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Testing of Plant Growth Regulator and Organic Fertilizers on Black Rice Plants

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ABSTRACT

One effort to increase food security is to increase rice production by providing adequate nutrition to rice plants with organic fertilizers and growth regulators (PGR). The aim of this study was to measure the growth and production of black rice (black oryza), as well as the distribution of the average plus or minus data through the treatment of various concentrations of PGR and doses of organic fertilizer. The research design was a two-factor factorial randomized block design. The first factor of PGR concentration (Z) consisting of 5, namely 0 (Z0), 1 (Z1), 1.5 (Z2), 2 (Z3) and 2.5 (Z4) ml/L of water. The second factor of organic fertilizer (P) consisting of 5, namely 0 (P0), 1 (P1), 2 (P2), 3 (P3) and 4 (P4) tons/ha. The treatment was repeated 5 times so that 125 experimental units were provided. The best grain yield 47.03 g/panicle was resulted from a single effect of PGR treatment at a concentration of 2 ml/L, whereas single treatment using organic fertilizer at a dose of 4 ton/ha produced grain of 46.23 g/panicle. The best combination of PGR concentration of 2 ml/L of water with organic fertilizer 4 tons/ha, resulted the highest grain yield of 50.24 g/panicle, equivalent to average dry harvested grain of 5.02 ton/ha or 3.26 ton/ha of dry unhusked grain. The distribution of the average plus minus data is good with a low average distribution for all measurement components.

1. INTRODUCTION

Rice is the most important food crop for Indonesian people. According to Statistic Agency (BPS, 2019) the average harvested area, production and productivity of rice for 3 years (2016 – 2018) has increased, respectively 1.80%, 0.52% and 2.33%. The average rice productivity for Kab. Wajo for 5 years (2013 – 2017) are 2013 (5.21), 2014 (4.87), 2015 (5.31), 2016 (5.30), and 2017 (5.25) (BPS, 2018). Black rice is good for diabetics, because of its high fiber content (Larasati, 2013), as well as nutritional content (Jaenudin *et al*., 2021). Anthocyanin is one of the causes of black color in rice (Maeda *et al*., 2014). The black rice of the Cempo Ireng type is capable of producing 6,935 tons/ha of dry unhulled rice and

the Inpari 24 variety only 6.7 tons/ha, with the height of the Cempo Ireng plant in the range of 120 cm. Improvement of black rice varieties using selected early maturing plants (Prastini & Damanhuri, 2017) is suitable for early crops (Warman *et al*., 2015).

Increasing rice production is an important effort to strengthen national food security. Increasing rice production can be done by providing adequate nutrition to rice plants in the form of organic fertilizers and growth regulators. Many organic fertilizers contain nutrients for plant growth and improvement of soil structure, while the application of growth regulators (PGR) is able to produce physiological, morphological and biochemical responses, so that they can stimulate and change plant growth and development. PGR can be naturally available in the form of organic materials, for example, palm wine, bamboo shoots, and corn sprout extract (Nurlaeni & Surya, 2015). These organic materials are easy to obtain, cheap, safe to use, and environmentally friendly.

According to (Asrijal *et al*., 2018), PGR from sweet corn extract is very good to use as a growth booster because it has a high hormone content compared to other types of corn, an auxin value of 27.93 ppm is obtained (Lab Dep. Biology, FMIPA-IPB, 2017). According to (Tetuko *et al*., 2015), that 100 ppm gibberellin hormone gave the highest results in increasing the germination percentage and germination rate of rubber seed (*Hevea brasilliensis* Mull. Arg). Giberilin can produce an average percentage of corn plant roots in the range of 59.05 – 63.44 percent at the age of 13 days of planting in the hydroponic system (Mulyani *et al*., 2020). Auxin is a plant hormone that can regulate physiological processes (Lawalata, 2011), including cell differentiation, protein synthesis, growth, and cell division. The content of certain plant hormones such as indole acetic acid (IAA) is included in the auxin group (Lestari, 2011), cytokinins, ethylene and gibberellic acid in plants can increase growth. Auxin functions as a trigger for the formation of lateral roots, cell elongation (Primilestari *et al*., 2019) and fibrous so that the absorption of water and minerals runs optimally (Zhao, 2010).

Organic fertilizers that have gone through engineering processes, are generally rich in mineral and microbial materials (Subardja *et al*., 2020) can increase soil organic matter and nutrient content, as well as improve physical properties (Andriyani & Patricia, 2021), soil biology and chemistry (Kaho & Naisanu, 2020; Sari *et al*., 2021), produces high organic C (Hendarto & Banjarnahor, 2021). According to (Asrijal, 2020), the use of organic fertilizer at a dose of 4 tons/ha, produces shallot bulbs var. Bima is high 17.23 tons/ha, then biological organic fertilizer can increase nutrient N absorption (201.33, 182.67, 170.67 and 161.33)% nutrient P (357.89, 273.68, 173.68 and 142.11)% and soybean yield (228.00, 208.00, 201.33 and 19 4.67) % (Marlina & Gusmiatun, 2020). According to (Fuady & Satriawan, 2019). Provision of organic fertilizers combined with inorganic fertilizers can increase the chlorophyll content of leaves (Buyana *et al*., 2019).

Based on the description above, an experiment was carried out to evaluate PGR and organic fertilizers on black rice plants. The aim of the research was to look at the single effect of PGR dan organic fertilizer, as well the interaction between PGR and organic fertilizer on black rice plants.

2. MATERIALS AND METHODS

This research is a continuation. The first research was the analysis of growth regulator (PGR) from four types of corn plants in the experimental field (Asrijal *et al*., 2018). Analysis for extract from corn as a growth regulator (PGR) was carried out at the SUA Usaha Jasa dan Industri, Biofuture Dep. Biologi, FMIPA-IPB in 2017. The PGR from

sweet corn extraction with the highest auxin and gibberellin content were 27.93 ppm and 442.83 ppm, respectively (Table 1).

The next research is testing PGR (sweet corn extract) and organic fertilizer on black rice rice plants in experimental gardens using bucket media. The research was carried out from February to June 2020 at the Experimental Field of Agriculture Faculty, Puangrimaggalatung University (Uniprima, Sengkang) located in Tonrongge, Wiringpalennae Village, Wajo Regency, South Sulawesi. The research materials were black rice seeds of Cempo Ireng, soil, water, sweet corn extract as PGR, and organic fertilizer. The tools in the study were plastic pot, machete, hoe, 2 liter hand sprayer, 5 ml syringe, plastic container, showering bucket (gembor), plastic, measuring tape, hammer, sickle, electric scale, camera, label paper, rubber strap, and stationery.

Table 1. Analysis of extract from some corn varieties as growth regulatory substance (PGR)

No.	Sample	IAA (ppm)	Giberelin (ppm)	Kinetin (ppm)
1.	Extract of sweet corn	27.93	442.83	34.57
2.	Extract of sticky corn	8.92	140.94	45.90
3.	Extract of white corn	18.39	398.96	41.12
4.	Extract of yellow corn	2.27	74.07	33.58

The PGR application begun by preparing 7 ml of extract, 5 L of water, 5 hand sprayers (2 liter capacity), 4 syringes (5 ml capacity), and 5 workers. Each hand sprayer was filled with 1 liter of water plus PGR extract of 0, 1.0, 1.5, 2.0, and 2.5 ml using a 5 ml syringe. The sprayer was shake so that the PGR mixed well with water. This preparation was carried out 5 times during the study for different PGR applications, namely at age of 10, 20, 30, 40 and 50 days after transplanting (DAT). The PGR was sprayed on all parts of the plant according to treatment concentrations, namely 0 (Z0), 1 (Z1), 1.5 (Z2), 2 (Z3), and 2.5 (Z4) ml/L of water.

Organic fertilizer application begun by preparing fermented materials including: 800 g dry chicken manure, 200 g rice bran, 100 ml EM4, sufficient water, measuring cup (500 ml), plastic container, plastic cover, rubber strap. The chicken manure and rice bran was put into the container, mixed thoroughly, added with EM4 which has been dissolved with 100 ml of water in a measuring cup. The mixed ingredients were ready to be fermented if the mixture was clenched by hand and did not scatter, if it was still scattered, add more water until the mixture was not scattered. The fermented material in the container was covered with plastic and tied tightly so that no oxygen enter. The lid of the container was opened every 2 days to release gas, stirred the mixture if it damp and then closed again. Fermentation was considered finished and the mixture was ready to be applied if mold is visible on the surface of the fermented material. Organic fertilizer was applied only once at a week before transplanting by placing it in a pot according to treatments 0 (P0), 1 (P1), 2 (P2), 3 (P3) and 4 (P4) tons/ha, which was equivalent to 0, 4, 8, 12 and 16 g/pot.

This study used a two-factor factorial randomized block design. The first factor was PGR concentration (Z) consisted of 5 levels, namely 0 (Z0), 1 (Z1), 1.5 (Z2), 2 (Z3), and 2.5 (Z4) ml/L of water. The second factor was organic fertilizer (P) consisting of 5 levels, namely 0 (P1), 1 (P1), 2 (P2), 3 (P3) and 4 (P4) ton/ha. Thus, there were 25 treatment combinations with five replications for each treatment, resulting in 125 experimental units. The plant parameters observed in this study were plant height and number of tillers at 60 DAT, number of panicles, length of panicles, weight of 100 grains, and

weight of grain per panicle at harvest. Data analysis used ANOVA (analysis of variance), followed by the Least Significant Difference (LSD) of 5% to find out the differences among the treatments using an Excel spreadsheet. The treatment that showed the highest significance value based on LSD was considered the best treatment.

Table 2. LSD test of the effect of treatment combination on the plant height and number of tillers of black rice at 60 DAT

Treatment combination	Plant Height (cm)	Number of tiller
PGR 0 ml/L water + PO 0 ton/ha	72.84 ^{n}	18.75 ^{i}
PGR 0 ml/L water + PO 1 ton/ha	75.48 ^{mn}	19.65 ^{hi}
PGR 0 ml/L water + PO 2 ton/ha	77.88 ^{lm}	20.39 ^{hi}
PGR 0 ml/L water + PO 3 ton/ha	81.72 ^{jk}	20.66 ^{hi}
PGR 0 ml/L water + PO 4 ton/ha	81.10 ^{jkl}	21.22 ^{ghi}
PGR 1 ml/L water + PO 0 ton/ha	78.90 ^{kl}	20.43 ^{hi}
PGR 1 ml/L water + PO 1 ton/ha	82.02 ^{jk}	21.03 ^{hi}
PGR 1 ml/L water + PO 2 ton/ha	84.42 ^{hij}	21.60 ^{fgh}
PGR 1 ml/L water + PO 3 ton/ha	85.74 ^{ghi}	22.32 ^{efgh}
PGR 1 ml/L water + PO 4 ton/ha	87.70 ^{fgh}	24.45 ^{de}
PGR 1.5 ml/L water + PO 0 ton/ha	81.22 ^{jkl}	21.01 ^{hi}
PGR 1.5 ml/L water + PO 1 ton/ha	86.76 ^{fghi}	23.78 ^{defg}
PGR 1.5 ml/L water + PO 2 ton/ha	87.82 ^{efg}	25.18 ^{cd}
PGR 1.5 ml/L water + PO 3 ton/ha	92.74 ^{bc}	28.66 ^{ab}
PGR 1.5 ml L^{-1}water + PO 4 ton/ha	94.52 ^{b}	29.36 ^{ab}
PGR 2 ml/L water + PO 0 ton/ha	81.92 ^{jk}	22.06 ^{efgh}
PGR 2 ml/L water + PO 1 ton/ha	91.14 ^{cde}	24.27 ^{def}
PGR 2 ml/L water + PO 2 ton/ha	92.22 ^{bcd}	27.75 ^{bc}
PGR 2 ml/L water + PO 3 ton/ha	95.14 ^{b}	29.43 ^{ab}
PGR 2 ml/L water + PO 4 ton/ha	100.60 ^{a}	31.17 ^{a}
PGR 2.5 ml/L water + PO 0 ton/ha	79.74 ^{kl}	20.91 ^{hi}
PGR 2.5 ml/L water + PO 1 ton/ha	83.40 ^{ij}	21.01 ^{hi}
PGR 2.5 ml/L water + PO 2 ton/ha	85.64 ^{ghi}	22.29 ^{efgh}
PGR 2.5 ml/L water + PO 3 ton/ha	88.34 ^{efg}	21.76 ^{efgh}
PGR 2.5 ml/L water + PO 4 ton/ha	89.20 ^{def}	23.93 ^{defg}
Overall average	**85.53**	**23.32**

Note: The average value followed by the same letter in the same column shows no significant difference at LSD test (α = 0.05)

3. RESULTS AND DISCUSSION

Analysis of variance of combinations between PGR concentrations and organic fertilizer doses had a significant effect on the height and number of tillers at the age of 60 HST. The 5% LSD test (Table 2), showed the interaction of PGR 2 ml/L water with organic fertilizer at a dose of 4 ton/ha (Z3P4) resulted the highest plant height (100.60 cm) and the highest number of tillers per clump (31.17 tillers) and they were significantly different compared to those of other treatments. While, the lowest yield was found in the interaction of PGR 0 ml/L water with organic fertilizer 0 ton/ha (Z0P0) with respectively 72.84 cm and 18.75 tillers. The overall mean height and number of tillers were 85.53 cm and 23.32 tillers, respectively. The distribution of the average plus minus standard deviation analysis obtained a good pattern with a low average

distribution, because the standard deviation value was generally much smaller than the mean value of interaction treatment (Figs. 1 and 2).

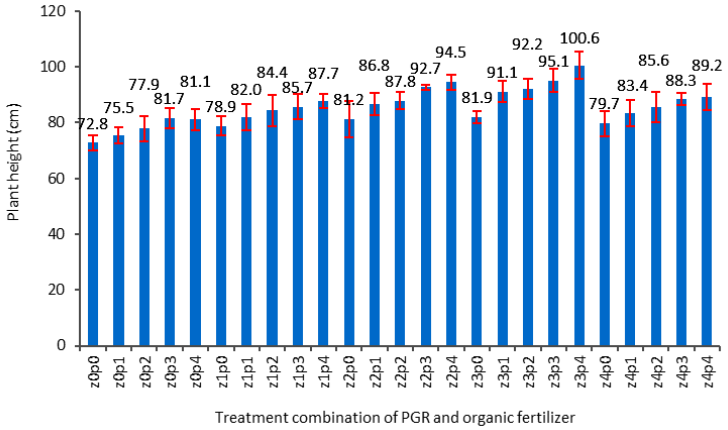

Figure 1. The average distribution plus minus standard deviation of treatment interaction PGR with organic fertilizer on the plant height of black rice Cempo Ireng.

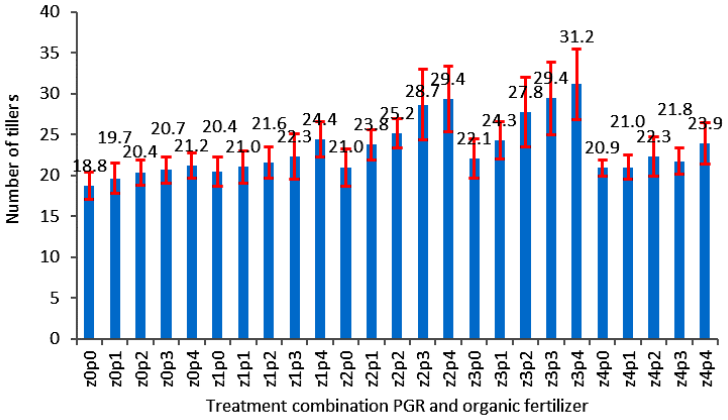

Figure 2. The average distribution plus minus standard deviation of treatment interaction PGR with organic fertilizer on the number of tillers of black rice Cempo Ireng.

Cempo Ireng rice is grouped as short variety with plant height in the range of 72.84 – 100.60 cm. According to IRRI (2015), short plants are <100 cm and medium plants are 100 – 120 cm. Short plants provide benefits from photosynthesis (Ahimsya *et al*., 2018; Winarsih *et al*., 2017) that allocate a lot to the formation of seeds (Afifah *et al*., 2020), reduce lodging (Aryana *et al*., 2018), and minimize bird attack. The range of number of tillers was 18.75 – 31.17 per clump, classified as medium (Ahimsya *et al*., 2018) to very high productive tillers >25 (IRRI, 2015). The number of rice tillers is heavily influenced by environmental factors, including soil organic matter (Sari *et al*., 2021), plant spacing, and climatic conditions including irradiation, water availability, and temperature (Afifah *et al*., 2020; Komalasari *et al*., 2019). The low Leaf Area Index (LAI) causes a low contribution to production (Ramadhan *et al*., 2019; Susanti & Safrina, 2018). Rice with high number of tillers is especially suitable for tidal land (Dirgasari *et al*., 2019; Gribaldi *et al*., 2020).

Table 3. The results of the BNT test α=0.05 on the components of black rice production at harvest time

Treatment combination	Number of panicle	Length of panicle (cm)	Weight 100 grains	Grain yield per panicle
PGR 0 ml/L water + PO 0 ton/ha	9.21 ^{j}	22.70 ^{o}	1.80 ^{m}	37.59 ^{o}
PGR 0 ml/L water + PO 1 ton/ha	9.59 ^{ij}	23.19 ^{no}	1.85 ^{lm}	38.12 ^{no}
PGR 0 ml/L water + PO 2 ton/ha	9.90 ^{hij}	23.55 ^{mno}	1.89 ^{klm}	38.82 ^{no}
PGR 0 ml/L water + PO 3 ton/ha	9.98 ^{hij}	23.93 ^{lmn}	1.94 ^{kl}	39.89 ^{mn}
PGR 0 ml/L water + PO 4 ton/ha	10.42 ^{ghi}	24.93 ^{jkl}	2.37 ^{j}	40.74 ^{lm}
PGR 1 ml/L water + PO 0 ton/ha	10.02 ^{hij}	24.63 ^{klm}	1.98 ^{k}	40.68 ^{lm}
PGR 1 ml/L water + PO 1 ton/ha	10.52 ^{fghi}	25.33 ^{hijk}	2.42 ^{ij}	42.05 ^{jkl}
PGR 1 ml/L water + PO 2 ton/ha	10.68 ^{fghi}	26.16 ^{fghi}	2.45 ^{hij}	43.49 ^{ij}
PGR 1 ml/L water + PO 3 ton/ha	11.68 ^{cdef}	27.25 ^{def}	2.45 ^{hij}	44.17 ^{hi}
PGR 1 ml/L water + PO 4 ton/ha	12.18 ^{cd}	28.17 ^{bcd}	2.48 ^{ghi}	45.42 ^{fgh}
PGR 1.5 ml/L water + PO 0 ton/ha	10.42 ^{ghi}	24.74 ^{jklm}	2.43 ^{ij}	41.33 ^{klm}
PGR 1.5 ml/L water + PO 1 ton/ha	11.88 ^{cde}	26.70 ^{efg}	2.43 ^{ij}	46.41 ^{ef}
PGR 1.5 ml/L water + PO 2 ton/ha	13.44 ^{ab}	27.64 ^{cde}	2.51 ^{fghi}	47.57 ^{cde}
PGR 1.5 ml/L water + PO 3 ton/ha	13.74 ^{a}	28.31 ^{bcd}	2.51 ^{fghi}	48.36 ^{bcd}
PGR 1.5 ml L^{-1}water + PO 4 ton/ha	14.18 ^{a}	29.83 ^{a}	2.73 ^{ab}	49.23 ^{abc}
PGR 2 ml/L water + PO 0 ton/ha	10.14 ^{ghij}	25.01 ^{ijkl}	2.45 ^{ij}	42.08 ^{jkl}
PGR 2 ml/L water + PO 1 ton/ha	11.97 ^{cde}	26.96 ^{efg}	2.59 ^{defg}	45.98 ^{efg}
PGR 2 ml/L water + PO 2 ton/ha	12.38 ^{bc}	28.59 ^{bc}	2.67 ^{bcd}	47.42 ^{de}
PGR 2 ml/L water + PO 3 ton/ha	13.77 ^{a}	29.36 ^{ab}	2.70 ^{abc}	49.43 ^{ab}
PGR 2 ml/L water + PO 4 ton/ha	14.28 ^{a}	30.50 ^{a}	2.81 ^{a}	50.24 ^{a}
PGR 2.5 ml/L water + PO 0 ton/ha	10.43 ^{ghi}	24.90 ^{jkl}	2.53 ^{efghi}	41.23 ^{klm}
PGR 2.5 ml/L water + PO 1 ton/ha	10.82 ^{efgh}	25.42 ^{hijk}	2.57 ^{defgh}	42.77 ^{ijk}
PGR 2.5 ml/L water + PO 2 ton/ha	10.97 ^{efgh}	25.91 ^{ghij}	2.60 ^{cdef}	43.77 ^{hij}
PGR 2.5 ml/L water + PO 3 ton/ha	11.08 ^{defgh}	26.42 ^{fgh}	2.64 ^{bcde}	44.53 ^{ghi}
PGR 2.5 ml/L water + PO 4 ton/ha	11.26 ^{cdefg}	26.85 ^{efg}	2.74 ^{ab}	45.50 ^{fgh}
Overall average	**11.40**	**26.28**	**2.42**	**43.87**

Note: The average values followed by the same letter in the same column shows no significant difference at LSD (α = 0.05)

Analysis of the variance of combinations between PGR concentrations and organic fertilizer doses significantly affected the number and length of panicles, the weight of 100 grains, and production at harvest. The 5% LSD test (Table 3), showed the interaction of PGR 2 ml/L water with organic fertilizer 4 ton/ha (Z3P4) resulted the highest number and length of panicles, the weight of 100 grains, and the production at harvest (respectively 14.28 panicles, 30.50 cm, 2.81 g, and 50.24 grains/panicle) and they were significantly different compared to those of other treatments. The lowest results was found in the interaction of PGR 0 ml/L water with organic fertilizer 0 ton/ha (Z0P0) as many as (9.21 panicles; 22.70 cm; 1.80 g, and 37.59 grains/panicle). The overall average number and length of panicles, weight of 100 grain, and grain production was respectively 11.40 panicles, 26.28 cm, 2.42 g, and 43.87 grains/panicle. The distribution of the average plus minus data through standard deviation analysis obtained the results of the interaction of the PGR treatment with organic fertilizer on the number of panicles, panicle length, 100 grain weight, and grain production per panicle at harvest, is classified as good with a low average distribution. The standard deviation values are generally smaller than the average value of treatment interactions (Figures 3, 4, 5, and 6).

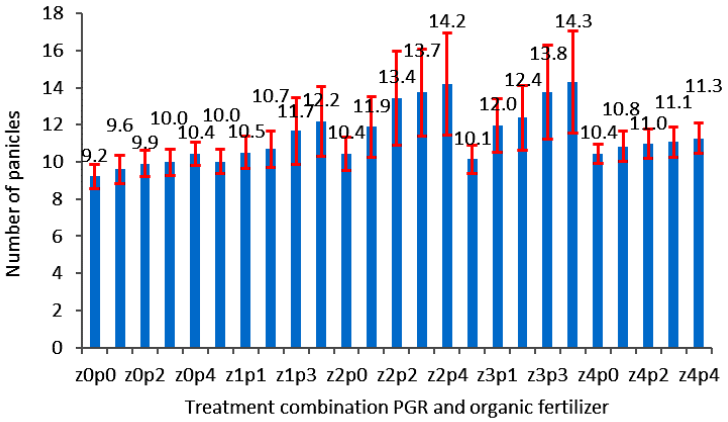

Figure 3. The average distribution plus minus standard deviation of treatment interaction PGR with organic fertilizer on the number of panicle of black rice Cempo Ireng.

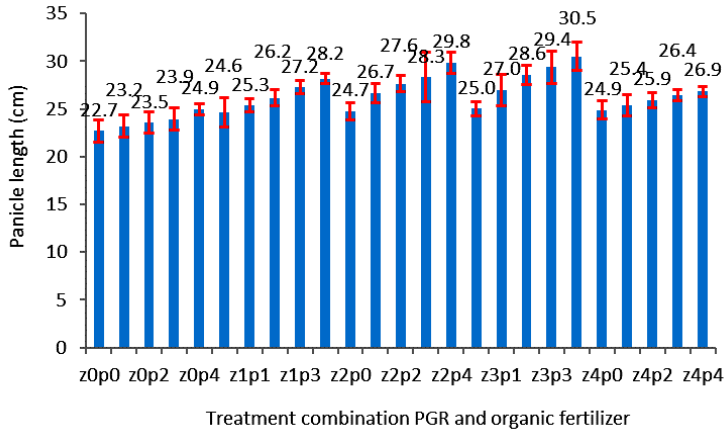

Figure 4. The average distribution plus minus standard deviation of treatment interaction PGR with organic fertilizer on the length of panicle of black rice Cempo Ireng.

The number of panicles was in the range of 9.21 – 14.28 panicles at harvest (Figure 3). The number of panicles affects grain production (Anggraini *et al*., 2013) with different densities. The number of productive panicles results in total plant productivity (Mohanan & Mini, 2007), panicle length 22.70 – 30.50 cm at harvest with an average of 26.28 cm. Research results of Prabawa & Purba (2019) obtained an average of 23.52 to 25.09 cm. While, the average panicle length is 21.10-23.96 cm (Figure 4). According (IRRI, 2015) rice plant with the panicle length of 15-25 cm is classified as medium. Optimal panicle length results in good rice grains (Fatimaturrohmah *et al*., 2016).

The weight of 100 grains (Figure 5) was 1.80 – 2.81 g at harvest with an average of 2.42 g, which was higher than the results of study by (Ahimsya *et al*., 2018) with the average weight of 100 rice grains to be 2.07 g. Our result was close to the research by Prabawa & Purba (2019) using the colchicine treatment with the average yield of the Cempo Ireng rice in the range of 2.42 g to 2.58 g per 100 grains.

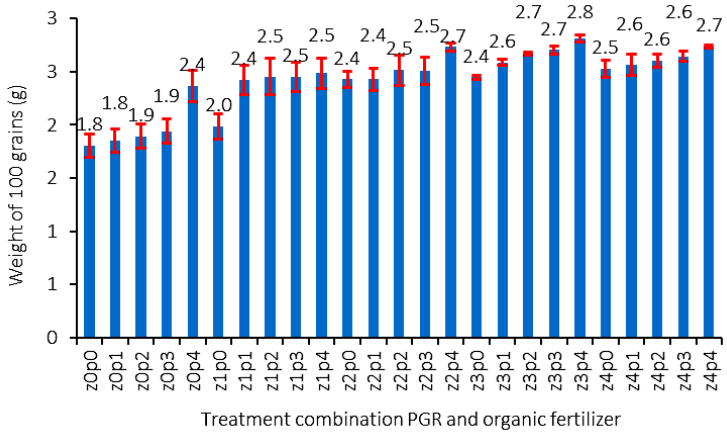

Figure 5. The average distribution plus minus standard deviation of treatment interaction PGR with organic fertilizer on the weight of 100 grains of black rice Cempo Ireng.

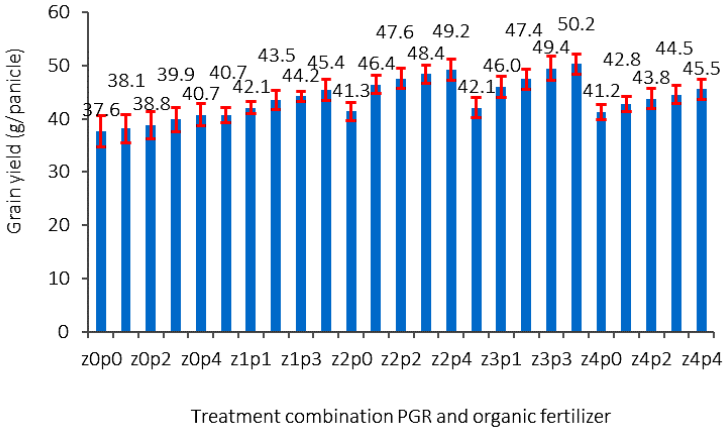

Figure 6. The average distribution plus minus standard deviation of treatment interaction PGR with organic fertilizer on the grain yield of black rice Cempo Ireng.

The average grain yield at harvest was 43.87 grain/panicle (Figure 6) which was equivalent to 4.39 ton/ha (harvest dry grain). While the research results of (Jamilah & Haryoko, 2019) obtained 4.04 ton/ha. This numbers demonstrate that Cempo Ireng is good candidate for black rice variety to be developed. In this context, there is a need to do a socialization on the counseling of black rice cultivation and post-harvest (Wicaksono *et al*., 2018).

4. CONCLUSION

The best black rice grain resulted from a single PGR treatment with a concentration of 2 ml/L of water was 47.03 g/panicle, and 46.23 g/panicle was produced from a single organic fertilizer treatment (dose 4 ton/ha). While the best results of the combination of PGR concentration of 2 ml/L of water with organic fertilizer 4 tons/ha, the highest harvested dry grain (GKP) of 50.24 g/panicles was obtained. This figure is equivalent to average GKP of 5.02 ton/ha or an average of 3.26 tons/ha dry unhusked grain (GKG). Furthermore, the distribution of the average plus minus data is good with a low

average distribution for all measurement components. It is recommended for future researchers to use PGR with a concentration of 2 ml/L water with a variation of organic fertilizer types at dose larger than 4 ton/ha or replace organic fertilizer with compost from recycled organic waste.

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