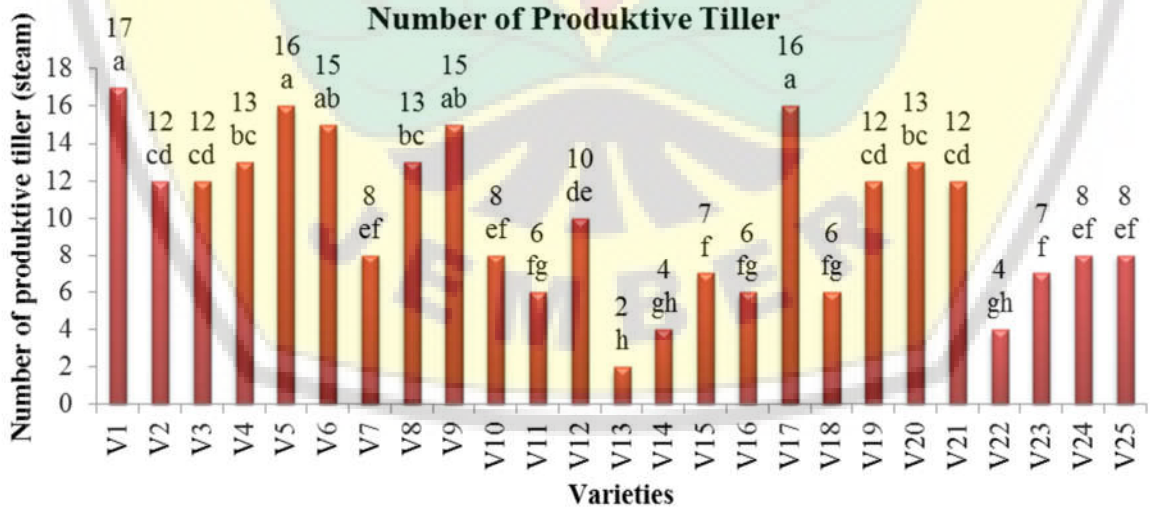

FIGURE 2. The average number of productive tillers of 25 black and aromatic rice varieties

Based on Fig. 2, it is known that the number of productive tillers of black and aromatic rice varieties above has a mixed result. The highest average value is shown in the Black Purwokerto variety (V1) and the lowest average value

is shown in the PPM variety (V13). Hairmansis [11] explained that the higher the plants are a relatively smaller number of tillers they tend to have. The number of productive tillers and plant height in the PPM variety (V13), which has a height of 143.67 cm, has an average value of the low number of 2 tillers. Besides, Pendok variety (V18), which has a height of up to 160.57 cm, also has an average number of 6 tillers. Short plants that have a large number of tillers are predicted to produce more optimal grain production because they produce more photosynthate. The metabolic process for growth is less because they maximize panicle formation rather than increasing height.

Flowering and Harvesting Periods

The flowering age was carried out to determine the length of grain filling until it reaches full maturity. IRRI [9] classifies the flowering period into the ultra-early period (<65 HSS), very early (65-79 HSS), early (80-99 HSS), moderate (100-125 HSS), and deep (>125 HSS). The highest value is shown in Rojolele Delanggu (V1) and PPM (V13) varieties which flower at 117 HSS (medium flowering period), while the lowest value is shown in Situ Bagendit (V14), Batang Gadis (V24), and Celebes (V17) varieties, flowering at the age of 67 - 71 HST (very early). The average flower period was then correlated with the harvesting period of black and aromatic rice plants. Flowering and harvesting period variables were used to calculate the grain maturation duration.

The harvesting period variable is an aspect that needs to be considered because it is a component to calculate rice productivity. The rice plant harvesting period can be classified into the ultra-early period (<90 HSS), very early (90-104 HSS), early (105-124 HSS), medium (125-150 HSS), and deep (>151 HSS) (Rice BB, 2009). Based on this classification, 25 black and aromatic rice varieties that can be differentiated into deep-period varieties are Rojolele Delanggu (V11), Pare Pulu Mandoti (V13), and Pandan Gilirang (V21) varieties; medium-period varieties are Pari Ireng (V5), Black Melik (V6), and Here Lahok (V7); and other varieties are classified as early varieties.

Weight of 1000 Grains

Determination of the weight of 1000 grains is one of the variables related to production ability. Each variety has a weight of 1000 grains which varies greatly with an average value of 14.33 - 33.67 g. The lowest value is indicated by Batang Gadis variety (V24) weighing 14.33 g, and the highest average value is shown by Here Lahok (V7) with an average value of 33.67 g.

The weight value of 1000 grains is related to plant height and age. The high rice posture tends to indicate the longer plant age so that the grain filling period is also getting longer, which then makes the grain weight gets heavier. The high plant posture indicates that more photosynthate is produced so that it will affect grain weight because it has long panicles and more rice grains.

Grain Shape

Grain shape is one of the qualitative aspects of the characteristics of rice morphology. Grain shape determination was measured by comparing the grain length and width, which were then grouped according to their values. Grain shape is classified as slender (>3.0 mm), medium (2.1-3.0 mm), long (1.1-2.0 mm), and round (<1.1 mm). Based on the following table, there are 2 grain shapes produced from 25 black and aromatic rice varieties, namely slender and medium shapes. In general, rice is classified into 2 groups, namely Indica and Japonica. Indica has the characteristic of not having a tail or hair on the tip of the lemma while Japonica has a tail at the end of the grain.

Grain Colour

The grain colour characteristic is a qualitative observation variable that gives the distinctive feature of each variety or cultivar. Grain colour differences are influenced by various factors, one of which is the level of anthocyanin contained. Based on the previous research by Chaudary [12], the blacker the grain colour is, the higher the anthocyanin level will be. The most fundamental factor in the diversity of grain colours is the genetic factor that expresses the grain colour of the variety.

Grain colours can be grouped into several colours, namely yellow straw, golden yellow and golden stripes with yellow straw background, brown spots on yellow straw background, brown stripes on yellow straw background, brown (brownish orange), reddish to light purple, purple spots on a yellow straw background, purple stripes on a yellow straw background, purple, black and white [9].

TABLE 1. Grain Shape, Grain Colour, and Rice Colour

No	Varieties	Grain Shape	Grain Colour	Rice Colour
1	Black Purwokerto	Slender	Golden Yellow and golden stripes with yellow straw background	Blackish Purple
2	Black Banjarnegara	Slender	Golden Yellow and golden stripes with yellow straw background	Blackish Purple
3	Black Purbalingga	Medium	Golden Yellow and golden stripes with yellow straw background	Blackish Purple
4	Black Bantul	Medium	Golden Yellow and golden stripes with yellow straw background	Blackish Purple
5	Pari Ireng	Medium	Golden Yellow and golden stripes with yellow straw background	Blackish Purple
6	Black Melik	Slender	Golden Yellow and golden stripes with yellow straw background	Blackish Purple
7	Black Timor Leste	Medium	Brown spots on the yellow straw background	Brown
8	Black Lumajang	Slender	Brown stripes on the yellow straw background	Blackish Purple
9	Black Blitar	Slender	Golden Yellow and golden stripes with yellow straw background	Blackish Purple
10	Black Toraja	Slender	Golden Yellow and golden stripes with yellow straw background	Blackish Purple
11	Rojolele Delanggu	Slender	Yellow Straw	White
12	Mentik Wangi Banjarnegara	Medium	Golden Yellow and golden stripes with yellow straw background	White
13	Pare Pulu Mandoti	Medium	Brown stripes on the yellow straw background	Red
14	Situ Bagendit	Slender	Golden Yellow and golden stripes with yellow straw background	White
15	White Radah	Slender	Yellow Straw	White
16	Milky Rice	Slender	Brown spots on the yellow straw background	White
17	Celebes	Slender	Golden Yellow and golden stripes with yellow straw background	White
18	Pendok	Medium	Golden Yellow and golden stripes with yellow straw background	White
19	Situ Patenggang	Medium	Golden Yellow and golden stripes with yellow straw background	White
20	Mapan 05	Slender	Yellow Straw	White
21	Mentik Wangi	Medium	Brown spots on the yellow straw background	White
22	Gilirang	Medium	Golden Yellow and golden stripes with yellow straw background	White
23	Kurik Kusut	Slender	Brown (Brownish Orange)	White
24	Batang Gadis	Slender	Golden Yellow and golden stripes with yellow straw background	White
25	Genjah Arum	Medium	Golden Yellow and golden stripes with yellow straw background	White

Rice Colour

Rice colours are also a qualitative characteristic needed in determining plant kinship. Based on their colours, types of rice are classified as white, red, and black rice. Rice colour grouping has been regulated in the System Evaluation

Standard for IRRI Rice [9] including white, light brown, small-spotted brown, brown, red, purple variant, and purple rice. Of the 25 black and aromatic rice varieties observed, there were only 4 colour groups, white and blackish purple, red and brown. The red colour in rice is formed from anthocyanin pigments contained in the pericarp, tegmen, and grain. Anthocyanin is a water-soluble pigment naturally found in various types of plants. Superior genes identify anthocyanin pigments in rice. Between black rice that has high anthocyanin levels and white rice, black rice, in general, has darker colours while rice that has fewer anthocyanins has brighter colours. The colour difference in rice can be used as a reference to predict the anthocyanin content in it.

Morphological Kinship Analysis

Phenotype kinship analysis is an analysis used to determine the degree of similarity of phenotypes possessed by 25 black and aromatic rice varieties according to all the variables studied including plant height (cm), the number of productive tillers (stems), flowering period (HSS), harvesting period (HSS), weight of 100 grains (grams), grain shape, grain colour, and rice colour. Phenotype kinship analysis is shown in the form of the dendrogram (kinship tree). This analysis uses UPGMA in NTSYS 2.02i software with DIST coefficients. This analysis was carried out by comparing each variety based on the variables observed.

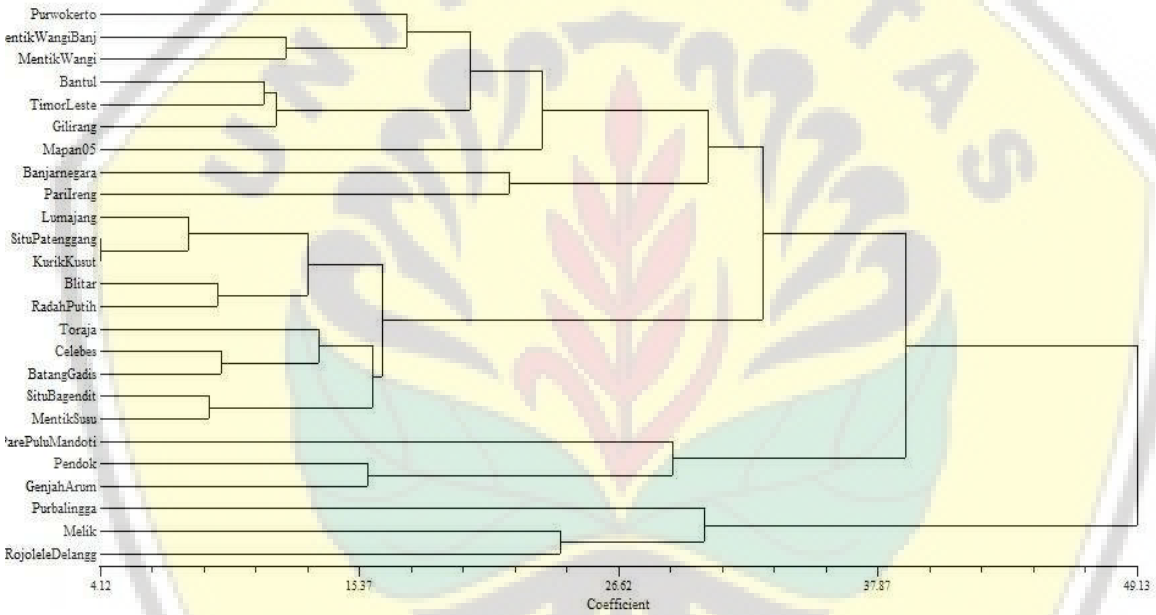

FIGURE 3. Dendrogram of grouping results based on 6 morphological observation parameters of 25 black and aromatic rice varieties

The taxonomic distance of 37.87 obtained by 3 groups), namely group I consisting of Black Purbalingga, Melik, Rojolelle Delanggu; group II consisting of PPM, Pendok, and Genah Arum; and group III consisting of Black Purwokerto, Mentik Wangi Banjarnegara, Mentik Wangi, Black Bantul, Here Lahok/Timor Leste, Gilirang, Mapan 05 Banjarnegara, Pari Ireng, Black Lumajang, Situ Patenggang, Kuriak Kusut, Blitar, White Radah, Toraja, Celebes, Batang Gadis, Situ Bagendit, and Milky Rice (Fig. 3). Based on the results of these groupings, cultivars in one group have the same or almost the same nature and have close kinship relationships. Therefore, it will be easier for selection as the parent of hybridization by choosing cultivars that can represent each group and the origin area of each different variety.

SUMMARY

Differences in morphological characters from 25 black and aromatic rice varieties, ranging from plant height, number of productive tillers, flowering and harvesting periods, weight of 1000 grains, grain shape, grain colour, and rice colour, which correlate or influence each other indicate that the role of the growth environment and the origin of

each different variety can affect the morphological character of the cultivated plant. The results of the dendrogram confirm that the diversity and degree of similarity differing from each variety are divided into 3 large groups, from which are divided into small sub-groups of rice which can be used as a reference for the selection of parent varieties in plant breeding.

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