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Research Article

Genetic parameters estimation on functional dryness traits of crossed black paddy rice "Baas Selem Cultivar X Situ Patenggang" variety

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Abstract: The aims of this study were to elucidate heritability and the role of drought traits genes of black paddy rice for determination base of the selection method to obtain drought tolerant and high yield potential of black paddy rice. The study was conducted through two experiments during February-November 2013. The first experiment was the establishment of populations from crosses carried out in the hybridization room. The second trial was evaluation of the genetic diversity of drought properties held in the greenhouse of the Faculty of Agriculture, University of Mataram. Planting was carried out in pots without experiment design. Population of P1 (parental-Situ Patenggang), P2 (parental-Baas Selem) were 50 plants of each; population of F1, F1BC.1.2, and F1BC.1.1 were 25 plants of each, and 250 plants of F2, as well as control of drought susceptible variety (IR20) was 10 plants. To determine the heritability and the role of genes controlling drought traits were used index of bud dry and cure of IRRI standard. The results showed that crossing of black paddy rice "Baas Selem x Situ Patenggang" had relatively moderate heritability in broad sense and low heritability in narrow sense. In the crossed F1 population was found that gene action of drought trait was not perfectly dominant.

Keywords: *backcrossing, genes, heritability, selfing, selection*

Introduction

Black paddy rice (*Oryza sativa* L.) is a high value functional staple food as well as high value of health and can be used as natural dye for food industry such as cakes, porridge, biscuits, bread, ice cream, and fermented drink. In Bali, black paddy rice usedc to food and also used for religious ceremonies (mecaru, mesegahan, and krikkramas). Aleuron and endosperm of rice produce very high anthocyanine so that purple color close to color black. Anthocyanine is phenolic compounds (as flavonoids group) as an antioxidant that plays an important role to the plant its self as well as to human health. The role of antioxidants for human health are to prevent liver disease (hepatitis), bowel cancer, stroke, diabetes, essential for brain function and reduce the effects of brain aging. Black paddy rice is more nutritious than white rice because both vitamin B1 and mineral content. Laboratory analysis showed that black paddy rice has protein (5.51%), fat (1.85%), amylose (22.97%), amylopectin (51.54 %), and starch (14.52 %) content. Black paddy rice also contains 804.16 mg/100 g beta-carotene and 393.93 ppm anthocyanine. Due to high content of starch and low amylose, the rice was fluffier and therefore it was expensive compared to other rice. Presently, the need for black paddy rice continued to increase in line with the public awareness of the health (Abdel et al., 2006; Harmanto, 2008; Kristaminanti and Purwaningsih, 2010).

Black paddy rice is one of the staple food germplasm that their existences become endangered. Until now there has been no black paddy rice were released as national varieties as drought tolerant paddy rice or upland rice. Related to black paddy rice, Muliarta and Kantun (2011) found that Balinese black paddy rice "Baas Selem" has a high anthocyanine content, good aroma and taste but low yield potential (around 2.7 t/ha) in paddy fields. Therefore, the yield potential needs to be improved throughout crossbreeding with superior high yielding varieties. National variety Situ Patenggang is one of drought tolerant upland rice germplasms having yield potential of 6 t/ha. Black paddy rice cultivars "Baas Selem" and Situ Patenggang could be used as sources of germplasm in crossings to produce new varieties of drought tolerant black paddy rice with high yield potential.

Development of upland rice is still a great chance since Indonesia has reached 28 million acres of dry land. The area is spread all over Indonesia, and the extent of their area tends to increase from year to year due to the opening of forest and grassland burning for transmigration settlements. Of the upland area, about 11.61 million hectares are potential for the development of upland rice planting area. It has been utilized only about 1.17 million hectares and the production was 2.65 million ton with productivity of 2:27 t/ha. The area of dry land in West Nusa Tenggara, which consists of two large islands, namely the Lombok and Sumbawa reached 1,673,476 hectares or about 83% of the area of the region. Only a small of the land used as agricultural activities. It consists of dry land rain-fed areas and cultivated land (BAPPEDA, Nusa Tengara Barat, 2008).

Breeding procedures for drought tolerance should follow the method that is widely used by plant breeders. Things that should be examined to produce drought tolerant black paddy rice varieties are to estimate the heritability, the role of control genes controlling drought tolerant, and determine the appropriate and correct selection methods. Back cross selection method is used if the donor genes for drought driven by monogenic gene high heritability. If the heritability is low or moderate, then bulk method is more appropriate selection method.

This article presents the results of research with aims to understand the heritability and genes role of drought trait of black paddy rice which are used for determination base of selection method for obtaining drought-tolerant and high yield black paddy rice.

Materials and Methods

The study was conducted through two experiments during February-November 2013. The first experiment was the establishment of populations from crosses carried out in the hybridization chamber. The material was in the form of P1 population, superior variety of Patenggang Situ, and P2 population of black paddy rice "Baas Selem". The cross of the first plant was single crosses between Situ Patenggang Situ varieties as male(♂) (P1) and black paddy rice cultivars "Baas Selem" as the female parent (♀) (P2) to produce F1. The second plant breeding methods was Back Cross between F1 as females and P1 and P2 parent as males to produce F1BC1.1 and F1BC1.2. A half of F1 was allowed for selfing to produce F2 population. Planting time was series with interval 6 days each level and it was arranged to the time of flowering for male and female at the same time in order the process of cross-bred easily and to do.

The second trial was evaluation of the genetic diversity of drought properties held in the greenhouse of the Faculty of Agriculture, University of Mataram. Planting was carried out in pots without experiment design. Population of P1 (parental-Situ Patenggang), P2 (parental-Baas Selem) were 50 plants of each; population of F1, F1BC.1.2, and F1BC.1.1 were 25 plants of each, and 250 plants of F2, as well as control of drought susceptible variety (IR20) was 10 plants. To determine the heritability and the role of genes controlling drought traits were used index of shoots dryness symptoms and healing of IRRI standard (Table 1).

Table 1. Value of index shoots dryness and healing according to the scoring system of raw rice by IRRI (1980).

Index value of shoot dryness		**Healing**	
Scale	**Description**	**Scale**	**Description**
0	No symptoms	1	99-100% recovery +
1	Most small shoots and leaves to dry	3	70-89%
3	Up to a quarter mostlyleaves dried	5	40-69%
5	Up to quarter to one half of leaves dry	7	20-39%
7	More than two-thirds of leaves dry		
8	All the plant look like dead		

+ = Leaves looked fresh after irrigated

The values of heritability in the broad sense and narrow sense were calculated using the the formula of Allard (1960) as follows:

Broad sense heritability based on diverse populations P1, P2, F1 and F2.

$$H^2 = \frac{\sigma^2 F2 - (\sigma^2 F1 + \sigma^2 P1 + \sigma^2 P2)/3}{\sigma^2 F2}$$

Narrow sense heritability based on variance F2, F1BC1.1 and F1BC1.2

$$h^2 = \frac{\sigma^2 F2 - (\sigma^2 F1BC1.1 + \sigma^2 F1BC1.2)}{\sigma^2 F2}$$

Value on heritability estimation of drought trait indicates the value of genetic diversity. Its value used to determining base of selection method.

The following Petr and Frey (1966) formula was used to determine the role of control genes on drought traits:

$$hp = \frac{F1 - MP}{HP - MP}$$

Hp = the value of potential ratio/degree of dominance
HP = the average value of the best parent
MP = the average value of the two parent

Based on the value of potential ratio the degree of dominance can be classified as follows:

hp = <0.25): The role of additive gene
hp = 0.25 to 0.75: the role of partially dominant genes/not perfect
hp = 0.75 to 1.25: a dominant gene
hp = >1.25 over the role of dominant genes

Results and Discussion

Estimation on genetic parameter

Estimation on genetic parameters of drought trait is genetic characters of population that will be used as the base in determining the method of breeding towards the establishment of drought resistance population. Materials used in the estimation of genetic parameters on drought trait were 2 parents population (P1, P2), the population of F1, the population of F2the population of BC1(1) and the population of BC1(2). Those six populations were as follows: P1=Situ Patenggang; P2=Baas Selem; F1=Baas Selem x Situ Patenggang; F2=Baas Selem x Situ Patenggang; F1BC1.1=F1 of Baas Selem x Situ Patenggang//Situ Patenggang (P1); F1BC1.2=F1 Baas Selem x Situ Patenggang//Baas Selem.

Heritability on drought trait

Heritability is a genetic parameters used in the estimation of genotype variance proportion which is expressed on phenotype variance. Heritability values ranging between 0 to 1, where the higher the value the higher the effect of genotype diversity. Heritability is low if values 0-0.2, and moderate if value >0.2-0.5, and if value of >0.5 the heritability is high (Chaudhary and Tran, 2001). Heritability analysis was conducted to know the broad sense heritability is the proportion of total variant genotypes to phenotype, and narrow sense heritability indicates the proportion of additive genetic variance in phenotype.

Heritability analysis aimed to determine the proportion of genetic variance in paddy rice plant phenotypic properties to against drought. From this value can be known phenotypic differences of parent that heritage to the offspring, therefore it is useful to determine the method of selection. Broad sense heritability and narrow sense of drought trait base on index of shoot dryness and healing of black paddy rice crossed "Baas Selem" with Situ Patenggang can be seen in Table 2.

Table 2. Values of broad sense and narrow sense of heritability on drought trait base on shoot dryness and healing index of crossed black paddy rice "Baas Selem" with Situ Patenggang

Traits	Broad sense of heritabilty	Criterion	Narrow sense of heritability	Criterion
Index of shoot dryness	0.21	Moderate	-0.05	Low
Healing	0.45	Moderate	-0,39	Low

In Table 2 shows that index value of broad sense heritability of drought trait based on the criteria of shoot dryness and healing was classified of moderate, due to that value was ranged of >0.2-0.5. While, narrow sense heritability of drought trait index was low, because it is considered a negative heritability or it was of 0. Low heritability values describe the character more influenced by environmental factors, inheritance is difficult, and is only effective on the selection further generation (Fehr, 1987). The effective selection method to produce high-yielding varieties of drought tolerant black paddy rice at the next generation should be done with the bulk selection method.

Potential Ratio/Degree of Dominance

The results of the analysis of the potential ratio or gene action based on shoot dryness drought index healing index of crosses "Baas Selem " with Situ Patenggang population can be seen in Table 3. Based on Table 3, drought trait dominance criteria also can be known.

Table 3. The drought gene action based on index of shoot dryness and healing in population of crosses black paddy rice “Baas Selem" with Situ Patenggang

Criteria	Value of potential ratio	Genes action
Shoot dryness index	0.41	Partially Dominance
Healing	0.34	Partially Dominance

The value of potential ratio of F1 needs to be known as it is necessary to estimate the degree of drought trait dominance genes (gene actions) of parent (Situ Patenggang). Data presented in Table 3 show that crosses F1 of "Baas Selem" with Situ Patenggang was showed the ration of drought trait potential of 0.41 based on shoot dryness index and 0.34 of healing index so that it was incomplete dominant or partially dominant. This means there is one parent who has a more important role than the other parent. If the ratio value below 0.25 means the potential role of additive was lower degree of dominance, the role of the females and males were relatively similar. Muliarta (2010) found that cross breed between Piong, Sri, Angka, and Pujut cultivars with Kenya to estimate the role of drought trait gene based on root length and root dry weight was produced over dominant of the genes role or more dominant which means that the offspring have better character than the average of parent or the best parent.

Conclusion

Broad sense heritability of drought trait base on shoot dryness and healing index of black paddy rice crosses "Baas Selem" x Situ Patenggang was classified as moderate, whereas narrow sense heritability was low. Gene action on drought trait based on shoot dryness and healing index of F1 populations of black paddy rice "Baas Selem" x Situ Patenggang crosses was not perfectly dominant.

Recommendation

Based on the broad sense heritability were moderate and narrow sense heritability was low with incomplete dominant gene actions on drought trait of black paddy rice “Baas Selem" x Situ Patenggang crosses, the bulk selection method can be applied to generate expected lines of drought tolerant and high yield black paddy rice. The bulk selection methods ensure the achievement of production superior varieties of upland black paddy rice.

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