Effects of high temperature and organic fertilizer on growth of several varieties of rice (*Oryza sativa* L) during the flowering stage

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Abstract. Climate change significantly increased the occurrence of high temperatures. High temperature significantly reduces rice yield and quality due to induced floret sterility in rice. Organic manure is one of the nutrients that is expected to maintain the soil temperature of rice. The study aims to determine the effect of application organic fertilizer in high temperature during the flowering stage in several varieties of rice (*Oryza sativa* L.). This research was conducted in a greenhouse with an average temperature of 28–34 °C from July to December 2020. The experiment consisted of 3 factors, namely: Varieties of Rice, V (IR64 and Gogo); Application of Organic Fertilizer, O (with and without organic fertilizer); and High Temperature, T (35 and 40 °C). The treatments were arranged in a completely randomized design with 4 replicates. Growth parameters observed were rice plant height, number of tillers, and rice biomass. The result showed that Interaction on varieties, application of organic fertilizer at a high temperature significantly reduce the rice plant height and rice biomass. The estimation of the global warming impact of rice growth can be predicted by this information and mitigating for it.

1. Introduction
Rice (*Oryza sativa* L.) is one of the main food crops for Indonesian people. Rice consumption needs in Indonesia from January to December 2018 are estimated at 29.57 million tons [1]. The increase in the population resulted in challenges to provide a sufficient and stable supply of rice. Rising global average temperatures have become a threat to food crop production, which could lead to a decline of more than 25% of key food yields by 2050 [2]. The issue of global climate change is one of the obstacles in efforts to increase national rice production. Evaluation of the estimated impact of global warming on rice production is important to secure rice supply. Thus, to develop rice cultivars with not only high yields but also tolerance to high temperatures [3].

Rice production can increase in an optimal environment. Rice can grow optimally in the temperature range of 27-32 °C and the limit of the temperature of 35 °C. The flowering phase is the most temperature-sensitive period [4]. Spikelets on flowers exposed to temperatures over 35°C for 3 days during the flowering and grain filling period induced floret sterility and do not form seeds cause the effect of elongation of anther dehiscence [3]. Based on modeling exercise, rice exposed to high temperature on 5
days coinciding with reproductive stages in 2050 more than 27% of the global rice-producing areas would be affected by heat stress exposure [5].

Various cultivation practices have been conducted to increase rice productivity in such as the addition of organic fertilizer in the soil to increase rice production in rice fields because there is soil amelioration in order to provide nutrients more effectively [6]. Plant nutrients were released into the soil eventually by application of the organic amendment [7]. Rice productivity improvement through the rice varieties tolerant to high temperatures has been widely developed in anticipation of future climate change. Therefore, it is necessary to conduct research on the influence of application organic fertilizer in high temperature during the flowering stage in several varieties. Differences in morphological character and physiology of each variety require a deep understanding of the impact of high temperatures on generative stadia on rice fertility. The study aims to determine the effect of application organic fertilizer in high temperature during the flowering stage in several varieties of rice (*Oryza sativa* L.).

2. Methods

2.1. Experimental material

The field experiment was conducted at the Greenhouse faculty of agriculture Sebelas Maret University. Research implemented in June 2020 until February 2021. The research was conducted using Complete Random Design (RAL). The plant materials used are varieties of IR 64 and Situ Bagendit (Gogo varieties). Seeds of the varieties used are sowed using a plastic tub for 14 days later transferred into a pot size of 5 kg and added organic fertilizer on treatment with the addition of organic fertilizer. Temperature treatment consists of 35°C (T1) and 40°C (T2). Temperature treatment is carried out by the transfer of plants coinciding with a reproductive stage for 3 days to the plant growth chamber. In each pot Urea, SP 36, and K Cl doses of 0.5, 0.5, and 0.5 g were provided as a basal dressing before transplanting. Irrigation is given periodically by maintaining a height as high as 2 cm. Grain harvesting is done at the time of 80% panicle yellowed. Harvesting is done by cutting the upper rice stem is then inserted into the envelope panicles. Observations on agronomic components consisted of: plant height at harvest, the total number of tillers, and dry weight at harvest.

2.2. Statistical analysis

Multiple comparisons were conducted using SPSS 25.0 software to determine the significance of variations. Afterward, the Duncan multiple range (DMR) test analysis was performed to determine the significance of variations between the treatments at a 95 % significance level. Figures were drawn using Microsoft Excel, 2017 version.

3. Result and discussion

Based on the results of the analysis of variance (ANOVA) the influence of varieties, temperature, and addition of organic fertilizer to plant variables is shown in Table 1. At the parameters of plant height, generally, the whole treatment has a significant effect on the height of the plant but on the interaction of varieties and the addition of organic fertilizer is not significant. In the treatment of the number of tillers, generally insignificant, but on the treatment of varieties and interactions between varieties and organic fertilizers significantly affected. In dry weight, the treatment of varieties, the interaction between temperature and the addition of organic fertilizers, and the interaction of all three have a very significant effect, on the treatment of the addition of organic fertilizer significantly.

3.1. Plant height

Plant height is one of the parameters that indicate the influence of the environment on plant growth [8]. Plant height is an indicator of plant growth that is easily measured and observed. The result of variance analysis showed that interaction between varieties, temperature, and the organic fertilizer applied in the soil had a significant effect on plant height.
Table 1. Summary of ANOVA test of the influence of varieties, temperature, and addition of organic fertilizers to plant growth.

| S     | db | Plant height (cm) | Number of tillers | Dry weight (g) |
|-------|----|-------------------|-------------------|----------------|
| V     | 1  | <0.01**           | <0.01**           | <0.01**        |
| T     | 1  | <0.01**           | ns                | Ns             |
| O     | 1  | <0.01**           | ns                | 0.006*         |
| V*T   | 1  | <0.01**           | ns                | Ns             |
| V*O   | 1  | ns                | 0.014*            | Ns             |
| T*O   | 1  | 0.011*            | ns                | <0.01**        |
| V*T*O | 1  | <0.01**           | ns                | <0.01**        |
| Error | 24 | 24                | 24                | 24             |
| Total | 32 | 32                | 32                | 32             |

Description: * : significant (p<0.05); ** : very significant (p<0.01); ns : non-significant (p>0.05) V : varieties; T : temperature; O : organic fertilizer; V*T : interaction of varieties and temperature; V*O : interaction of varieties and organic fertilizers; T*O : interaction of temperature and organic fertilizer; V*T*O : interaction of varieties, temperature, and organic fertilizer.

Figure 1. Influence of varieties, temperature, and organic fertilizer on plant height of rice (Oryza sativa L.). Description: Mean values are shown with letter group indicating significant differences based on the DMR (Duncan’s Multiple Range) tests.

Based on Figure 1, it can be known that the highest plant height is reported in the treatment of V1T1O2 (121.60 cm) which has a higher height of 1.26x than the treatment of V1T1O1. The treatment with the lowest value is the treatment with the interaction of IR 64 varieties and without the addition of organic fertilizer exposed at a temperature of 40 °C (V1T2O1). Plant height differences are a response to genetic differences and physiological responses to environmental conditions [8]. Gogo varieties (V2) have significantly higher plant height than IR 64 varieties (V1). Plant height is one of the growth variables is influenced by genetic factors of the variety. Genetic properties can affect the plant height beside the ability to the environment adaptation, so it can possible in the same environmental conditions will show a different response of plants height [9]. Based on figure 1 shows that the addition of organic fertilizer in the cultivation phase can increase the height of plants significantly compared to without the addition of organic fertilizer. It can be suspected that the increase in the height of plants in rice is caused by differences in nutritional sources, based on research observing that the addition of organic fertilizer in the form of compost on rice can increase the index of leaf area and height of plants because it produces photosynthate assimilation and higher accumulation of dry materials than without the addition of organic
fertilizer [10]. The addition of organic fertilizers can affect the height of plants as it is associated with increasing nitrogen in the soil and nitrogen uptake [11].

3.2 Number of tillers
The results of the variance analysis (Table 1) showed that the single factor of varieties had significantly increased the number of tillers. The productivity of rice plants can be determined by the number of tillers as one of the responses to the genetic properties of plants [12].

![Figure 2. Influence of single factor varieties on the number of tillers of rice (Oryza sativa L.). Description: Mean values are shown with letter group indicating significant differences based on the DMR (Duncan’s Multiple Range) tests.](image)

The result for the number of tillers shows no significant difference between the interactions of the treatments (Figure 2). Based on the figures shows that the IR 64 variety produces higher tillers (19 tillers/plant) than the gogo variety (13 tillers/plant). According to the Rice Standard Evaluation System, the number of tiller between IR 64 and gogo variety is medium. The genetic properties of plants can affect the number of tillers in ideal conditions and there are no limiting factors [13]. The different number of tillers in each variety is caused by the different genetic characteristics [8] and external factors such as environmental conditions, biotic factors, chemical, or biological fertilization [14].

3.3. Dry weight
The pattern of rice plants in absorbing the results of the process of photosynthesis of plants influenced by various environmental factors can affect the dry weight of rice plants [15]. The results of the variance analysis (Table 1) showed that the interaction between varieties, temperature and the addition of organic fertilizers had a significant effect on the dry weight of rice (Oryza sativa L.). It is suspected because of the addition of organic fertilizer as a provider of nutrients so that the interaction between the addition of organic fertilizer, varieties and temperature can optimize the dry weight of biomass plants.

![Figure 3. Influence of varieties, temperature and organic fertilizer on the dry weight of rice (Oryza sativa L.). Description: Mean values are shown with letter group indicating significant differences based on the DMR (Duncan’s Multiple Range) tests.](image)
Based on figure 3 showed that the highest dry weight in the treatment of V1T1O2 (91.80 g) which has a higher dry weight of plants 2.25x from the V1T1O1. It can be suspected that the addition of organic fertilizer can increase the dry weight of rice crops during harvest. Organic fertilizers with high N levels (more than 4%) and moderate P and K levels can increase biomass and rice crop yields (Oryza sativa L.) [16]. Organic fertilizer addition integrated with synthetic fertilizer could improve soil fertility, which in turn will have a positive role in achieving higher biomass and grain yield of rice [17].

4. Conclusion
Increasing high temperature during climate change decreasing rice growth. IR 64 varieties with stress temperature of 35°C and the application of organic fertilizer increase plant height and dry weight of rice plant. The V1T1O2 treatment had the highest plant height, which was 1.26x higher than the V1T1O1 treatment, and the highest dry weight, which was 2.22x higher than the V1T1O1.

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