ISBN : 978-602-14917-9-9

# HERITABILITY AND GENETIC GAIN OF THE AGRONOMIC CHARACTERS OF CROSSES BETWEEN LOCAL BLACK RICE AND WHITE RICE IN F2 GENERATION

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**Abstract.** Black rice is a local variety that has advantages and disadvantages. This rice has a high anthocyanin content. However, it has a long life span, high plant habitus, and low yield potential. Productivity improvement of black rice can be done through crossing. The purpose of crossing between two having certain superiority is to assemble superior cultivars and proceed with selection. The effectiveness and efficiency of selection is determined, among others, by the value of heritability and genetic gain. This study aims to determine the genetic gain and the estimated value of heritability of the agronomic characters of F2 generation resulting from crosses between local black rice with several superior varieties of white rice. The research was carried out in the Jember State Polytechnic seed production field, from May to November 2019. This study was conducted using experimental design without replication. The estimated genetic parameters are broad-sense heritability and the genetic gain. The seeds used were F2 generation from the crossing of Arum, BSM, Sertani 9, Cidenuk and Cimelati varieties with local black rice. The observed characters include qualitative and quantitative characters. The expected output target of this research is to obtain one or more lines of hope from crossing results that can be developed.

**Keywords :** heritability, agronomy character, and paddy rice

## 1.Intoduction

Black rice and brown rice is one of the local genetic resources that is starting to scarce so that it needs conservation efforts. Now black rice and brown rice are gaining in popularity and are consumed as functional food along with the increasing standard of living and awareness of the importance of health. Black rice and brown rice have high anthocyanin content which functions as antioxidants. Antioxidants are molecules that inhibit the oxidation of other molecules. Oxidation reactions can produce chain reactions of free radicals that can cause cell damage or death. Antioxidants stop this chain reaction by removing free radical intermediates, and inhibiting other oxidation reactions.

Based on the results of the study, the antioxidant group Cyanidin-3-O-glucoside was found to be the highest level in brown / black rice followed by Peonidin-3-O-glucoside. The disadvantages of black rice are high plant habitus, long life span, and low yield potential, as well as less desirable taste. This condition is one of the causes of the farmers' low interest to grow black rice and brown rice. To improve the nature of black rice and brown rice, crosses have been carried out with white rice which has short plant habitus, early maturity, and high yield potential. From the results of the crossing, it is expected to obtain lines of hope of superior black rice. To assemble superior varieties, it is necessary to know genetic parameters such as genetic diversity, heritability, and estimation of genetic progress that will be achieved. Rachmadi et al. (1990) [12] stated that the genetic parameters used in the process of plant breeding include the estimated value of heritability, genetic variability, and genetic gain, which is important as an indicator of the genetic value of a population selection. According to Barmawi et al. (2013) [4], genetic diversity and heritability are useful for predicting genetic gain from

ISBN : 978-602-14917-9-9

selection. Therefore, it can be indicated that the selection in F2 population resulting from crossing of black rice with white rice have a high genetic gain, if the traits involved in the selection have high genetic diversity and heritability.

Thus, selection is expected to obtain high genetic gain for some desired agronomic traits. The purpose of this study was to determine the expected genetic gain and the estimated value of heritability of several agronomic characters of F2 generation of black rice and red rice F2 resulted from crossing with superior varieties of white rice. The long-term goal of this research is to assemble new superior varieties (New High Yielding Variety) from the crossing of local varieties that have high anti-toxin properties (black rice) with white rice varieties which have high productivity and early maturity and taste good. Hence, the specific target that is expected to be achieved is the release of high-yielding superior rice varieties with high anti-toxin properties.

## 2. Implementation method

The research was carried out in the Jember Polytechnic seed production field, from June to November 2019. The seeds used are F2 from crossing of Arum, BSM, Sertani 9, Cidenuk, and Cimelati varieties with local black rice.

The experiment was designed without replication because the seed used was the F2 population which was still experiencing segregation (Baihaki 2000 in Barmawi et al. 2013) [4]. Observations were made on the characters of harvest age, plant height, and the number of productive tillers. The analysis carried out in the form of variance, heritability, and the estimated value of genetic gain. Variance of phenotypes ($\sigma^2 p$) was calculated by the formula proposed by Suharsono et al. (2006) [15] as follows:

$$\sigma_p^2 = \frac{\sum_{i=1}^{N}(xi - \mu)^2}{N}$$

Xi = i-th plant observation value
μ = middle population
N = number of plants observed
The environmental variance (σE2) is assumed from the various environmental elders by the formula:

$$\sigma_E^2 = \frac{n_1\sigma_{p1+} \ \ n_2\sigma_{p2}}{n_1 + n_2}$$

σp1 = standard deviation of parent 1
σp2 = standard deviation of parent 2
n1 + n2 = number of parent plants

The parents population is genetically uniform so that the genotype is equal to zero and the variance of parents is equal to the environmental variance. The parents and their descendants' population were grown on the same farm. Therefore, the variance of the parents' population was the same as the variance of their descendants. So the diversity of the population can be calculated using the following formulas:

$$\sigma_G^2 = \sigma_p^2 + \sigma_E^2$$

Heritability in broad sense is calculated by the formula

$$H = \sigma_G^2 + \sigma_p^2$$

McWhirter (1979) in Martono (2004) divided the estimated heritability value into three categories: low = H <0.20; moderate = 0.20 <H <0.50; and height = H> 0.50.
The value of two genetic gain is calculated by the formula:

$$R = i.H.\sigma_p$$

σp = standard deviation of phenotype
R = selection response
i = selection intensity in this study the selection intensity of 20% with a value of 1.40 (Aryana, 2010)
H = Heritability in a broad sense

$$Genetic\ Gain\ (KG) = \frac{R}{Mean}\ x\ 100\%$$

The criteria for estimating genetic gain based on Begun and Sohban (1991) cited by Hadiati et al (2003) is:

a. High when KG value> 14%
b. Medium when 7% ≤ KG values ≥ 14%
c. Low when KG <7%

**3. Experimentation**

Land preparation (greenhouse cleaning) was carried out 2 weeks before planting. After land preparation, the media was prepared, using ultisol soil taken from dry land with reeds vegetation in the Ambulu area. All the soil for media was taken in one day. The weight of the soil used as the medium for each polybag is 10 kg in total. So the soil + water content with a moisture content of 20% weighted at around 12.5 kg. The organic material used is cow manure at a dose of 10 tons / ha, so that cow manure (manure + water content) weighted at 28.58 tons / ha (142.9 g / polybag) with a water content of 65%. The diameter of the polybag was 30 cm and the height of the growing media in the polybag was 25 cm. The seeds were soaked in water for 1 day before the seeding. Then the seeds were sown in plastic cups containing a mixture of soil and manure with a ratio of 1: 1 until the plants were 2 weeks old. The seedlings were then planted into polybags. Basic fertilizer that was used was NPK with a dose of 150 kg / ha (0.8 g / polybag) and fertilization was then performed when the plants were 3 and 5 weeks after planting. Plant maintenance includes irrigation, by adding water to the media until it reaches its saturation point. Weeds were controlled manually by pulling weeds around the plant. Insect pests were controlled with 500 g/l BPMC insecticide. Bird pests were controlled by installing nets, and *Cercospora* spp. fungi were controlled with 250 g/l Difenoconazole fungicide. Harvesting was conducted when the plants showed signs of harvesting, namely the rice panicles ducking, the grain of rice feels hard when pressed, the panicle stems turn yellow and 95% of the grain has yellowed.
Observed Variables
a. Qualitative Variable
• Grain Type
Grains were differentiate as ‘cere’ or hairy and were observed after harvested.
• Grain color
The grain color was distinguished as straw yellow, golden yellow, red or purple and was observed after harvest.
• Grain shape
The shape of grain was distinguished as slender, medium, oval, or round and was observed after harvest.
• Plant shape
The shape of plants was distinguished as upright (<300), moderate (+450), open (+600), scattered (> 600), and the stem or the bottom of the soil surface is observed when the grain is fully cooked.

ISBN : 978-602-14917-9-9

• Grain loss
Grain loss was determined by grasping panicles and then the percentage of unhulled grain was calculated. They were divided into five categories, which are difficult (<1%), somewhat difficult (1-5%), moderate (6-25%), rather easy (26-50%) or easy (51 -100%). It was observed after harvest.
• Leaf surface
Leaf surface were distinguished as hairy, medium or hairless. It was observed in the flowering phase.
• Position of the flag leaf
Flag leaf position were distinguished as upright, medium (± 450), horizontal, or drooping. It was observed in the primordia phase.
• Color of the stem
The colors of the stems were distinguished as green, golden yellow, purple striped, and purple. It was observed when the grain was fully mature
• Leaf foot color
Color foot leaves were distinguished as green, striped purple, light purple, or purple. It was observed when the grain is fully cooked.
• Leaf color
Leaf color was distinguished as light green, green, dark green, purple at the tip, purple at the edges, a mixture of purple with green, or purple. It was observed in the flowering phase.
• Leaf tongue color
The colors of the leaf tongue were distinguished as white, purple stripped, or purple. It was observed in the primordia phase.
• Leaf ear color
Color ear leaves were distinguished as white (not colored), striped purple, or purple. It was observed in the primordia phase.

b. Quantitative Variable
• Plant height (cm)
Plant height was measured from the base of the stem to the first ring at the highest panicle at harvest using the meter.
• Number of tillers (stems)
The number of tillers was obtained by counting all tillers that appear during the primordial phase.
• Number of productive tillers (stems)
The number of tillers was calculated on each stem that produced panicles and was carried out at harvest ie by counting the number of panicles per clump.
• Flowering age (days)
Age of flowering was calculated by counting the number of days from planting to rice entering the primordial phase.
• Age of harvest (days)
The age of harvest was calculated by counting the number of days from planting to the ducking of the panicles, and when grain is hard when pressed, and 95% of the grain has yellowed.
Panicle length (cm)
The panicle length is measured from the first ring on the panicle to the tip of the panicle by using a ruler. It was observed after harvest. Panicle length measurements were carried out on 5 panicles from plants taken at random.
• Number of grains per panicle (grain)
The number of grains per panicle was calculated by counting the number of empty and pithy grains from each panicle after harvest. Observations were made on 5 panicles which were used to measure panicle length.
• Percentage of pithy grain (%)
The percentage of pithy grain was calculated by comparing the number of pithy grains to the total number of grains in plants multiplied by 100. It was observed at harvest.

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• Weight of 100 seeds (g)
The weight of 100 seeds was obtained from the dry weight of 100 pithy rice grains per unit of experiment. The 100 seeds and then weighed to get the weight of 100 seeds. Measurements were made on the milled dry grain (± 12% moisture content) after harvest.
• Yield per clump (g)
Yield per clump was measured by weighing all paddy grain in 1 batch after harvest

**4. Result and discussion**
The results of this study indicated that the phenotype and genotype diversity values were broadly found in the characters of flowering age, harvest age, plant height, whereas the characters of productive tillers and weights of 100 grains indicated narrow diversity values. Selection will be effective if the population has wide genetic diversity. The extent of diversity produced, both phenotype and genetic diversity showed that there was a great opportunity to select the desired traits. The wide diversity of genotypes and phenotypes caused by the seeds used are F2 seeds with the highest level of segregation. Wide diversity can also occur because the parents used have different genetic characteristics. The range of the mean value of a character will determine the extent of the diversity of characters. The wider the range of values of a character, the greater the diversity. Plant height characters had the greatest range of values, so the diversity of this character is broad. The estimated value of heritability on the character of flowering age, harvest age, plant height, number of tillers, and weight of seeds per plant is high.

The value of genetic gain which is categorized as high is found in plant height and the number of productive tillers. Heritability determines the success of selection because heritability can provide clues to a trait more influenced by genetic or environmental factors. A high heritability value indicates that genetic factors play a role in controlling a trait compared to environmental factors. Characters with high category of heritability are more controlled by genetic factors than environmental factors. Selection of characters of high heritability can be done in the early generations. Sharma (1994) stated that a character that has a high heritability value can be selected in the early generation (F2 and F3). Conversely, if the value of heritability is low, then the character must be selected in the next generation. The high value of genetic gain in a character indicates that the character's appearance is supported by genetic factors, so that it can complement the progress of selection (Satoto and Suprihatno, 1996). Thus selection to obtain superior genotypes can be applied to these characters.

**5. Conclusion**
Based on the results of the study it can be concluded that the estimated value of heritability (inheritance) was high in the characters of flowering age, harvest age, plant height. The estimated value of heritability is found in the number of productive tillers. The estimated value of genetic gain was found in the characters of plant height, number of productive tillers.

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