Correlation of phenotype components with yield of promising tungro resistant superior rice lines

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Abstract. The assembly of new high-yield and disease-resistant rice varieties is one of the efforts to increase the rice production and productivity in Indonesia. New site-specific varieties that match farmer preferences are targeted for plant breeding. The yield test is one of the activities in plant breeding to identify any promising lines that have adaptability to a specific growing environment. The purpose of this study was to determine the correlation of the phenotypic components with the yield of the promising superior rice lines which have high yield potential and are resistant to tungro disease. The research was conducted in the tungro endemic area of Lanrang South Sulawesi during the rainy season (MH) December 2017 to March 2018. A total of 20 rice slaves were arranged in an augmented design consisting of 4 blocks, each block there were 5 test lines and 2 comparison varieties namely Ciherang and Inpari 7 Lanrang. The components observed included plant height, flowering age, number of panicles, number of filled grains per panicle, number of empty grains per panicle, 1000 grain weight, yield weight per hectare, clump shape and level of lodging. The results showed that the yields of 10 lines were higher than one or both comparators, namely BP11224F, BP12280-4F-7, BP57964F, BP11206F, BP12280-4F-4, BP12280-3F-16, BP12280-3F-2, BP122803F5, BP11208F-7, and BP12280-3F-13. The value of R = 0.557, which means that there is a strong correlation between the components of growth and the level of yield. The value of R square = 0.310 indicates that the ability of the six growth components were observed affects the rice yield by 31% and there are still 69% other components that affect the yield.

1. Introduction
Indonesia has a high diversity of biological natural resources [1] and is one of the capital in the assembly of new superior varieties, especially of rice. The problem of the limited adaptation of a variety to various pests and diseases requires the discovery of the new site-specific superior varieties. Varieties that are able to survive and adapt to the specific agroecologies can provide of more optimal results than varieties that have wide adaptations.

Tungro is a disease in rice plants that is still an obstacle to increasing rice production in Tropical Asia. Tungro attacks can destroy for very large plantations in a short time. Tungro is caused by a virus that transmitted by green leafhoppers (Nephotettix virescens) [2]. Tungro endemic areas in Indonesia are concentrated in the rice production centers such as South Sulawesi, Java, Bali and West Nusa Tenggara [3]. The extent of tungro attacks in Indonesia were varies from year to year. In the 2011 planting season (MT), the area of tungro attack is predicted to reach of 5161 ha [4] and in MT 2020 an area of 1,837 ha [5].

The use of resistant varieties is an effective component in tungro control [6, 7], is very environmentally friendly, and is suitable and easily accepted by farmers [8]. Tungro control using
several resistant varieties is suitable for application in endemic areas in Southeast Asia [9]. Variety rotation using several resistant varieties with different genetic backgrounds can prevent tungro epidemics [10]. One of the barriers to the use of resistant varieties is the decreased of the durability of resistance due to the population selection pressure and variations in pathogenic virulence [11]. The durability of resistance must be a major component in the assembly and improvement of resistant varieties in order to provide of sustainable varieties [12].

Tungro control using resistant varieties must be adapted to the virulence variations of the tungro virus, so availability and mapping are needed in the distribution of resistant varieties. Diversification of resistant varieties with a diversity of genes for resistance to tungro virus is an important component in the successful control of tungro disease [13]. Improvement of variety resistance can be pursued through assembling varieties with several sources of resistance, assembling varieties based on the suitability of parents with tungro virus variants and green leafhoppers, and assembling transgenic rice [12]. In order to improve the resistance of varieties, a number of promising rice lines for tungro resistant crossed from several resistant elders such as Balimau Putih, Utri Merah, Habiganj DW8, O. longistaminata and O.rufipogon with a number of selected resistant lines have been evaluated for their resistance level against tungro viruses and green leafhoppers in Indonesia, Philippines, and India [14]. The efforts to increase of rice productivity can be carried out through the innovation of assembling rice varieties with high yield, resistant to biotic and abiotic stress, and having good quality rice [15]. In the process of improving high yielding varieties, a yield test stage is needed to test the yield of the available rice lines, then they are selected to be developed into varieties [16].

In the early stages of breeding, there is generally a large number of genotypes, but the number of seeds available per genotype is very limited. To solve this problem, breeders typically use an augmented design to screen for a number of genotypes in a breeding experiment. In this design, the new genotype tested is not repeated but the control genotype is repeated [17]. Scott and Milliken [18] state that comparators in the augmented design are used to estimate of block and environmental effects. The augmented design is a way of comparing tested genotypes with comparators, and adjusting the results of different genotypes from block to block [19].

According to Priya and Joel [20], the correlation of value and cross-fingerprint coefficient can help the breeders in determining the choice of components to be used as selection criteria to increase of grain yield more effectively. The correlation and cross-fingerprint analysis show the closeness of the relationship between grain yield and yield components, so that an understanding of the relationship between yield components and grain yield is important. Cross analysis is an advanced correlation analysis and is a form of structural analysis that details the causal relationships between variables in a closed system. The cross analysis can describe the correlated properties of the direct and indirect effects of the independent components with the response components. The selection will provide an optimal response if it is supported by a growth component and a yield component that has a strong correlation with yield [21].

This study aims to obtain the information on the correlation between phenotypic components and grain yields of a number of tungro-resistant superior rice lines which can be used as selection criteria directly or indirectly, in the selection of prospective tungro-resistant rice varieties that have high yield potential.

2. Methodology
The research was conducted in the tungro endemic area of Lanrang, Sidrap, South Sulawesi, the coordinate of location was at -3.8488126, 119.8251185, during the rainy season (MH) from December 2017 to March 2018. The material used was 20 promising tungro-resistant superior rice lines. The research was carried out using an augmented design consisting of 4 blocks, each block contained 5 test lines and 2 comparison varieties namely Ciherang and Inpari 7 Lanrang. Seedlings are 21 days old after planting in a plot of 1 m x 5 m with a spacing of 25 cm x 25 cm, as many as 1-2 seeds/hole. Fertilization using a dose of Urea 300 kg ha$^{-1}$, SP-36 and KCl 100 kg ha$^{-1}$. SP-36 and KCl were given at planting and one third of Urea was given one week after planting, the remaining at 45 days after
planting. The plants are maintained in such a way that there is enough water available and clean from weeds.

Observations were made on 3 sample plants that were randomly selected in each plot. The components were observed included the plant height, flowering age, number of panicles, number of filled grains per panicle, number of empty grains per panicle, 1000 grain weight, yield weight per hectare, clump shape and level of lodging. Analysis of variance used the F test and if there were significant differences between genotypes, then continued with the LSD test at the level of \( \alpha = 95\% \), while the analysis of the relationship between the phenotype components and the results was tested through correlation and regression analysis using SPSS 16.0.

3. Results and Discussion

3.1. Yield performance

The results showed that the yields of 10 lines were higher than the comparison varieties with a range of 4941.63 - 5863.26 kg ha\(^{-1}\) (Table 1). The line that showed the highest yield was BP12280-4F-1 at 5863.26 kg ha\(^{-1}\), which was supported by the higher number of filled grains per panicle and less empty grain per panicle than the comparison varieties. Based on the results of yield, the number of filled grains per panicle, the number of empty grains per panicle, the weight of 1,000 grains, and the number of panicles per m\(^2\), all tested lines were not significantly different from the comparison varieties.

The number of panicles per m\(^2\) produced by the BP12190-1 line was 2227.00, but it was not included in the best line because it had the lowest 1000 grain weight and its yield was below the comparison variety. The value of the empty grain per panicle of the BP 12280-3F-13 line was greater than the value of filled grain per panicle, but resulted in a weight of 1000 grains and higher yield of the two comparison varieties. The best weight range of 1000 grain is 27.20 g (BP11206F) to 29.04 g (BP12190-1F). The weight of 1000 grains of the best line were on average greater than those of the two comparison varieties. However, all of the test lines were classified as having high yield potential, in accordance with the statement of Abdullah et al. [22] stated that the new types of rice that have high yield potential generally have characteristics such as a weight of 1000 grains of 25-26 g.

The mean age of 50% of the early flowering was 51 days in the BP11224F line and 52 days in the BP1122804F9 line. Based on the plant height value, there were 3 best lines that were shorter than the Ciherang variety, namely BP11206F, BP11208F and BP12280-3, while the other lines were higher than the two comparison varieties. Lubis et al. [23] classified the height of rice plants into three groups, namely short if less than 110 cm, moderate between 110-125 cm, and tall if more than 125 cm. All the best lines were included in the medium - high group because they had a plant height of more than 110 cm.

The average tested lines were in a good category because only 3 lines were fell slightly, namely BP12'90-1, BP12280-3F-16 and BP12280-3F-3, and one line that fell was BP12280-3F-13. The plant height can affect the level of a variety. The higher a plant is likely to have a high level of grooming. However, the lines with the highest plant height value (BP122804F8) had a good level of incense, because they had good stems rigidity. The results of Ahyuni and Dulbari's [24] study showed that the components of stem strength were positively correlated with the plant height, stem diameter, and panicle length, but negatively correlated with the stem rigidity.

Based on the regression calculation, it was obtained the value of R = 0.557, which indicates a strong relationship between the growth components and yields. Meanwhile, R square has a value of 0.310 which indicates that the ability of the six growth components affects the rice yield by 31% and there are still 69% of other components that affect the yield.
Table 1. The average of the yield, number of filled grains per panicle, number of empty grains per panicle, weight of 1000 grains, age of 50% flowering, number of panicles per m², plant height, and level of lodging of 20 promising tungro resistance superior rice lines with and 2 control varieties.

| No. | Tests and varieties of comparison | Results (ton ha⁻¹) | Content grain | Empty grain | Weight 1000 seeds (g) | Flowering age | Number of panicle per m² | Plant height | Level of recklessness |
|-----|---------------------------------|--------------------|--------------|------------|-----------------------|---------------|-------------------------|-------------|----------------------|
| 1   | BP12280-3F                       | 4.37               | 76           | 23         | 26.74                 | 55            | 1445.00                 | 124         | good                 |
| 2   | BP11224F                         | 5.65               | 64           | 41         | 26.73                 | 51            | 1623.50                 | 127         | good                 |
| 3   | BP12280-3F2                      | 3.94               | 60           | 59         | 26.60                 | 54            | 1904.00                 | 124         | good                 |
| 4   | BP12280-3F3                      | 4.83               | 92           | 74         | 26.83                 | 59            | 1693.50                 | 124         | good                 |
| 5   | BP12280-4F-7                     | 4.94               | 111          | 31         | 26.56                 | 56            | 1383.33                 | 129         | good                 |
| 6   | BP122804F9                       | 3.50               | 93           | 30         | 28.94                 | 54            | 1742.50                 | 127         | good                 |
| 7   | BP12280-4F-18                    | 4.87               | 72           | 42         | 28.26                 | 52            | 1674.50                 | 129b        | good                 |
| 8   | BP 5796 4F                       | 5.67               | 94           | 16         | 26.65                 | 55            | 1683.00                 | 123         | good                 |
| 9   | BP12190-1F                       | 4.67               | 77           | 41         | 20.04                 | 55            | 2227.00                 | 126         | Some collapsed       |
| 10  | BP11206F                         | 5.74               | 67           | 31         | 27.20a                | 53a           | 1870.00                 | 117         | good                 |
| 11  | BP12280-4F-1                     | 4.08               | 75           | 52         | 27.76                 | 53            | 1649.00                 | 125         | good                 |
| 12  | BP12280-4F-4                     | 5.86               | 93           | 18         | 26.40                 | 56            | 1649.00                 | 132b        | good                 |
| 13  | BP122804F8                       | 4.36               | 68           | 43         | 29.16                 | 55            | 1640.50                 | 132         | good                 |
| 14  | BP12280-3F-16                    | 5.30               | 81           | 51         | 27.86                 | 54            | 1742.50                 | 123         | Some collapsed       |
| 15  | BP12280-3F-2                     | 5.36               | 75           | 54         | 26.92                 | 53            | 1385.50                 | 122         | Some collapsed       |
| 16  | BP 12280-3F-7                    | 4.28               | 73           | 60         | 28.23                 | 59            | 1640.50                 | 125         | Some collapsed       |
| 17  | BP122803F5                       | 5.14               | 69           | 37         | 28.25                 | 58            | 1666.00                 | 125         | good                 |
| 18  | BP12280-3F-14                    | 4.56               | 65           | 52         | 28.17                 | 58            | 1521.50                 | 114         | good                 |
| 19  | BP11208F-7                       | 5.56               | 75           | 64         | 28.33                 | 54            | 1275.00                 | 116         | good                 |
| 20  | BP 12280-3F-13                   | 5.44               | 68           | 69         | 27.66                 | 55            | 1555.50                 | 124         | collapsed            |
| 21  | CIHERANG                         | 5.41               | 71           | 38         | 27.01                 | 53            | 1723.38                 | 122         | good                 |
| 22  | INPARI 7                         | 4.90               | 52           | 41         | 26.14                 | 54            | 1727.63                 | 116         | good                 |

Description: a = significantly different from the two control varieties inpari 7 and ciherang, b = significantly different from the Ciherang; The figures not followed by notation are not significantly different from Ciherang and Inpari 7 Lanrang.

3.2. Correlation of yield components and yield
The relationship pattern between the yield components and grain yield is known from the correlation value. Correlation analysis is performed by measuring the degree of closeness of the linear relationship between two or more components. The correlation between the two components can be in the form of a correlation of growth components or a correlation of plant yield components [25]. The component of the number of filled grains per panicle showed a positive correlation with the yield with a correlation value of 0.067. The components of the number of empty grains per panicle, weight of 1000 grain, flowering age, number of panicles, and plant height were negatively correlated with the yield with a correlation value of -0.134 (no correlation), -0.404 (moderate correlation), -0.334 (weak correlation), -0.140 (no correlation), and -0.67 (strong correlation) respectively (Table 2).
Kartina et al. [26] stated that the plant height indicates the large proportion of the crown or biomass as the source. The canopy is a part of the plant that plays a role in the photosynthesis process. The more photosynthetic products produced, the greater its effect on grain weight. This is in line with the correlation of plant height with filled grain per panicle of 0.426 which shows a significant difference at the 95% confidence level. The results of the research by Safriyani et al. [27] also showed that the plant height and number of filled grains were correlated with grain weight with higher values compared to the other growth and yield components.

A positive correlation was also obtained between the number of empty grains and flowering age, but the value was very small (0.025), which indicates that the longer of flowering plant, so the greater of the number of empty grains. This is presumably because the genotype with a long flowering has a longer vegetative period. The vegetative period is required by plants to accumulate photosynthetic products which will then be distributed to all plant organs for growth and filling [26].

The components that can be analyzed using a cross-fingerprint are those that show a real correlation coefficient based on the correlation analysis. The cross-fingerprint analysis can help to explain the direct and indirect effects of a component on the grain yield [21]. In this study, there was only one component that showed the moderate correlation with grain yield, namely the number of filled grains per panicle, while plant height showed a strong negative correlation. The cross-sectional matrix can be seen in Table 2 and Figure 1.

**Table 2.** The correlation coefficient of the yield components with yields of promising tungro resistance superior rice lines.

| Character            | Yield | Number of grain contains | Number of empty grains | Weight 1000 grains | Age flowering | Number of panicles | Plant height |
|----------------------|-------|--------------------------|------------------------|-------------------|---------------|-------------------|--------------|
| Yield                | 1     |                          |                        |                   |               |                   |              |
| N.of grain contains  | 0.067tn|                          |                        |                   |               |                   |              |
| N. of empty grains   | -0.134tn| -0.206tn                 |                        |                   |               |                   |              |
| Weight 1000 grains   | -0.404tn| -0.081tn                 | -0.005tn               |                   |               |                   |              |
| Age flowering        | -0.338tn| 0.264tn                  | 0.025tn                | 0.124tn           |               |                   |              |
| Number of panicle    | -0.140tn| -0.105tn                 | -0.119tn               | 0.134tn          | 0.055tn       |                   |              |
| Plant height         | -0.67tn | 0.426*                   | -0.0082tn              | 0.159tn          | -0.06tn       | 0.110tn           |              |

Description: tn = correlation is not real at 5% level, * = real correlation at 5% level.

The yield components that have a direct effect on the grain yield have a positive and negative correlation. The indirect effects of plant height on empty grain and flowering age were negatively correlated with values of -0.082 and -0.06, respectively. The indirect effect of plant height on the number of filled grains, weight of 1000 grain, and the number of panicles was positively correlated with a value of 0.426; 0.159; and 0.110.

According to Rohaeni and Permadi [28], the residual value is the value of the direct effect that has not been calculated on components that have not been identified. The residual value has an effect on the diversity of the yields measured by weight of 1000 grains, number of empty grains, number of filled grains, plant height, number of panicles, and flowering age. The residual value close to zero means that the cross-fingerprint analysis used is very effective in explaining the cause and effect of the observed correlation and the component values completely and explaining the values of direct and indirect effects. The environmental influence on the tested genotypes is quite large, so that it affects the residual values were obtained from the results of cross-fingerprint analysis.
Figure 1. The correlation of grain yield components and correlation coefficients between components. x1 = number of filled grains; x2 = long empty grain panicles; x3 = 1000 grain weight; x4 = age of flowering; x5 = number of panicles; and x6 = plant height.

4. Conclusion
The yield of dried grain from 10 lines was higher than one or both comparators, namely BP11224F, BP12280-4F-7, BP57964F, BP11206F, BP12280-4F-7, BP12280-3F-16, BP12280-3F-2, BP122803F5, BP11208F-7, and BP12280-3f-13, which are supported by the high number of filled grains and weight of 1000 grain, so they were selected to be evaluated in the next generation. The value of R = 0.557, which means that there is a strong correlation between the components of growth and the level of yield. The value of R square = 0.310 indicates that the ability of the six growth components were observed affects the rice yield by 31% and there are still 69% other components that affect the yield.

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