Gene action and heritability of F4 generation derived from the crossing of Silopuk red rice cultivar with superior Fatmawati variety

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Abstract. Population F4 is a segregated population the character of certain, so important to know the parameters of genetics. The purpose of our research to determine action of gene and the values expected heritability population F4 (Silopuk X Fatmawati). The research has been from month of October 2017 to February 2018 in land farmer Padang Limau Manis. The research use method experiment without repitition the head to row with analysis Z Skewness and Z Kurtosis. The genetic material of this research is rice seed on the F3 generation from the selection of pedigree crosses between silopuk and Fatmawati superior variety and the other seeds were Silopuk cultivar and Fatmawati superior variety as control. The research data showed that Z test skewness and Z test Kurtosis for whole characters observed were dominant controlled by minor genes. The character age of flowering, plant height, length of panicle and percentage filled grain per panicle were controlled by many gene additive. The broad heritability value for all character observed in the F4 population ranged from 0.01-0.99 with low to high criteria.

1. Introduction
One way to obtain high yielding rice variety is by assembling variety. To create a superior rice variety need to for a long time. Red rice is consumed without need to be refining process, but it direct into cracked rice. Apart from being a primary food, red rice has long been knowing to be beneficial to health and has been being popular in the research topic. The red colour in red rice contains antioxidants so that it has a low glycemic index value, the same as the vove type promising antioxidant agent due to its antihyperglycemic property [1].

Characterization of local red rice of West Sumatra has been obtained regarding its advantage and disadvantage. Among the local red rice is the Silopuk cultivar. Silopuk cultivar is one of the local cultivars of West Sumatera originating from West Pasaman which has the superiority of dry rice texture, red rice, and high protein content (13.3%) [2]. However, it has weaknesses such as high plant age and low production of Silopuk cultivar. This allows local cultivars to be used as a potential source of genes and needs to be improved while maintaining specific advantages, such as high protein content and rice color.

Self pollination could produce superior rice varieties by hybridization or cross. Cross between the superior fatmawati variety and silopuk variety, have obtained the desired segment [3].
Genetic parameter value is basic information that is important for the effectiveness of selection to improve plant character. The highly dependent on the effectiveness of selection, which is determined by the level of genetic diversity and the degree of character inheritance as measured by heritability value is success of plant breeding [4]. Value of heritability, genetic diversity, population frequency distribution, and the closeness of the relationship with the result, are character criteria to be selected. The frequency distribution information is important to determine whether or not the prediction of the progress of selection is carried out on a character.

The aimed of our study was action of gene and the predicted value of heritability that control character on the F4 generation.

2. Materials and methods
The genetic material of this research is rice seed on F3 generation from selection of pedigree crosses between silopuk and Fatmawati superior variety. The research has been from October 2017 to February 2018 in land of farmer Limau Manis with a height of +200 mdpl. The research was arranged in the experimental method without repetition the Head to Row. The data were analyzed using Skewness test and Kurtosis test [4] on SPSS program.

The research started with land preparation, seed selection, seeding, planting, maintenance (irrigation, fertilizing, weeding and controlling pests and diseases), and harvesting. The observation made were the character number of productive tiller, length of panicle, total number of grain per panicle, percentage of filled grain per panicle, weight of one thousand grains of grain, and weight of filled grain per hill.

3. Results and discussion
Based on the table 1 and 2, Character with significantly different skewness value were found in all observed character except for the characters of flowering age, plant height, length of panicle, and filled grains per panicle percentage, the skewness value were not significantly different. This show that the character that have significantly different skewness value are controlled by the dominant gene with the effect of the total dominant gene being less than environment. But, the affect per unit gene greater than environment. The action of these gene in self-pollinating plant result in interaction between gene so that in the next generation the proportion of homozygote will be achieved more slowly [5].

| Character                            | Skewness | SE Skewness | Skewness Z Test | Gene Action |
|--------------------------------------|----------|-------------|----------------|-------------|
| Flowering age                        | 0.19     | 0.11        | 1.73 ns         | Additives   |
| Harvest age                          | 0.76     | 0.11        | 6.91 *          | Dominant    |
| Plant height                         | 0.21     | 0.11        | 1.92 ns         | Additives   |
| Total number of tiller               | 1.17     | 0.11        | 10.64 *         | Dominant    |
| Number of productive tiller          | 0.90     | 0.11        | 8.18 *          | Dominant    |
| Length of panicle                    | 0.15     | 0.11        | 1.36 ns         | Additives   |
| Total grain per panicle              | 0.24     | 0.11        | 2.18 *          | Dominant    |
| Percentage of total filled grain per | -0.27    | 0.11        | -2.45 ns        | Additives   |
| panicle                              |          |             |                 |             |
| Weight of one thousand grain of pure | 0.39     | 0.11        | 3.55 *          | Dominant    |
| rice                                 |          |             |                 |             |
| Total grain weight per panicle       | 2.21     | 0.11        | 20.09 *         | Dominant    |
| Content of grain weight per panicle  | 3.11     | 0.11        | 28.27 *         | Dominant    |

Note: **Not Significantly Different at 5% Level (1.96), *Significantly different at the 5% level (1.96), SE Standard Error.
Table 2. Total of genes in population character F4 derivative by (Silopuk × Fatmawati).

| Character                          | Kurtosis | SE Kurtosis | Kurtosis Z test | Number of Genes |
|-----------------------------------|----------|-------------|-----------------|-----------------|
| Flowering age                     | -0.64    | 0.23        | -2.78 ns        | Many            |
| Harvest age                       | 1.50     | 0.23        | 6.25 *          | Little          |
| Plant height                      | 0.17     | 0.23        | 0.74 ns         | Many            |
| Total number of tillers           | 2.94     | 0.23        | 12.78 *         | Little          |
| Number of productive tillers      | 1.66     | 0.23        | 7.22 *          | Little          |
| Length of panicle                 | 0.18     | 0.23        | 0.78 ns         | Many            |
| Total grain per panicle           | 1.28     | 0.23        | 5.30 *          | Little          |
| Percentage of total filled grains per panicle | -0.81 | 0.23 | -3.52 ns | Many |
| Weight of thousand grains of pure rice | 1.16 | 0.23 | 5.04 * | Little |
| Total grain weight per panicle    | 8.83     | 0.23        | 38.39 *         | Little          |
| Content of grain weight per panicle| 14.05    | 0.23        | 61.09 *         | Little          |

Note: *ns* Not Significantly Different at 5% Level (1.96), *Significantly different at the 5% level (1.96), SE Standard Error.

On the contrary, character with insignificant skewness value were thought to be controlled by multiple genes / polygenic by mean of the additive gene action. It indicates that the allele is the result of genetic contributions between the two parent and the parental allel will be passed down in the heredity [6].

This is in line with the research of [7] which states that in the F2 generation had a normal distribution pattern and were controlled by multiple genes with additive gene action. Then, [8] which states that F3 generation have a normal distribution with additive gene action by many genes are controlled by many genes. The similarity of gene action from generation F2 to generation F4 on these character show that are controlled by free genes without any influence from gene interaction or the environment.

Effect on the phenotype appearance of the character on the result of the study in table 2 show that the treatment level of salinity does not significantly increased affect the number of leaves on each WAP. The estimation of the variance component, variability, heritability estimate value, and genetic diversity coefficient are presented in Table 3.

Based on table 3, the estimated value of heritability for all observed characters was high except for the tillers total number, the total grain weight per hill, and the filled grain weight per hill was low and the heritability value for the number of productive tillers was moderate. Characters that have high heritability value indicate that the genetic factors is more great than the environment factor and that the inheritance of these trait is passed down properly and easily.

The character of flowering age and harvest age have heritability value of 0.63 and 0.99 with high criteria. That is genetic factors which are greatly influenced than environmental factors. In addition to the character of flowering and harvesting age, the character of plant height is also high, namely 0.99. This shows that the character of plant height is also more influenced by genetic factor which are more dominant than environmental factor. This is line with Wahyuni's research [8] that in the F3 population the character of flowering age, harvesting age, and height of plant have relatively aloft heritability value.

Tiller total number and productive tiller number had heritability value of 0.10 and 0.31 with low and medium criteria. Based on the heritability value criteria, the tillers total number was influenced by environmental factors that were more dominant than the influence of genetic factors, and the character
of productive tillers number was influenced by genetic and environmental factor which were equally large.

**Table 3.** Estimation of variety component and estimated value of population heritability F4 derivatives of (Silopuk x Fatmawati).

| Character                     | e    | g    | p    | H_b | Criteria | KKG (%) | Criteria |
|-------------------------------|------|------|------|-----|----------|---------|----------|
| Flowering age                 | 14.92| 24.89| 39.81| 0.63| High     | 6.04    | Narrow   |
| Harvest age                   | 0.14 | 54.90| 55.04| 0.99| High     | 8.99    | Narrow   |
| Plant height                  | 34.19| 22781.41| 22815.60| 0.99| High     | 183.04  | Large    |
| Total number of tillers       | 11.05| 1.27 | 12.31| 0.10| Low      | 0.35    | Narrow   |
| Number of productive tillers  | 8.82 | 3.97 | 12.79| 0.31| Moderate | 16.48   | Moderate |
| Length of penicle             | 2.71 | 5.53 | 8.23 | 0.67| High     | 8.62    | Narrow   |
| Total grain per penicle       | 2448.45| 2832.89| 5281.34| 0.54| High     | 16.72   | Moderate |
| Percentage of total filled grains per panicle | 73.26 | 209.61 | 282.86 | 0.74 | High | 24.67 | Large |
| Weight of thousand grains of pure rice | 2.17 | 9.45 | 11.62 | 0.81 | High | 12.87 | Moderate |
| Total grain weight per panicle| 150.52| 1.98 | 152.49| 0.01| Low      | 4.27    | Narrow   |
| Content of grain weight per panicle | 111.99| 7.89 | 119.88| 0.07| Low      | 14.62   | Moderate |

Note: *Not Significantly Different at 5% Level (1.96), *Significantly different at the 5% level (1.96), SE Standard Error, e Environment, g Genetic and p Phenotype.

The heritability value of panicle length character and total grain character per panicle, namely 0.62 and 0.54, were classified as high criteria. This show the character length of panicle and total number grain per panicle has a more dominant influence compared to environmental factor. This is following the result of previous study, namely in population F2 and F3, length of panicle characters have estimated heritability value of 0.84 and 0.92 and are classified as high criteria.

The percentage character number of filled grain per panicle and the weight character of 1000 pithy grain had heritability value of 0.74 and 0.81 which were classified as high criteria that are influenced by genetic factors. This character has a great opportunity to be passed on to the next generation. According to, the high heritability value is caused by the maximum level of segregation in the F2 population High heritability value for the observed character indicate that selection can be applied efficiently to these character [9].

The heritability value of total grain weight per hill and filled grain weight per hill were 0.01 and 0.07 and classified as low. When compared with the F2 and F3 population, there was a decrease in grain weight character. The decrease in heritability value is thought to be due to environmental influence that are more dominant than genetic influence [10].

The KKG value which was classified as a narrow criterion was found in all characters except for the height of plant character and the percentage of filled grain per panicle which were classified as broad criteria and the character of the productive tiller number character, the total number of grains per panicle and the 1000 pithy grain weight were classified as moderate criteria. Thus, the level of segregation of characters with moderate criteria is still high, so the opportunity for selection is very
large to get superior individual [11]. Besides, individual selection is still effective in the F4 population intending to cultivate or handle the early generation of genotype that will become new type of red rice variety resulting from pedigree selection results from crosses of Silopuk cultivars and superior Fatmawati varieties.

4. Conclusions
The outcome of Z skewness test and Z kurtosis test were a few dominant gene controlling all observed characters except, the character of flowering age, plant height, length of panicle, and filled grain percentage per panicle are controlled of multiple gene / polygenic by mean of additive gene action. The broad-sense heritability value for all characters observed in the F4 population ranged from 0.01 to 0.99 with low to high criteria.

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