

# Agronomic character of ratoon rice Stem cutting sizes and seprint liquid organic fertilizer



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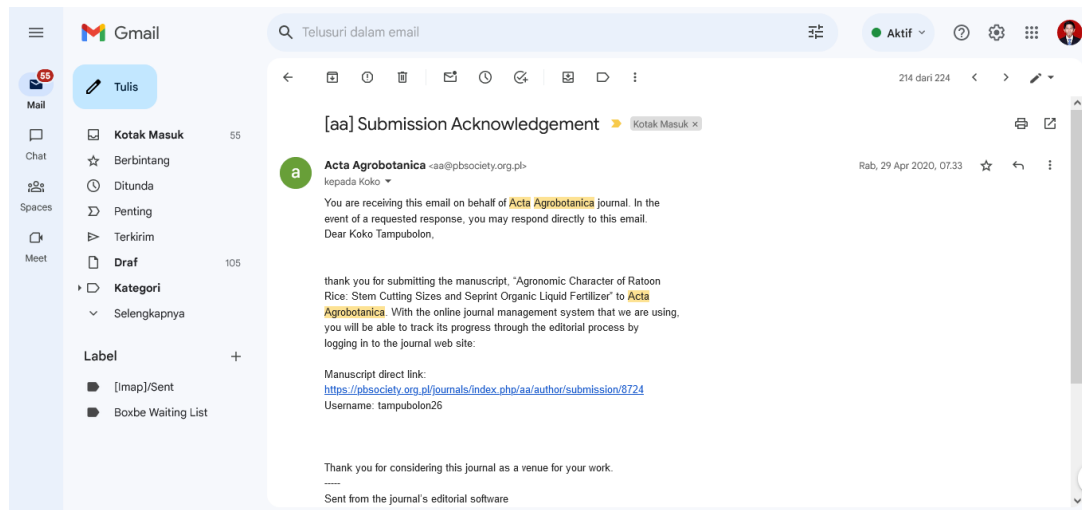
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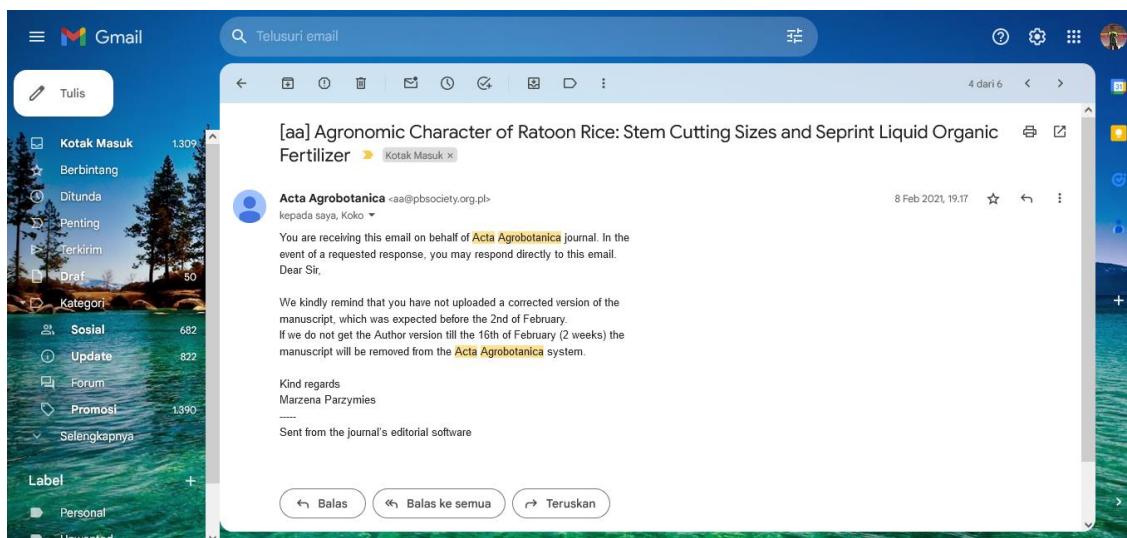
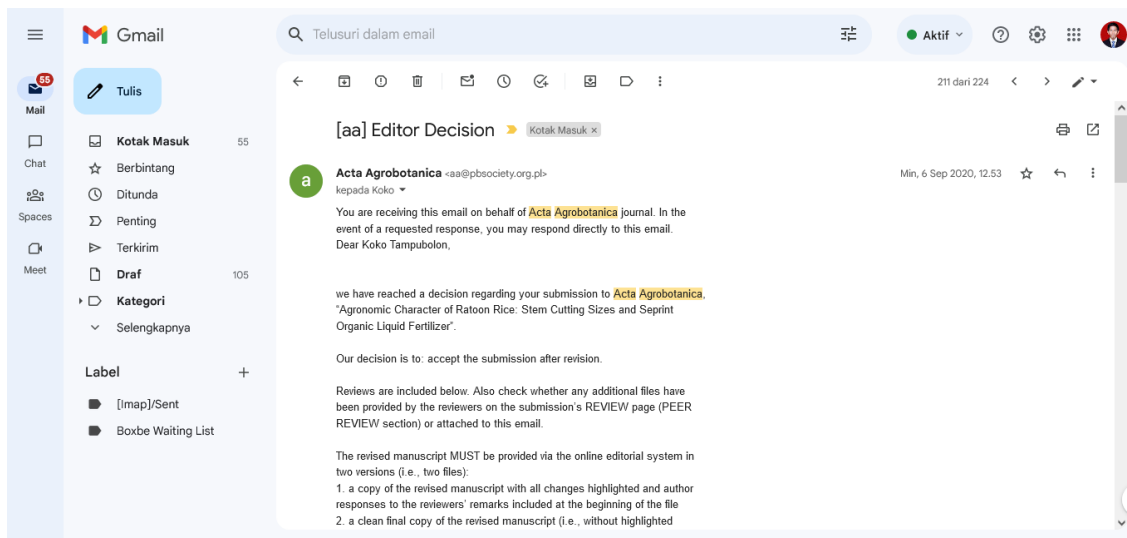
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**ORIGINAL RESEARCH PAPER**

**Agronomic Character of Ratoon Rice: Stem Cutting Sizes and Seprint Organic Liquid Fertilizer**

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**ABSTRAK**

The research aimed to identify the optimum size of rice stem cutting (ratoon) in combination with the application of Seprint liquid organic fertilizer (SLOF) in promoting the growth and production of the ratoon rice variety Inpari 30. This study used the rice variety Inpari 30 that was harvested 115 days after planting and then continued with the post-harvest cutting of the rice stems and SLOF application. This

research was conducted in the greenhouse, Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, North Sumatra Province, Indonesia from January until August 2018. Moreover, the study was set-up as a completely randomized factorial design with four replications. The first factor consisted of rice stem cutting (R1= 5 cm, R2= 10 cm, R3= 15 cm) and the second factor involved SLOF dosage (S1= 5 ml.l<sup>-1</sup>, S2= 10 ml.l<sup>-1</sup>, S3= 15 ml.l<sup>-1</sup>). The parameters were analyzed using the analysis of variance (ANOVA) and the mean was determined by Duncan's test at the level of 5% using IBM SPSS statistics v.20 software. The results showed that cutting 10 cm of the rice stem significantly increased the height of the ratoon rice of 20.33 to 53.89 cm at 10 until 30 days after cutting (DAC), the number of tillers amounted to 25.58 to 29.08 tillers at 40 until 60 DAC and production.ha<sup>-1</sup> of 3.58 tons.ha<sup>-1</sup>. The giving of 10 ml.l<sup>-1</sup> and 15 ml.l<sup>-1</sup> SLOF significantly increased the production.hill<sup>-1</sup> and the height of ratoon rice amounted to 54.32 g and 35.71 cm at 20 DAC, respectively. The combination of cutting 10 cm of the rice stem with 5 ml.l<sup>-1</sup> and 10 ml.l<sup>-1</sup> SLOF significantly increased the number of filled grains.panicle<sup>-1</sup> and the height of ratoon rice amounted to 114.30 grains and 27.98 cm at 10 DAC, respectively.

**Keywords:** dosages; growth; production; ratoon rice; seprint liquid organic fertilizer.

## **Running Head : Growth and Production of Ratoon Rice**

## **INTRODUCTION**

Food is a basic human need and sufficient, nutritious and safe food can lead to quality human resources. One food that is a major source of energy is grain (rice). According to USDA data, the countries that have the highest level of rice consumption in the world are located in Asia. Countries with the highest level of rice consumption in

the World from 2015 until 2019 were China of 29.66%, India of 20.39%, Indonesia of 7.88%, Bangladesh of 7.32%, and Vietnam of 4.54% (USDA in Ministry of Agriculture, 2019). In Indonesia, rice is the main food needs of more than 90% of populations. Consumption rice per capita tends to decrease, from 107.71 kg.capita<sup>-1</sup>.year<sup>-1</sup> in 2002 to be 96.33 kg.capita<sup>-1</sup>.year<sup>-1</sup> in 2018 (Ministry of Agriculture, 2019). Domestic rice production from year to year continues to increase, although it had a trend towards a slower growth rate. Indonesia population growth had increased linearly from 2005 to 2015 (226.71 to 258.16 million) and the projected population until 2035 is estimated up to 305.65 million (Badan Pusat Statistik, 2019). The total domestic consumption of Indonesian rice will continue to increase even though per capita shown decreased.

Increased domestic consumption of rice in Indonesia must be followed by the program to increase rice production through intensification. One of the intensification programs that can be conducted by the system cultivation of ratoon rice. Mengel & Wilson, (1981) stated that the ratoon is a technique of harvesting production from tillers from main plant stumps that can increase grain yield without increasing land area. The ratoon technique is used to shorten the age of rice harvest. Maturing of hybrid rice varieties was needed at 105 until 124 days after scattering or around of 4 months (Balai Besar Penelitian Padi Kementerian Pertanian, 2019). Therefore, in a year can only be 2-fold the rice planting until harvesting. The ratoon system can produce 3- to 4-fold of rice harvesting. The advantages of the ratoon system are the higher efficiency of resource use per unit area of land and unit per timing (Santos et al., 2003), reducing land preparation, saving the cost of planting seeds (Zandstra & Samson, 1979), saving use of

machine, efficient use water (Prashar, 1970) and saving the time of planting because reduction in growth time (Haque & Coffman, 1980).

System cultivation of ratoon rice has been reported by researcher, Pratama et al., (2018) stated that the time of cutting the remaining stumps on 10 days of rice harvest was significantly on the largest root diameter of 0.89 mm with stump cutting height of 4 cm above the soil surface and could up to grain productivity of 3.39 to 3.54 tons.ha<sup>-1</sup>. Nuzul et al., (2018) stated that the highest yield component and yield of rice were achieved in the cutting at harvest with the height of 3 cm above the soil surface with grain yield of 3.54 tons.ha<sup>-1</sup>. Susilawati et al., (2012) stated that the cutting height of ratoon rice was related to the internode of plant, the nodes contain lateral shoots which will produce shoots of ratoon. Jichao & Xiaohui, (1996) stated that the number of growing shoots can be determined by the cutting height of the main plant stems, but the condition is strongly influenced by residual assimilates as reserves in the stems that can be utilized for ratoon growth, and the rate of ratoon vigor. The stem cutting height of the main plant can also affect the number of tillers and seed yields (Harrel et al., 2009) and triggers dormant shoots to grow (Mahadevappa & Yogeessa, 1988).

However, the system of rice cultivation cannot be separated from the use of fertilizer to achieve optimal production. Islam et al., (2008) reported that the fertilizer application of N= 130 kg.ha<sup>-1</sup>, P<sub>2</sub>O<sub>5</sub>= 75 kg.ha<sup>-1</sup>, K<sub>2</sub>O= 80 kg.ha<sup>-1</sup>, S= 13 kg.ha<sup>-1</sup>, Zn= 4 kg.ha<sup>-1</sup> significantly increased the yield of the Boro rice ratoon by 1.42 tons.ha<sup>-1</sup>. The high price of fertilizer with limited availability had resulted in the use of liquid organic fertilizer to be an alternative to increase the availability and efficiency of irrigation rice nutrient uptake. The effect of liquid organic fertilizer on the growth and yield of irrigation rice has been widely reported, but the use of liquid organic fertilizer on the

growth and production of ratoon rice is still relatively limited. Thus, a special assessment of the specific liquid organic fertilizers impact is needed to increase the growth and production of ratoon rice. The research aimed to identify the optimum size of rice stem cutting (ratoon) in combination with the Seprint liquid organic fertilizer (SLOF) application in promoting growth and production of the ratoon rice variety Inpari 30.

## **MATERIAL AND METHODS**

### **Experiment I (Preliminary Research Stage)**

The source of the main plant (rice variety Inpari 30) from Balai Pengkajian Teknologi Pertanian (BPTP) Pasar Miring, Pasar Miring Village, Pagar Merbau Sub-district, Deli Serdang District, North Sumatra Province, Indonesia. Planting was conducted in the water bucket of 20 l with an upper diameter of 31 cm, the lower diameter of 22 cm and the height of 31 cm (Figure 1). Planting was conducted at the greenhouse in the Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, Indonesia on January until August 2018. The water bucket is filled with soil from the Salemba area, Amplas, Medan City. The soil into the water bucket until less 5 cm from the water bucket surface. The water bucket was inundated with water up to the vegetative phase of the main plant, then the water in the bucket was reduced to the bearing capacity toward harvesting. The main plant was harvested at 115 days after planting then cutting of the rice stem (experiment II).

### **Experiment II (Main Research Stage)**

Experiment II continues the experiment I. After the rice was harvested, stem rice was conducted with cutting based on the size of treatment (Figure 2). The water bucket

was inundated when cutting rice stems until the vegetative phase was done. Then reduce the water toward the harvesting of ratoon rice plants. The giving of Seprint Liquid Organic Fertiliser (SLOF) was conducted at a week after cutting of rice stems. The main nutrient content of SLOF is 11% N, and 2% K<sub>2</sub>O (Source: Bunga Tani Products).

#### **Design Research and Data Analyzed**

This research was used in the Completely Randomized factorial Design with four replications. The first factor consisted of rice stem cutting (R1= 5 cm, R2= 10 cm, R3= 15 cm), and the second factor involved SLOF dosage (S1= 5 ml.l<sup>-1</sup>, S2= 10 ml.l<sup>-1</sup>, S3= 15 ml.l<sup>-1</sup>). The distance between treatments of 50 cm x 50 cm. The parameters of this research were the height and the growth quickness of ratoon rice, the number of tillers at 10 to 60 Days After Cutting (DAC), the yield component of ratoon rice (the number of the productive tillers, the number of grains.penicle<sup>-1</sup>, the number of filled grains.penicle<sup>-1</sup>, the number of empty grains.penicle<sup>-1</sup>, 1000 grains weight, the production.hill<sup>-1</sup>, and the production.ha<sup>-1</sup>). The calculation of the growth quickness and production.ha<sup>-1</sup> of ratoon rice can be seen in equations 1 and 2.

$$\text{Growth quickness (cm.day}^{-1}\text{)} = \frac{\text{Average height of ratoon rice}}{\text{days of cutting}} \quad (1)$$

$$\text{Production.ha}^{-1} = \text{NP} \times \text{NPT} \times \text{NFGP} \times 1000\text{-GW} \quad (2)$$

Note :

$$\text{NP} = \text{number population.ha}^{-1} = \frac{\text{land area.ha}^{-1}}{\text{plant spacing}} = \frac{10,000 \text{ m}^2}{0.5 \text{ m} \times 0.5 \text{ m}} = 40,000 \text{ populations.}$$

NPT = number of productive tillers

NFGP = number of filled grains.penicle<sup>-1</sup>

1000-GW = 1000 grains weight (g)

The parameters were analyzed using the analysis of variance (ANOVA) and the mean was determined by DMRT at the level of 5% using IBM SPSS statistics v.20 software.

## **RESULTS**

### **Height and Growth Quickness of Ratoon Rice**

Based on the ANOVA showed that cutting stems significantly increased the height of ratoon rice at 10 to 30 DAC, in contrast not significantly at 40 to 60 DAC. The giving of SLOF significantly increased the height of the ratoon rice at 20 DAC, in contrast not significantly at 10, 30, 40, and 60 DAC. Interaction of the cutting of rice stems with SLOF showed significantly increased the height of ratoon rice at 10 DAC, in contrast, not significant at 20 until 60 DAC (Table 1). The results showed that the cutting 10 cm of the rice stem was increased the highest of the height of ratoon rice at 10-60 DAC compared to other cutting sizes, although it has significantly at 10-30 DAC. The giving of 15 ml.l<sup>-1</sup> SLOF was increased the highest of the height of ratoon rice at 10-40 DAC compared to other doses, although it was significant only at 20 DAC. The highest of the height of ratoon rice was found in the given 10 ml.l<sup>-1</sup> SLOF at 60 DAC. Interaction of the cutting 10 cm of rice stem with 10 ml.l<sup>-1</sup> SLOF (R2S2) is the combination significantly increased the height of ratoon rice amounted to 27.98 cm at 10 DAC. Whereas the highest of the height of ratoon rice was found in the combination cutting 10 cm of the rice stem with 15 ml.l<sup>-1</sup> SLOF (R2S3) at 20 until 60 DAC.

### **Number of Ratoon Rice Tillers**

Based on the ANOVA showed that the cutting of rice stems significantly increased the number of ratoon rice tillers at 40-60 DAC, in contrast not significantly at

10-30 DAC. The giving SLOF and their interactions showed not significantly increased the number of ratoon rice tillers (Table 2). The results showed that the cutting 10 cm of the rice stem can impact in increasing the highest of the number of ratoon rice tillers at 10-60 DAC compared to other cutting sizes, although significantly was found in 40 until 60 DAC. The giving of 10 ml.l<sup>-1</sup> SLOF (S2) was given the highest of the number of ratoon rice tillers of 25.33 tillers until the end observation (60 DAC) compared to other doses. The combination cutting 10 cm of the rice stem with 15 ml.l<sup>-1</sup> SLOF (R2S3) was given the highest of the number of ratoon rice tillers of 36.25 tillers at 60 DAC compared to other combinations.

#### **Yield Component of Ratoon Rice**

Based on the ANOVA showed that the cutting of rice stems, SLOF dosages, and their interactions not significantly on the yield component of ratoon rice (the number of productive tillers, the number of grains.panicle<sup>-1</sup>, the number of empty grains.panicle<sup>-1</sup>, and 1000 grains weight) (Figure 3-5). The results showed that the cutting 10 cm of the rice stem (R2) was given the highest of the number of productive tillers, the number of grains.panicle<sup>-1</sup>, the number of empty grains.panicle<sup>-1</sup>, and 1000 grains weight amounted to 35.75 tillers, 116.77 grains, 19.08 grains, and 25.91 g, respectively compared to other cutting sizes. The giving 10 ml.l<sup>-1</sup>, 5 ml.l<sup>-1</sup>, 15 ml.l<sup>-1</sup> of SLOF also given the highest of the number of productive tillers, 1000 grains weight, the number of grains.panicle<sup>-1</sup>, and the number of empty grains.panicle<sup>-1</sup> amounted to 32.75 tillers, 25.92 g, 113.59 grains, and 17.89 grains, respectively compared to other doses. The combination cutting 10 cm of the rice stem with 10 ml.l<sup>-1</sup>, 5 ml.l<sup>-1</sup>, 15 ml.l<sup>-1</sup> of SLOF was given the highest of the number of productive tillers, 1000 grains weight, the number of grains.panicle<sup>-1</sup>, and the

number of empty grains.panicle<sup>-1</sup> amounted to 41.50 tillers, 26.78 g, 139.85 grains, and 15.60 grains, respectively compared to other combinations.

Based on the ANOVA showed that the cutting of rice stems and SLOF dosages not significantly on the number of filled grains.panicle<sup>-1</sup>, in contrast, their interactions significantly increased the number of filled grains.panicle<sup>-1</sup> of ratoon rice (Figure 3-5). The results showed that cutting 10 cm of the rice stem (R2) was given the highest of the number of filled grains.panicle<sup>-1</sup> of 97.58 grains compared to other cutting sizes. The giving of 10 ml.l<sup>-1</sup> SLOF (S2) was given the highest of the number of filled grains.panicle<sup>-1</sup> of 91.53 grains compared to other doses. The combination cutting 10 cm of the rice stem with 5 ml.l<sup>-1</sup> SLOF (R2S1) significantly increased the highest of the number of filled grains.panicle<sup>-1</sup> of 114.30 grains compared to other combinations.

Based on the ANOVA showed that the SLOF dosages significantly increased the production.hill<sup>-1</sup> of ratoon rice, in contrast, the cutting of the rice stems and their interactions not significantly increased the production.hill<sup>-1</sup> of ratoon rice (Figure 3-5). The results showed that the giving of 10 ml.l<sup>-1</sup> SLOF (S2) significantly increased in the highest of the production.hill<sup>-1</sup> of ratoon rice amounted to 54.32 g compared to other doses. The cutting 10 cm of the rice stem (R2) was given the highest of the production.hill<sup>-1</sup> of ratoon rice of 46.56 g compared to other cutting sizes. The combination cutting 10 cm of the rice stem with 10 ml.l<sup>-1</sup> SLOF (R2S2) was given the highest of the production.hill<sup>-1</sup> of ratoon rice amounted to 60.63 g compared to other combinations.

Based on the ANOVA showed that the cutting of rice stems significantly increased the production.ha<sup>-1</sup> of ratoon rice, in contrast, the SLOF dosages and their interactions not significantly increased the production.ha<sup>-1</sup> of ratoon rice (Figure 6). The

results showed that the cutting 10 cm of the rice stem (R2) significantly increased the highest of the production.ha<sup>-1</sup> of ratoon rice amounted to 3.58 tons.ha<sup>-1</sup> compared to other cutting sizes. The giving of 10 ml.l<sup>-1</sup> SLOF was given the highest of the production.ha<sup>-1</sup> of ratoon rice amounted to 3.12 tons.ha<sup>-1</sup> compared to other dosages, whereas the combination cutting 10 cm of rice stem with 15 ml.l<sup>-1</sup> SLOF (R2S3) was given the highest of the production.ha<sup>-1</sup> of ratoon rice amounted to 3.88 tons.ha<sup>-1</sup> compared to other combinations.

## **DISCUSSION**

The cutting 10 cm of the rice stem significantly increased the highest of the height of ratoon rice at 10-30 DAC. The result similar to the growth quickness of ratoon rice on the cutting 10 cm was higher (1.20 to 2.03 cm.day<sup>-1</sup>) compared to the cutting 5 cm and 15 cm, ranging from 0.89 to 1.26 cm.day<sup>-1</sup> and 1.05 to 1.49 cm.day<sup>-1</sup>, respectively. This is caused by the optimal carbohydrates supply that the emergence of ratoon shoots. The results of this research were authenticated that the higher or smaller of the ratoon rice variety Inpari 30 does not show the higher of the height growth compared to cutting 10 cm. This is consistent with the height and the number of ratoon rice tillers at cutting 10 cm was higher compared to other sizes (Table 1-2). The optimal cutting size of rice stems will support the growth and production of ratoon rice. According to Vergara et al., (1988) stated that the optimal cutting height of ratoon rice ranged from 15-20 cm with leaving 2 to 3 internode able to increased vigor and seed production on panicles of ratoon. Santos et al., (2003) stated that a decrease in yield ranging from 12-37% in the cutting < 5 cm of rice stem, while the cutting > 20 cm of rice stem can be produced tillers faster emerge in contrast the number of grains was fewer compared to the optimal cutting size. Susilawati et al., (2012) stated that the

height of the ratoon rice genotype IPB106-F-8-1 at the cutting 10 cm was higher compared to the cutting 20 cm and 30 cm.

The giving of 15 ml.l<sup>-1</sup> SLOF significantly increased the highest of the height of ratoon rice at 20 DAC. This is caused by the SLOF have the main nutrient content of 11% N more higher compared to K nutrient (2%) with the result that the dose of 15 ml.l<sup>-1</sup> SLOF can support the photosynthesis level and have an impact on increasing the vegetative phase of ratoon rice. This is linear with the height of ratoon rice at the dose 15 ml.l<sup>-1</sup> SLOF was higher compared to other dosages at 20 DAC (Table 1). According to Gardner et al., (1985) stated that nitrogen is a structural component of important organic compounds, such as amino acids, proteins, nucleoproteins, various enzymes, purines, and pyrimidines. Nitrogen is needed by plants in cell division and enlargement that the optimum giving of nitrogen will increase the plant's vegetative phase. Engelstad, (1997) stated that the optimal giving of N nutrients can support plant growth, increased protein synthesis, increased chlorophyll formation and increased the plant root shoot ratio.

The combination cutting 10 cm of rice stem with 10 ml.l<sup>-1</sup> SLOF (R2S2) significantly increased the height of the ratoon rice amounted to 27.98 cm at 10 DAC. This authenticates the combination of cutting 10 cm of rice stem with 10-15 ml.l<sup>-1</sup> SLOF was showed the highest of the height of ratoon rice compared to other combinations. This is caused to the main nutrients N and K in the 10 to 15 ml.l<sup>-1</sup> of SLOF dosages can be promoted the photosynthesis rate in forming assimilates at cutting 10 cm as to stimulate the growth process of the ratoon rice, such as plant height, number of tillers, and the number of productive tillers (Table 1-2, Figure 3-5). According to Nurhayati, (2009) stated that the application of liquid organic fertilizer can be promoted

the process of metabolism in plants through the process of nutrient solubility, that nutrient transport will be going well from the roots to all parts of the plant. Hamzah, (2014) stated that the use of liquid organic fertilizer can an increase plant height, the number of branches, and the number of soybean pods.

The cutting 10 cm of rice stem significantly increased the highest of the number of ratoon rice tillers at 40-60 DAC. This is caused by that result assimilate in the optimal cutting of ratoon can be produced well vegetative growth. This is can be seen from the growth quickness of ratoon rice on cutting 10 cm was higher compared to other cutting sizes (Table 1). This is supported by the number of ratoon rice productive tillers on cutting 10 cm higher compared to other cutting sizes (Figure 3-5 ). According to Harrel et al., (2009) stated that the height cutting of the main plant stems can also affect the number of tillers and seed yields. Susilawati et al., (2012) stated that the number of ratoon rice productive tillers on genotypes IPB106-F-8-1 in the cutting 10 cm was higher compared to the cutting 20 cm and 30 cm.

The combination cutting 10 cm of rice stem with 5 ml.l<sup>-1</sup> SLOF (R2S1) significantly increased the highest of the number of filled grains.panicle<sup>-1</sup> amounted to 114.30 grains. This is caused by the giving of SLOF that can be stimulated the metabolic process with growth quickness of ratoon rice on cutting 10 cm that the results of photosynthesis will form assimilates and lead to production grain.panicle<sup>-1</sup>. According to Nurhayati, (2009) stated that the application of liquid organic fertilizer can be supporting the process of metabolism in plants through the process of nutrient solubility, that nutrient transport going well from the roots to all parts of the plant. Susilawati et al., (2012) stated that the cutting 10 cm of the IPB106-F-8-1 genotype rice stem significantly increased the number of grain.panicle<sup>-1</sup> and was higher of 108.0

grains compared to cutting 20 cm of rice stem amounted to 78.5 grains and the cutting 30 cm of rice stem amounted to 71.1 grains. Mareza et al., (2016) stated that the cutting 10 cm of rice stem significantly improved the length of the panicle (14.93 cm) and the number of grains.panicle<sup>-1</sup> of ratoon rice (47.05 grains) compared to cutting 20 until 50 cm of rice stem.

The giving of 10 ml.l<sup>-1</sup> SLOF (S2) significantly increased the highest of the production.hill<sup>-1</sup> of ratoon rice amounted to 54.32 g. This is caused the main nutrient content in SLOF (N= 11% and K= 2%) had an important role in cell division and increases assimilation has an impact on increasing biomass and production of ratoon rice. According to Gardner et al., (1985) stated that nitrogen nutrient was needed by plants in cell division and enlargement that the giving of optimum nitrogen will increase the plant's vegetative phase. Vachhani & Patel, (1996) stated that the application of K fertilizer can increase the vegetative growth of the onion plant. Vidigal et al., (2002) stated that the growth of onion was increased progressively with the increasing application of K fertilizer. El-Bassiony, (2006) stated that K fertilizer was affected by increasing the dry weight of the onion plant.

The cutting 10 cm of stem rice (R2) can significantly increased the highest of the production.ha<sup>-1</sup> of ratoon rice amounted to 3.58 tons.ha<sup>-1</sup> compared to other cutting sizes. The production.ha<sup>-1</sup> of ratoon rice on the research was smaller compared to the production.ha<sup>-1</sup> of main plants (rice variety Inpari 30) when the initial planting up to 5.08 tons.ha<sup>-1</sup>, or the production was reduced by 29.53% of the main plant. This is caused the growth pattern (the height and number of tillers) of ratoon rice were higher in cutting 10 cm compared to other cutting sizes that the results of photosynthesis produced will be distributed in the assimilates form and produce filled grains. This is

linear with the number of productive tillers, the number of filled grains.panicle<sup>-1</sup> and 1000 grains weight on the cutting 10 cm was higher compared to other cutting sizes (Figure 3-5). According to Harrel et al., (2009) stated that the height cutting stems of the main plant can affect the number of tillers and grains production. Susilawati et al., (2012) stated that the production.ha<sup>-1</sup> ratoon rice genotype IPB106-F-8-1 on the cutting of 10 cm was greater of 2.1 tons.ha<sup>-1</sup> compared to the cutting 20 cm of 1.6 tons.ha<sup>-1</sup> and the cutting 30 cm of 1.1 tons.ha<sup>-1</sup>. Nuzul et al., (2018) also stated that the yield of ratoon rice was decreased from 6.54 tons.ha<sup>-1</sup> to 2.70 tons.ha<sup>-1</sup> or amounted to 58.72% of main plants.

The application of ratoon rice technology combine with the SLOF greatly encourages of rice production in achieving food sufficiency, because in a year of rice cultivation (main plants and ratoon technology) can produce an average production of 8.66 tons.ha<sup>-1</sup>. Thus, farmers will get a double benefit by applying ratoon technology in a cycle of irrigation rice.

## CONCLUSIONS

The cutting 10 cm of rice stem significantly increased the height of ratoon rice ranging from 20.33 to 53.89 cm at 10 until 30 DAC, the number of tillers ranging from 25.58 to 29.08 tillers at 40 until 60 DAC and the production.ha<sup>-1</sup> of ratoon rice amounted to 3.58 tons.ha<sup>-1</sup>. The giving of 15 ml.l<sup>-1</sup> SLOF significantly increased the height of ratoon rice amounted to 35.71 cm at 20 DAC, and the 10 ml.l<sup>-1</sup> SLOF also significantly increased the production.hill<sup>-1</sup> of ratoon rice amounted to 54.32 g. The combination cutting 10 cm of rice stem with 10 ml.l<sup>-1</sup> SLOF significantly increased the height of ratoon rice amounted to 27.98 cm at 10 DAC and the combination cutting 10 cm of rice stem with 5 ml.l<sup>-1</sup> SLOF also significantly increased the number of filled

grains.panicle<sup>-1</sup> of ratoon rice amounted to 114.30 grains. The application cutting 10 cm of rice stem combined with various dosages of SLOF showed that the higher growth and production of ratoon rice compared to other cutting sizes.

## ACKNOWLEDGMENTS

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## TABLES

Table 1. Effect of rice stems cutting and SLOF on the height of ratoon rice at 10 until 60 days after cutting (DAC).

| Treatment             | Height of Ratoon Rice (cm) |          |           | average  | Growth quickness (cm.day <sup>-1</sup> ) |
|-----------------------|----------------------------|----------|-----------|----------|------------------------------------------|
|                       | S1                         | S2       | S3        |          |                                          |
| 10 Days After Cutting |                            |          |           |          |                                          |
| R1                    | 9.46 d-h                   | 7.05 h   | 10.33 c-h | 8.95 b   | 0.89                                     |
| R2                    | 7.45 gh                    | 27.98 a  | 25.55 a   | 20.33 a  | 2.03                                     |
| R3                    | 13.13 b-h                  | 8.90 fgh | 9.45 e-h  | 10.49 b  | 1.05                                     |
| average               | 10.01                      | 14.64    | 15.11     |          |                                          |
| 20 Days After Cutting |                            |          |           |          |                                          |
| R1                    | 15.53                      | 17.35    | 22.93     | 18.60 b  | 0.93                                     |
| R2                    | 15.25                      | 42.35    | 48.80     | 35.47 a  | 1.77                                     |
| R3                    | 27.90                      | 12.73    | 35.40     | 25.34 ab | 1.27                                     |
| average               | 19.56 b                    | 24.14 ab | 35.71 a   |          |                                          |
| 30 Days After Cutting |                            |          |           |          |                                          |
| R1                    | 31.28                      | 39.95    | 36.88     | 36.04 b  | 1.20                                     |
| R2                    | 39.70                      | 58.33    | 63.63     | 53.89 a  | 1.80                                     |
| R3                    | 46.40                      | 38.13    | 49.93     | 44.82 ab | 1.49                                     |
| average               | 39.13                      | 45.47    | 50.15     |          |                                          |
| 40 Days After Cutting |                            |          |           |          |                                          |
| R1                    | 46.90                      | 52.98    | 50.73     | 50.20    | 1.26                                     |
| R2                    | 61.90                      | 63.93    | 75.23     | 67.02    | 1.68                                     |
| R3                    | 60.70                      | 54.28    | 55.83     | 56.94    | 1.42                                     |
| average               | 56.50                      | 57.06    | 60.60     |          |                                          |
| 60 Days After Cutting |                            |          |           |          |                                          |
| R1                    | 59.20                      | 65.80    | 58.18     | 61.06    | 1.02                                     |
| R2                    | 67.50                      | 70.38    | 77.53     | 71.80    | 1.20                                     |
| R3                    | 67.93                      | 66.28    | 64.63     | 66.28    | 1.10                                     |
| average               | 64.88                      | 67.49    | 66.78     |          |                                          |

Note: Data was followed by different letters on the same line show significantly different based on the DMRT test at the level 5%. Size cutting of rice stems (R1= 5 cm; R2= 10 cm; R3= 15 cm). SLOF dosages (S1= 5 ml.l<sup>-1</sup>; S2= 10 ml.l<sup>-1</sup>; S3= 15 ml.l<sup>-1</sup>).

Table 2. Effect of rice stems cutting and SLOF on the number of ratoon rice tillers at 10 until 60 DAC.

| Treatment             | Number of Ratoon Rice Tillers |       |       | average  |
|-----------------------|-------------------------------|-------|-------|----------|
|                       | S1                            | S2    | S3    |          |
| 10 Days After Cutting |                               |       |       |          |
| R1                    | 6.75                          | 2.00  | 3.75  | 4.17     |
| R2                    | 7.00                          | 7.00  | 6.00  | 6.67     |
| R3                    | 8.00                          | 5.00  | 4.50  | 5.83     |
| average               | 7.25                          | 4.67  | 4.75  |          |
| 20 Days After Cutting |                               |       |       |          |
| R1                    | 8.75                          | 4.25  | 5.00  | 6.00     |
| R2                    | 8.25                          | 14.50 | 15.25 | 12.67    |
| R3                    | 15.00                         | 9.00  | 8.75  | 10.92    |
| average               | 10.67                         | 9.25  | 9.67  |          |
| 30 Days After Cutting |                               |       |       |          |
| R1                    | 9.00                          | 7.25  | 8.00  | 8.08     |
| R2                    | 9.25                          | 19.25 | 24.00 | 17.50    |
| R3                    | 20.00                         | 12.75 | 15.00 | 15.92    |
| average               | 12.75                         | 13.08 | 15.67 |          |
| 40 Days After Cutting |                               |       |       |          |
| R1                    | 10.75                         | 12.00 | 10.50 | 11.08 b  |
| R2                    | 10.50                         | 33.25 | 33.00 | 25.58 a  |
| R3                    | 22.75                         | 23.00 | 19.50 | 21.75 ab |
| average               | 14.67                         | 22.75 | 21.00 |          |
| 60 Days After Cutting |                               |       |       |          |
| R1                    | 13.00                         | 13.25 | 13.25 | 13.17 b  |
| R2                    | 16.00                         | 35.00 | 36.25 | 29.08 a  |
| R3                    | 24.00                         | 27.75 | 23.50 | 25.08 a  |
| average               | 17.67                         | 25.33 | 24.33 |          |

Note: Data was followed by different letters on the same line show significantly different based on the DMRT test at the level 5%. Size cutting of rice stems (R1= 5 cm; R2= 10 cm; R3= 15 cm). SLOF dosages (S1= 5 ml.l<sup>-1</sup>; S2= 10 ml.l<sup>-1</sup>; S3= 15 ml.l<sup>-1</sup>).

## FIGURES

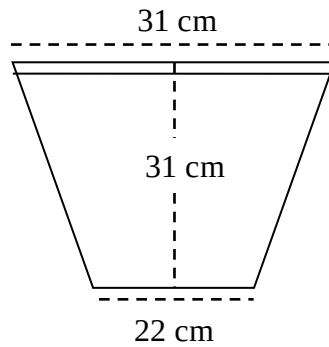


Figure 1. The size of the water bucket.



Figure 2. Design experiment II.

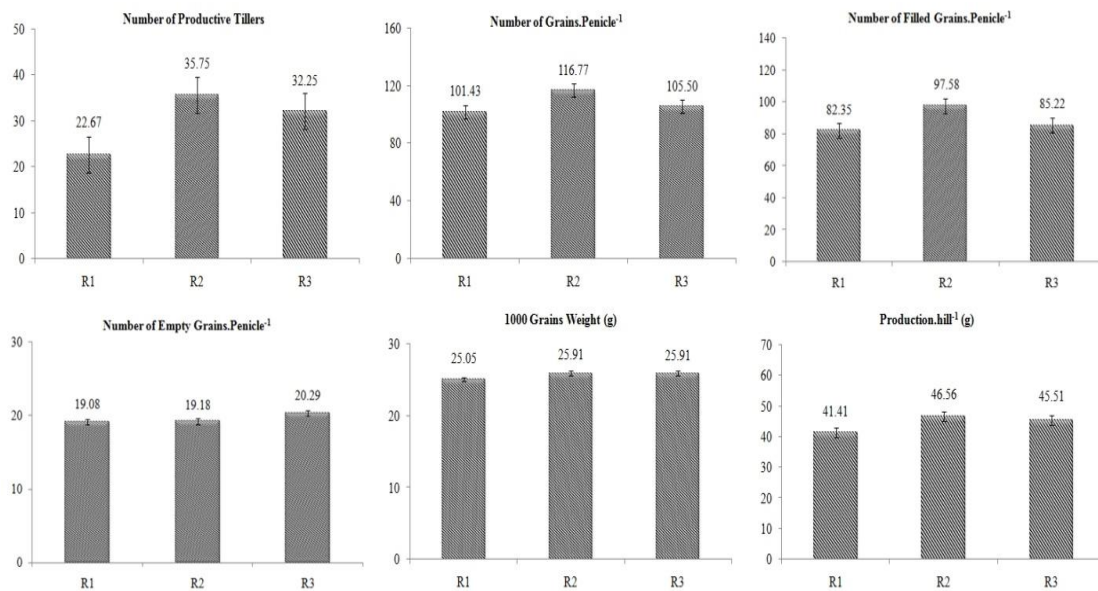


Figure 3. Effect of rice stem cutting sizes (R1= 5 cm; R2= 10 cm; R3= 15 cm) on the yield component of ratoon rice. Data followed by different letters on the same line show significantly different based on the DMRT test at the level of 5%  $\pm$  SE.

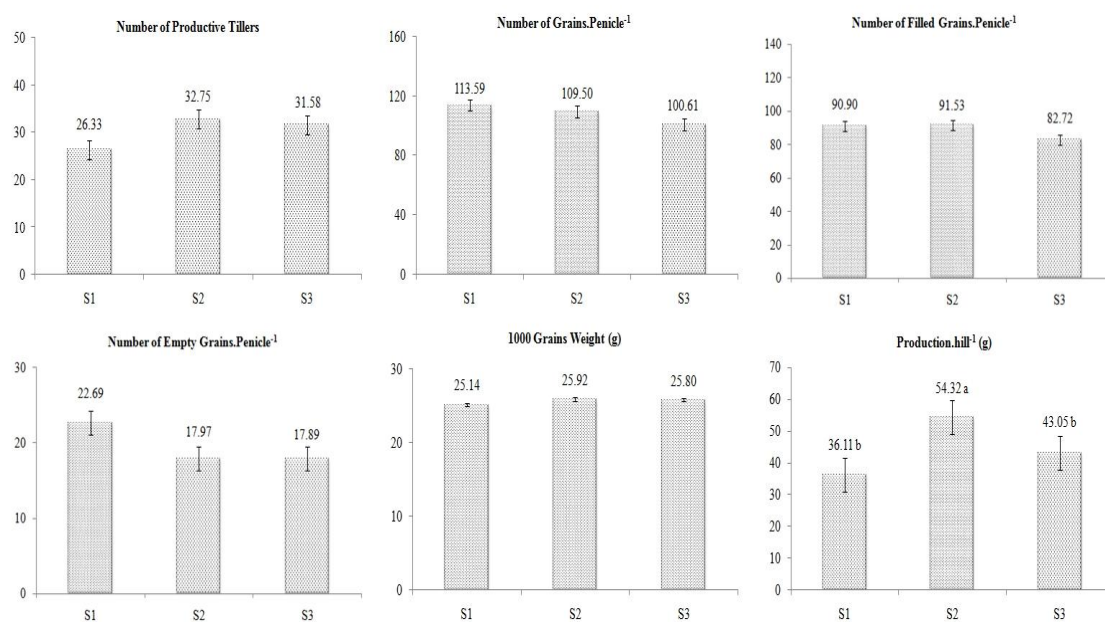


Figure 4. Effect of SLOF dosages (S1= 5 ml.l<sup>-1</sup>; S2= 10 ml.l<sup>-1</sup>; S3= 15 ml.l<sup>-1</sup>) on the yield component of ratoon rice. Data followed by different letters on the same line show significantly different based on the DMRT test at the level of 5%  $\pm$  SE.

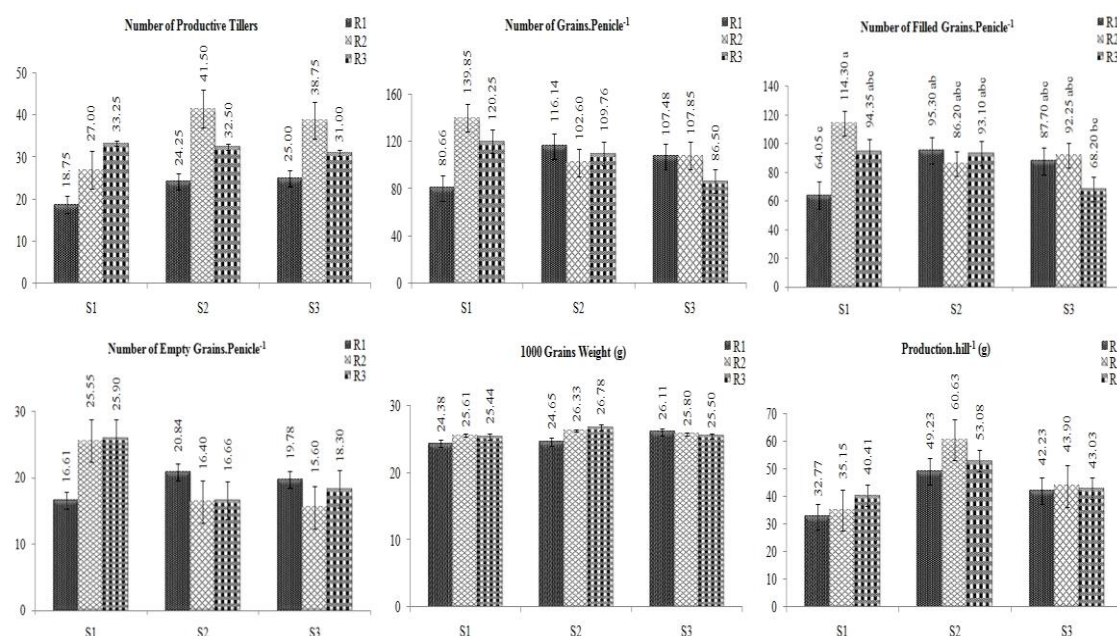


Figure 5. The combinations of stem cutting sizes (R1 = 5 cm; R2 = 10 cm; R3 = 15 cm) and SLOF dosages (S1= 5 ml.l<sup>-1</sup>; S2= 10 ml.l<sup>-1</sup>; S3= 15 ml.l<sup>-1</sup>) on the yield component of ratoon rice. Data followed by different letters on the same line show significantly different based on the DMRT test at the level 5%  $\pm$  SE.

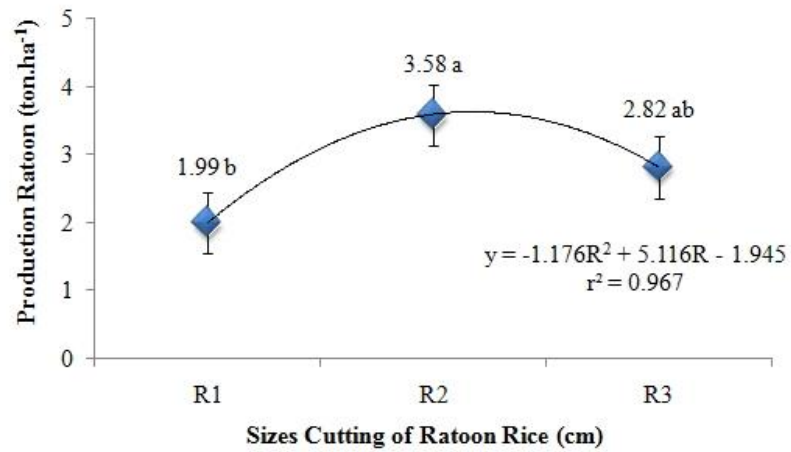


Figure 6. Effect of rice stem cutting sizes (R1= 5 cm; R2= 10 cm; R3= 15 cm) on the production.ha<sup>-1</sup> of ratoon rice. Data followed by different letters on the same line show significantly different based on the DMRT test at the level of 5% ± SE.

## [aa] Editor Decision

You are receiving this email on behalf of Acta Agrobotanica journal. In the event of a requested response, you may respond directly to this email.

Dear Koko Tampubolon,

we have reached a decision regarding your submission to Acta Agrobotanica, "Agronomic Character of Ratoon Rice: Stem Cutting Sizes and Seprint Organic Liquid Fertilizer".

Our decision is to: accept the submission after revision.

Reviews are included below. Also check whether any additional files have been provided by the reviewers on the submission's REVIEW page (PEER REVIEW section) or attached to this email.

The revised manuscript MUST be provided via the online editorial system in two versions (i.e., two files):

1. a copy of the revised manuscript with all changes highlighted and author responses to the reviewers' remarks included at the beginning of the file
2. a clean final copy of the revised manuscript (i.e., without highlighted changes and author responses).

Detailed guideline on how to submit the revised manuscript is available at:

[pbsociety.org.pl/journals/index.php/aa/pages/view/helpforauthors#q6](https://pbsociety.org.pl/journals/index.php/aa/pages/view/helpforauthors#q6)

The revised manuscript should be uploaded within one month; if provided later the revised version will be considered as a new submission.

Prof. dr hab. Bożena Denisow  
Editor-in-Chief,

Acta Agrobotanica

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Reviewer B:

Does the title accurately reflect the content of the article?:

Yes

Are the current state of knowledge and the aim of the study presented properly?:

No

Has the authors used appropriate and coherent research methods?:

No

Were the results correctly interpreted and the conclusions well justified?:

No

Are the figures, tables and photos appropriate and necessary?:

No

Is the article grammatically and stylistically correct?:

No

What is scientific significance of the paper?:

Should not be published in this journal

Other comments::

First of all, English was very poor thus it was hard to understand. Authors did not make a clear argument and raise the probleme and weak explanation of why they tested this particular organic liquid fertiliser in the introduction. In M&M, authors should have explained why they used this particular genotype of rice and the fertiliser they used. the explanations were missing. Statistic analysis was confusing, hard to understand.

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Reviewer D:

Does the title accurately reflect the content of the article?:

Yes

Are the current state of knowledge and the aim of the study presented properly?:

Yes

Has the authors used appropriate and coherent research methods?:

Yes

Were the results correctly interpreted and the conclusions well justified?:

No

Are the figures, tables and photos appropriate and necessary?:

Yes

Is the article grammatically and stylistically correct?:

Yes

What is scientific significance of the paper?:

Important in some respect

Other comments::

The reviewed article presents new content and interesting research. However, doubts are raised by the presentation, discussion and methodology. The comments are presented below and collected in the points:

1. There is no information about chemical composition of the water and the soil in which rice was grown. In studies where fertilization was a factor, this element is necessary for the correct interpretation of the obtained results.
2. No Seprint Liquid Organic Fertilizer (SLOF) performance. What was the form of nitrogen in this fertilizer? The potassium content is given once as K and as K<sub>2</sub>O. If the fertilizer contained 2% of K<sub>2</sub>O converted to K it would be only 1.66%. This error appears throughout the work. Does this fertilizer contain phosphorus, which is responsible for plant tillering? Is it a fertilizer without micronutrients?
3. The specified units are incorrect. Tons per kg, liters per dm<sup>-3</sup> should be changed according to the SI system. The entries ml.l<sup>-1</sup> are incorrect, it should be ml · dm<sup>-3</sup>
4. Discussions should be extended with new items of literature because the work is mostly based on the literature from 1980-1990.
5. In the discussion, lines 294 and 246 contain the same informations. Information on the influence of nitrogen and potassium on the yielding should be extended.
6. Poor quality of figure 5, no statistics in the figures.

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**ORIGINAL RESEARCH PAPER**

**Agronomic Character of Ratoon Rice: Stem Cutting Sizes and Seprint Liquid Organic Fertilizer**

**ABSTRACT**

The research aimed to identify the optimum size of rice stem cutting (ratoon) in combination with the application of Seprint liquid organic fertilizer (SLOF) in promoting the growth and yield of the ratoon rice. This research was conducted in the greenhouse, Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, North Sumatra Province, Indonesia from January to August 2018. The research was set-up as completely randomized design factorial within four replications. The first factor

involved the cutting sizes of the rice stem (R1= 5 cm, R2= 10 cm, R3= 15 cm) and the second factor involved SLOF dosages, including S1= 5 ml l<sup>-1</sup>, S2= 10 ml l<sup>-1</sup>, S3= 15 ml l<sup>-1</sup>. Parameters were analyzed using the ANOVA and the means was determined by Duncan Multiple Range Test (DMRT) at 5% using IBM SPSS statistics v.20 software. The results showed that cutting 10 cm of the rice stem significantly increased the ratoon rice height at 10 until 30 days after cutting (DAC), number of tillers at 40 until 60 DAC, the number of productive tillers, and the yield ha<sup>-1</sup>. The SLOF at the dose of 10 and 15 ml l<sup>-1</sup> significantly increased the yield hill<sup>-1</sup> and the ratoon rice height at 20 DAC. The combination of cutting 10 cm of the rice stem with SLOF at the dose of 5 and 10 ml l<sup>-1</sup> significantly increased the number of filled grains panicle<sup>-1</sup> and the ratoon rice height at 10 DAC. Application cutting steem at 10 cm combined with various dosages of SLOF resulted the greater growth and yield of ratoon rice in achieving food sufficiency.

**Keywords:** dosage; growth; yield; ratoon rice; seprint liquid organic fertilizer.

## **Running Head : Growth and Yield of Ratoon Rice**

## **INTRODUCTION**

Food is a basic human need and sufficient, nutritious and safe food can lead to quality human resources. One food that is a major source of energy is grain (rice). According to USDA data, the countries that have the highest level of rice consumption in the world are located in Asia. Countries with the highest level of rice consumption found in China by 29.66%, India by 20.39%, Indonesia by 7.88%, Bangladesh by 7.32%, and Vietnam by 4.54% of the world from 2015 to 2019 (USDA in Ministry of Agriculture, 2019). In Indonesia, rice is the main food needs of more than 90% of populations. Consumption rice capita<sup>-1</sup> tends to decrease, from 107.71 kg capita<sup>-1</sup> year<sup>-1</sup>

in 2002 to be 96.33 kg capita<sup>-1</sup> year<sup>-1</sup> in 2018 (Ministry of Agriculture, 2019). Domestic rice yield from year to year continues to increase, although it had a trend towards a slower growth rate. Indonesia population growth had increased linearly from 2005 to 2015 at 226.71 until 258.16 million and the projected population until 2035 is estimated up to 305.65 million (Statistics of Indonesia, 2019). The total domestic consumption of Indonesian rice will continue to increase even though per capita shown decreased.

Increased domestic consumption of rice in Indonesia must be followed by the program to increase rice yield through intensification. One of the intensification programs that can be conducted by the system cultivation of ratoon rice. Mengel & Wilson, (1981) stated that the ratoon is a technique of harvesting production from tillers from main plant stumps that can increase grain yield without increasing land area. The ratoon technique is used to shorten the age of rice harvest. Maturing of hybrid rice varieties was needed at 105 until 124 days after scattering or around of 4 months (Indonesian Center for Rice Research, 2019). Therefore, in a year can only be 2-fold the rice planting until harvesting. The ratoon system can produce 3- until 4-fold of rice harvesting. The advantages of the ratoon system are the higher efficiency of resource use per unit area of land and unit per timing (Santos et al., 2003), reducing land preparation, saving the cost of planting seeds (Zandstra & Samson, 1979), and saving the time of planting because reduction in growth time (Haque & Coffman, 1980). In addition, the ratoon rice is considered by farmers because of its high quality including cooking, flavor, short growing, reduce the cost of water, fertilizer and pest control (Yazdpour et al., 2012). Alizadeh & Habibi, (2016) also reported that the grain thickness and amylose content for ratoon rice was higher ranged of 1.18 to 2.25% and 2.28 to 7.69% compared to the main crop.

System cultivation of ratoon rice has been reported, Pratama et al., (2018) stated that the time of cutting the remaining stumps on 10 days of rice harvest was significantly on the largest root diameter of 0.89 mm with stump cutting height of 4 cm above the soil surface and could up to grain productivity of 3.39 to 3.54 ton ha<sup>-1</sup>. Nuzul et al., (2018) stated that the highest yield component (number and length of panicle, harvest age, grain number panicle<sup>-1</sup>, filled grain, 1000-grains weight, total dry weight, harvest indeks) and yield (grain ha<sup>-1</sup>) of rice were achieved in the cutting at harvest with the height of 3 cm above the soil surface with the grain yield of 3.54 ton ha<sup>-1</sup>. Susilawati et al., (2012) stated that the cutting height of ratoon rice was related to the internode of plant, the nodes contain lateral shoots which will produce shoots of ratoon. Jichao & Xiaohui, (1996) stated that the number of growing shoots can be determined by the cutting height stems of the main plant, but the condition is strongly influenced by residual assimilates as reserves in the stems that can be utilized for ratoon growth, and the rate vigor of ratoon. The stem cutting height of the main plant can also affect the number of tillers and seed yields (Harrel et al., 2009) and triggers dormant shoots to grow (Mahadevappa & Yogeessa, 1988).

However, the system of rice cultivation did not be separated from the use of fertilizer to achieve optimal yield. Islam et al., (2008) reported that the fertilizer application of N= 130 kg ha<sup>-1</sup>, P<sub>2</sub>O<sub>5</sub>= 75 kg ha<sup>-1</sup>, K<sub>2</sub>O= 80 kg ha<sup>-1</sup>, S= 13 kg ha<sup>-1</sup>, Zn= 4 kg ha<sup>-1</sup> significantly increased the yield of the Boro rice ratoon by 1.42 ton ha<sup>-1</sup>. The high price of fertilizer with limited availability had resulted in the use of liquid organic fertilizer to be an alternative to increase the availability and efficiency of irrigation rice nutrient uptake. The effect of liquid organic fertilizer on the growth and yield of irrigation rice has been widely reported (Oh & Kim, 2013; Niis & Nik, 2017; Ginting,

2019; Solihin et al., 2019; Mahmoodi et al., 2020), but the use of liquid organic fertilizer on the growth and yield of ratoon rice is still relatively limited. Thus, a special assessment of the specific liquid organic fertilizers impact is needed to increase the growth and yield of ratoon rice. The research was aimed to identify the optimum size of rice stem cutting (ratoon) in combination with the application of Seprint liquid organic fertilizer (SLOF) in promoting growth and yield of the ratoon rice in variety Inpari 30.

## MATERIAL AND METHODS

### Experiment I (Preliminary Research Stage)

The source of the main plant of lowland rice variety Inpari 30 because it has an average yield up to 7.2 ton ha<sup>-1</sup> (Ministry of Agriculture, 2020) and the higher compared to Ciherang, Situ Bagendit and Pepe varieties (Pramono et al., 2011) as well as the taste of rice preferred by farmers in Cicantayan sub-District compared to Inpari 22, Inpari 24 and Inpari 25 (Putra & Haryati, 2018) from Assessment Institute for Agricultural Technology (AIAT) Pasar Miring, Pagar Merbau sub-District, Deli Serdang District, North Sumatra Province, Indonesia. The main plant was conducted in the water bucket of 20 l with an upper diameter of 31 cm, the lower diameter of 22 cm and the height of 31 cm (Figure 1A). This research was conducted at the greenhouse in the Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, Indonesia from January to August 2018. The bucket was filled with soil until 5 cm from the surface. Planted two seedling of lowland rice in the bucket and was inundated with water up to the vegetative phase of the main plant, then the water in the bucket was reduced to the bearing capacity toward harvesting. The main plant was harvested at 115 days after planting then cutting of the rice stem (experiment II).

## Experiment II (Main Research Stage)

After the main rice was harvested, it was cut from the base of rice stem as shown in Figure 1B. The giving of **Seprint** Liquid Organic Fertilizer (SLOF) **only conducted at one week after cutting of rice stems by** dissolving in 1 liter of water based on the treatment and then applied by pour on the surface soil. The nutrient content of SLOF **consists of** 11% N; 2% K<sub>2</sub>O; 0.17% P<sub>2</sub>O<sub>5</sub>; 0.49% Bioret; 8.98% Boron (B); 5.35% Cobalt (Co); 5.83% Manganese (Mn); <0.01 ppm Molybdenum (Mo); 18.16 ppm Zinc (Zn); and 9.94 ppm Copper (Cu) **could be presented in Figure 1C** (Source: Bunga Tani Products). **The bucket was inundated when cutting rice stems until the end of vegetative phase, then reduce the water toward the harvesting of ratoon rice.**

## Design Research and Data Analyzed

This research was used in the Completely Randomized Design factorial with four replications. The first factor consisted of rice stem cutting (R1= 5 cm, R2= 10 cm, R3= 15 cm), and the second factor involved SLOF dosage (S1= 5 ml l<sup>-1</sup>; S2= 10 ml l<sup>-1</sup>; S3= 15 ml l<sup>-1</sup>). The distance between treatments were 50 cm x 50 cm. The parameters including the height and the growth quickness of ratoon rice, the number of tillers at 10 to 60 Days After Cutting (DAC), the yield component of ratoon rice including number of productive tillers; number of grains penicle<sup>-1</sup>; number of filled grains penicle<sup>-1</sup>; number of empty grains penicle<sup>-1</sup>; 1000-grains weight, yield hill<sup>-1</sup>; and yield ha<sup>-1</sup>. The calculation of the growth quickness and yield ha<sup>-1</sup> of ratoon rice can be seen in equations 1 and 2.

$$\text{Growth quickness (cm day}^{-1}\text{)} = \frac{\text{Average height of ratoon rice}}{\text{days of cutting}} \quad (1)$$

$$\text{Yield ha}^{-1} = \text{NP} \times \text{NPT} \times \text{NFGP} \times 1000\text{-GW} \quad (2)$$

Note :

NP = number population  $\text{ha}^{-1} = \frac{\text{land area } \text{ha}^{-1}}{\text{plant spacing}} = \frac{10,000 \text{ m}^2}{0.5 \text{ m} \times 0.5 \text{ m}} = 40,000 \text{ populations.}$

NPT = number of productive tillers

NFGP = number of filled grains penicle<sup>-1</sup>

1000-GW = 1000-grains weight (g)

The parameters were analyzed using the analysis of variance (ANOVA) and the mean was determined by DMRT at 5% using IBM SPSS statistics v.20 software.

## RESULTS

### Height and Growth Quickness of Ratoon Rice

Based on the ANOVA showed that cutting stems significantly increased the height of ratoon rice at 10 to 30 DAC. In contrast, it was insignificant at 40 to 60 DAC. The SLOF significantly increased the height of the ratoon rice at 20 DAC. In contrast, it was insignificant at 10, 30, 40, and 60 DAC. The interaction of the cutting of rice stems with SLOF significantly increased the height of ratoon rice at 10 DAC. However, it was insignificant at 20 until 60 DAC (Table 1). The results showed that the cutting 10 cm of the rice stem increased the highest height of ratoon rice at 10 until 60 DAC compared to other cutting sizes, although it had significantly at 10 until 30 DAC. The giving SLOF at the dose of 15  $\text{ml l}^{-1}$  increased the highest height of ratoon rice at 10 until 40 DAC compared to other doses, although it had significantly only at 20 DAC. The highest height of ratoon rice was found in 10  $\text{ml l}^{-1}$  SLOF at 60 DAC. The interaction of the rice stem cutting of 10 cm with 10 and 15  $\text{ml l}^{-1}$  of SLOF (R2S2 and R2S3) significantly increased the height of ratoon rice by 27.98 cm and 25.55 cm, respectively at 10 DAC. The highest height of ratoon rice was found in the combination cutting 10 cm of the rice stem with 15  $\text{ml l}^{-1}$  SLOF (R2S3) at 20 until 60 DAC.

## **Number Tillers of Ratoon Rice**

Based on the ANOVA showed that the cutting of rice stems significantly increased the number tillers of ratoon rice at 40 to 60 DAC. In contrast, it was insignificant at 10 until 30 DAC. The SLOF and their interactions insignificant increased the number tillers of ratoon rice (Table 2). The average number tillers of lowland rice before becoming a ratoon ranged from 9.25 to 11.75 tillers. The cutting 10 cm can impact in increasing the highest number tillers of ratoon rice at 10 until 60 DAC compared to other cutting sizes, although it had significantly affected at 40 until 60 DAC. The giving SLOF of 10 ml l<sup>-1</sup> (S2) given the highest number tillers of ratoon rice at 25.33 tillers until 60 DAC compared to other doses. The combination cutting 10 cm of the rice stem with 15 ml l<sup>-1</sup> SLOF (R2S3) showed the highest number tillers of ratoon rice by 36.25 tillers at 60 DAC compared to other combinations.

## **Yield Component of Ratoon Rice**

Based on the ANOVA showed that the cutting of rice stems was significantly on the number of productive tillers. In contrast, the SLOF dosages and their interactions insignificantly increased number of productive tillers of ratoon rice (Figures 2 to 4). The cutting 10 cm of the rice stem significantly increased the highest number of productive tillers by 24.92 tillers compared to other cutting of rice stems.

Based on the ANOVA showed that the cutting of rice stems and SLOF dosages were insignificant on the number of filled grains panicle<sup>-1</sup>. In contrast, their interactions significantly increased number of filled grains panicle<sup>-1</sup> of ratoon rice (Figures 2 to 4). The combination cutting 10 cm of the rice stem with 5 ml.l<sup>-1</sup> SLOF (R2S1) significantly increased the highest number of filled grains panicle<sup>-1</sup> of 114.30 grains compared to other combinations. The cutting 10 cm of the rice stem (R2) had the highest number of

filled grains panicle<sup>-1</sup> of 97.58 grains compared to other cutting sizes. The giving of 10 ml.l<sup>-1</sup> SLOF (S2) had also the highest number of filled grains panicle<sup>-1</sup> of 91.53 grains compared to other doses.

Based on the ANOVA showed that the SLOF dosages significantly increased the yield hill<sup>-1</sup> of ratoon rice. In contrast, the cutting of the rice stems and their interactions were insignificant increased the yield hill<sup>-1</sup> of ratoon rice (Figures 2 to 4). The SLOF at the dose of 10 ml.l<sup>-1</sup> (S2) significantly increased the highest yield hill<sup>-1</sup> of ratoon rice by 54.32 g compared to other doses. The cutting 10 cm of the rice stem (R2) had the highest yield hill<sup>-1</sup> of ratoon rice by 46.56 g compared to other cutting sizes. The combination cutting 10 cm of the rice stem with 10 ml l<sup>-1</sup> SLOF (R2S2) had the highest yield hill<sup>-1</sup> of ratoon rice by 60.63 g compared to other combinations.

Based on the ANOVA showed that the cutting of rice stems significantly increased the yield ha<sup>-1</sup> of ratoon rice. In contrast, the SLOF dosages and their interactions were insignificant increased the yield ha<sup>-1</sup> of ratoon rice (Figure 5). The cutting 10 cm of the rice stem (R2) significantly increased the highest yield ha<sup>-1</sup> of ratoon rice by 3.58 tons ha<sup>-1</sup> compared to other cutting sizes. The SLOF at the dose of 10 ml l<sup>-1</sup> had the highest yield ha<sup>-1</sup> of ratoon rice by 3.12 tons ha<sup>-1</sup> compared to other dosages, whereas the combination cutting 10 cm of rice stem with 15 ml l<sup>-1</sup> SLOF (R2S3) had the highest yield ha<sup>-1</sup> of ratoon rice by 3.88 tons ha<sup>-1</sup> compared to other combinations.

Based on the ANOVA showed that the rice stem cutting sizes, SLOF dosages, and their interactions were insignificant on the yield component of ratoon rice (number of grains panicle<sup>-1</sup>; number of empty grains panicle<sup>-1</sup> and 1000-grains weight) are presented in Figures 2 to 4. The cutting 10 cm of the rice stem (R2) had the highest

number of grains panicle<sup>-1</sup> and 1000-grains weight of 116.77 grains and 25.91 g, respectively compared to other cutting sizes. The cutting 15 cm of the rice stem (R3) had the highest number of empty grains panicle<sup>-1</sup> of 20.29 g compared to other cutting sizes. The giving SLOF of 5 ml l<sup>-1</sup> (S1) had the highest number of grains panicle<sup>-1</sup> and number of empty grains panicle<sup>-1</sup> of 113.59 and 22.69 grains, respectively compared to other doses. The giving SLOF of 10 ml l<sup>-1</sup> (S2) had the highest in 1000-grains weight of 25.92 grains compared to other doses. The combination cutting 10 cm of the rice stem with SLOF at 5 ml l<sup>-1</sup> (R2S1) had the highest number of grains panicle<sup>-1</sup> by 139.85 grains compared to other combinations. The combination cutting 15 cm of the rice stem with SLOF of 5 ml l<sup>-1</sup> and 10 ml l<sup>-1</sup> (R3S1 and R3S2) had the highest number of empty grains panicle<sup>-1</sup> and 1000-grains weight of 25.90 grains and 26.78 g, respectively compared to other combinations.

## DISCUSSION

The cutting 10 cm of the rice stem significantly increased the highest height of ratoon rice at 10 until 30 DAC and also significantly increased the highest number tillers of ratoon rice at 40 until 60 DAC, as well as the number of productive tillers. The result similar to the growth quickness of ratoon rice on the cutting 10 cm was higher of 1.20 to 2.03 cm day<sup>-1</sup> compared to the cutting 5 cm and 15 cm, ranged of 0.89 to 1.26 cm day<sup>-1</sup> and 1.05 to 1.49 cm day<sup>-1</sup>, respectively. It was caused by the optimal carbohydrates supply that the emergence of ratoon shoots and result in greater vegetative growth. It was supported by the plant height, number of tillers, growth quickness and number of productive tillers for ratoon rice on cutting 10 cm was higher compared to other cutting sizes (Tables 1-2 and Figures 2-4). The optimal cutting size

of rice stems will support the growth and yield of ratoon rice. According to Santos et al., (2003) the decrease in yield ranging from 12 until 37% in the cutting < 5 cm of rice stem, while the cutting >20 cm of rice stem can be produced tillers faster emerge in contrast the number of grains was fewer compared to the optimal cutting size. Harrel et al., (2009) the height cutting of the main plant stems can also affect the number of tillers and seeds yield. Susilawati et al., (2012) stated that the height and number of productive tillers for ratoon rice in genotype IPB106-F-8-1 at the cutting 10 cm was higher compared to the cutting 20 cm and 30 cm. Mareza et al., (2016) stated that the cutting 40 until 50 cm of the main stem of rice was significant for the number of productive tillers and the highest was found in 40 cm of 6.55 tillers compared to other cutting sizes.

The cutting 10 cm of stem rice (R2) significantly increased the highest yield  $\text{ha}^{-1}$  of ratoon rice by 3.58 tons  $\text{ha}^{-1}$  compared to other cutting sizes. The yield  $\text{ha}^{-1}$  of ratoon rice on the research was smaller compared to the yield  $\text{ha}^{-1}$  of main plants (rice variety Inpari 30) when the initial planting until 5.08 tons  $\text{ha}^{-1}$ , or the yield was decreased of 29.53% of the main plant. It was caused the growth pattern (the height and number of tillers) of ratoon rice were higher in cutting 10 cm compared to other cutting sizes that the results of photosynthesis produced will be distributed in the assimilates form and produce filled grains. It was linear with the number of productive tillers, number of filled grains panicle<sup>-1</sup>, and 1000-grains weight on cutting 10 cm was higher compared to other cutting sizes (Figures 2-4). According to Harrel et al., (2009) the height cutting stems of the main plant can affect the number of tillers and grains. Susilawati et al., (2012) stated that the yield  $\text{ha}^{-1}$  for ratoon rice in genotype IPB106-F-8-1 on cutting 10 cm was greater of 2.1 tons  $\text{ha}^{-1}$  compared to the cutting 20 cm and 30 cm of 1.6 tons  $\text{ha}^{-1}$  and 1.1 tons  $\text{ha}^{-1}$ , respectively. Nuzul et al., (2018) also added that the yield of ratoon

rice was decreased by 58.72% from the main plants.

The giving SLOF of 15 ml l<sup>-1</sup> significantly increased the highest height of ratoon rice at 20 DAC. It was caused by the SLOF had the main nutrient content of 11% N more higher compared to K nutrient only 2% with the result that the dose of 15 ml l<sup>-1</sup> SLOF can support the photosynthesis level and have an impact on increasing the vegetative phase of ratoon rice. It was linear with the height of ratoon rice at the dose 15 ml l<sup>-1</sup> SLOF was higher compared to other dosages at 20 DAC (Table 1). According to Surtinah, (2009) the application of liquid organic fertilizers is very efficient causes it is easily absorbed by plants. Parman, (2007) stated that the liquid organic fertilizers can improve soil physical, chemical, and biological properties, also increase the yield, and quality of plant. Niss & Nik, (2017) stated that the application of liquid organic fertilizer at the dose of 6 l ha<sup>-1</sup> significantly increased the highest number of seeds panicle<sup>-1</sup> and the dry seeds weight of rice by 107.38 seeds and 29.65 g compared to the dose of 2 and 4 l ha<sup>-1</sup>.

The giving SLOF of 10 ml l<sup>-1</sup> (S2) significantly increased the highest in yield hill<sup>-1</sup> of ratoon rice by 54.32 g. It was caused the SLOF had 11% N and 2% K along an important role in improve nutrient uptake and soil organic matter resulted the macro- and micro-nutrients be available to be absorbed by ratoon rice. The liquid organic fertilizers also had a role in cell division and increase assimilation which leads to increased biomass and yield of ratoon rice. According to Vidigal et al., (2002) stated that the growth of onion was increased progressively with the increasing application of K fertilizer. El-Bassiony, (2006) stated that K fertilizer was affected by increasing the dry weight of onion. Martínez-Alcántara et al., (2016) stated that the liquid organic fertilizers increases uptake of macro- and micro-nutrient, as well as organic matter in

soil compared to chemical fertilizers. Phibunwatthanawong & Riddech, (2019) also added the liquid organic fertilizers had the micro and supplement nutrient, beneficial microorganisms such as plant growth-promoting rhizobacteria (PGPR), and hormone Indole Acetic Acid (IAA) which are not found in chemical fertilizers.

The combination cutting 10 cm of rice stem with 10 ml l<sup>-1</sup> SLOF (R2S2) significantly increased the ratoon rice height of 27.98 cm at 10 DAC. It is authenticates the combination of cutting 10 cm with SLOF at the dose of 10 and 15 ml l<sup>-1</sup> had the highest of the ratoon rice height compared to other combinations. It was caused to the main nutrients N and K in the 10 and 15 ml l<sup>-1</sup> of SLOF dosages could be promoted the photosynthesis rate in forming assimilates at cutting 10 cm as to stimulate the growth process of the ratoon rice, such as the plant height, number of tillers, and number of productive tillers (Tables 1-2 and Figures 2-4). According to Nurhayati, (2009) the application of liquid organic fertilizer can be promoted the process of metabolism in plants through the process of nutrient solubility, that nutrient transport will be going well from the roots to all parts of the plant. Hamzah, (2014) stated that the use of liquid organic fertilizer can an increase the plant height, number of branches, and the number of soybean pods.

The combination cutting 10 cm of rice stem with SLOF at the dose of 5 ml l<sup>-1</sup> (R2S1) significantly increased the highest number of filled grains panicle<sup>-1</sup> by 114.30 grains. It was caused by the SLOF could be stimulated the metabolic process with the growth quickness of ratoon rice on cutting 10 cm that the results of photosynthesis will form assimilates and lead to be produced grains panicle<sup>-1</sup>. According to Susilawati et al., (2012) stated that the cutting 10 cm of rice stem in genotype IPB106-F-8-1 significantly increased the number of grain panicle<sup>-1</sup> and was higher of 108.0 grains compared to

cutting 20 cm and 30 cm of 78.5 and 71.1 grains, respectively. Mareza et al., (2016) stated that the cutting 10 cm of rice stem significantly improved the panicle length and number of grains panicle<sup>-1</sup> of ratoon rice by 14.93 cm and 47.05 grains, respectively compared to cutting 20 until 50 cm.

The application of ratoon rice technology combine with the SLOF greatly encourages of rice yield in achieving food sufficiency, because in a year of rice cultivation (main plants and ratoon technology) can be produce an average yield of 8.66 ton ha<sup>-1</sup>. Thus, farmers will get a double benefit by applying ratoon technology in a cycle of irrigation rice.

## CONCLUSIONS

The cutting 10 cm of rice stem significantly increased the ratoon rice height ranged of 20.33 to 53.89 cm at 10 until 30 DAC, number of tillers ranged of 25.58 to 29.08 tillers at 40 until 60 DAC, the number of productive tillers by 24.92 tillers, and the yield ha<sup>-1</sup> of ratoon rice by 3.58 tons ha<sup>-1</sup>. The SLOF at the dose of 15 ml l<sup>-1</sup> significantly increased the ratoon rice height of 35.71 cm at 20 DAC, and the dose of 10 ml l<sup>-1</sup> SLOF also significantly increased the yield hill<sup>-1</sup> of ratoon rice by 54.32 g. The combination cutting 10 cm of rice stem with SLOF at the dose of 10 ml.l<sup>-1</sup> significantly increased the ratoon rice height of 27.98 cm at 10 DAC and the combination cutting 10 cm of rice stem with 5 ml l<sup>-1</sup> SLOF also significantly increased the number of filled grains panicle<sup>-1</sup> of ratoon rice by 114.30 grains. The application cutting 10 cm of rice stem combined with various dosages of SLOF showed that the higher growth and yield of ratoon rice compared to other cutting sizes.

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## TABLES

Table 1. Effect of rice stems cutting and SLOF dosages on the ratoon rice height at 10 until 60 days after cutting (DAC).

| Treatment             | Ratoon Rice Height (cm) |          |           | average  | Growth quickness (cm.day <sup>-1</sup> ) |
|-----------------------|-------------------------|----------|-----------|----------|------------------------------------------|
|                       | S1                      | S2       | S3        |          |                                          |
| 10 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 9.46 d-h                | 7.05 h   | 10.33 c-h | 8.95 b   | 0.89                                     |
| R2                    | 7.45 gh                 | 27.98 a  | 25.55 a   | 20.33 a  | 2.03                                     |
| R3                    | 13.13 b-h               | 8.90 fgh | 9.45 e-h  | 10.49 b  | 1.05                                     |
| average               | 10.01 ns                | 14.64 ns | 15.11 ns  |          |                                          |
| 20 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 15.53 ns                | 17.35 ns | 22.93 ns  | 18.60 b  | 0.93                                     |
| R2                    | 15.25 ns                | 42.35ns  | 48.80 ns  | 35.47 a  | 1.77                                     |
| R3                    | 27.90 ns                | 12.73 ns | 35.40 ns  | 25.34 ab | 1.27                                     |
| average               | 19.56 b                 | 24.14 ab | 35.71 a   |          |                                          |
| 30 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 31.28 ns                | 39.95 ns | 36.88 ns  | 36.04 b  | 1.20                                     |
| R2                    | 39.70 ns                | 58.33 ns | 63.63 ns  | 53.89 a  | 1.80                                     |
| R3                    | 46.40 ns                | 38.13 ns | 49.93 ns  | 44.82 ab | 1.49                                     |
| average               | 39.13 ns                | 45.47 ns | 50.15 ns  |          |                                          |
| 40 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 46.90 ns                | 52.98 ns | 50.73 ns  | 50.20 ns | 1.26                                     |
| R2                    | 61.90 ns                | 63.93 ns | 75.23 ns  | 67.02 ns | 1.68                                     |
| R3                    | 60.70 ns                | 54.28 ns | 55.83 ns  | 56.94 ns | 1.42                                     |
| average               | 56.50 ns                | 57.06 ns | 60.60 ns  |          |                                          |
| 60 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 59.20 ns                | 65.80 ns | 58.18 ns  | 61.06 ns | 1.02                                     |
| R2                    | 67.50 ns                | 70.38 ns | 77.53 ns  | 71.80 ns | 1.20                                     |
| R3                    | 67.93 ns                | 66.28 ns | 64.63 ns  | 66.28 ns | 1.10                                     |
| average               | 64.88 ns                | 67.49 ns | 66.78 ns  |          |                                          |

Note: Data followed by different letters on the same column and row are significantly different according to DMRT at 5%. Size cutting of rice stems (R1= 5 cm; R2= 10 cm; R3= 15 cm). SLOF dosages (S1= 5 ml l<sup>-1</sup>; S2= 10 ml l<sup>-1</sup>; S3= 15 ml l<sup>-1</sup>). ns= not significant.

Table 2. The increase in the number tillers of ratoon rice after cutting the stems and SLOF dosages at 10 until 60 DAC.

| Treatment             | Number Tillers of Ratoon Rice |          |          | average  |
|-----------------------|-------------------------------|----------|----------|----------|
|                       | S1                            | S2       | S3       |          |
| 10 Days After Cutting |                               |          |          |          |
| R1                    | 6.75 ns                       | 2.00 ns  | 3.75 ns  | 4.17 ns  |
| R2                    | 7.00 ns                       | 7.00 ns  | 6.00 ns  | 6.67 ns  |
| R3                    | 8.00 ns                       | 5.00 ns  | 4.50 ns  | 5.83 ns  |
| average               | 7.25 ns                       | 4.67 ns  | 4.75 ns  |          |
| 20 Days After Cutting |                               |          |          |          |
| R1                    | 8.75 ns                       | 4.25 ns  | 5.00 ns  | 6.00 ns  |
| R2                    | 8.25 ns                       | 14.50 ns | 15.25 ns | 12.67 ns |
| R3                    | 15.00 ns                      | 9.00 ns  | 8.75 ns  | 10.92 ns |
| average               | 10.67 ns                      | 9.25 ns  | 9.67 ns  |          |
| 30 Days After Cutting |                               |          |          |          |
| R1                    | 9.00 ns                       | 7.25 ns  | 8.00 ns  | 8.08 ns  |
| R2                    | 9.25 ns                       | 19.25 ns | 24.00 ns | 17.50 ns |
| R3                    | 20.00 ns                      | 12.75 ns | 15.00 ns | 15.92 ns |
| average               | 12.75 ns                      | 13.08 ns | 15.67 ns |          |
| 40 Days After Cutting |                               |          |          |          |
| R1                    | 10.75 ns                      | 12.00 ns | 10.50 ns | 11.08 b  |
| R2                    | 10.50 ns                      | 33.25 ns | 33.00 ns | 25.58 a  |
| R3                    | 22.75 ns                      | 23.00 ns | 19.50 ns | 21.75 ab |
| average               | 14.67 ns                      | 22.75 ns | 21.00 ns |          |
| 60 Days After Cutting |                               |          |          |          |
| R1                    | 13.00 ns                      | 13.25 ns | 13.25 ns | 13.17 b  |
| R2                    | 16.00 ns                      | 35.00 ns | 36.25 ns | 29.08 a  |
| R3                    | 24.00 ns                      | 27.75 ns | 23.50 ns | 25.08 a  |
| average               | 17.67 ns                      | 25.33 ns | 24.33 ns |          |

Note: Data followed by different letters on the same column and row are significantly different according to DMRT at 5%. Size cutting of rice stems (R1= 5 cm; R2= 10 cm; R3= 15 cm). SLOF dosages (S1= 5 ml l<sup>-1</sup>; S2= 10 ml l<sup>-1</sup>; S3= 15 ml l<sup>-1</sup>). ns= not significant.

FIGURES

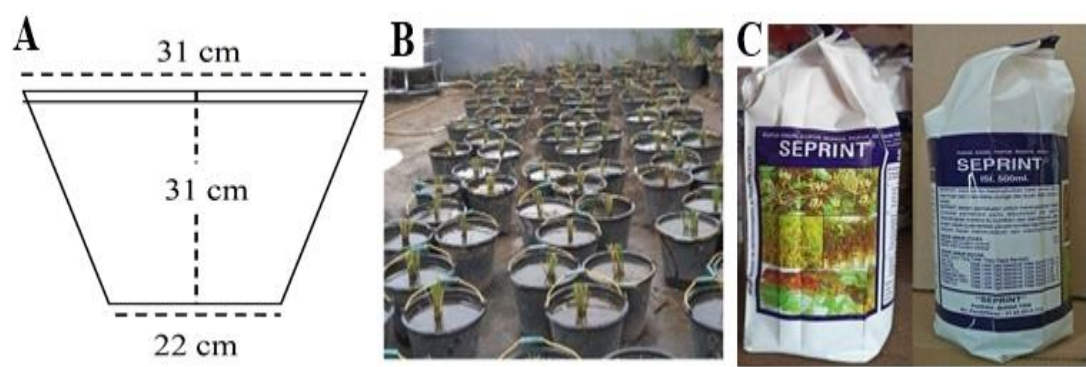


Figure 1. The size of the bucket (A); design of the second experiment (B); and seprint liquid organic fertilizer by bunga tani products (C).

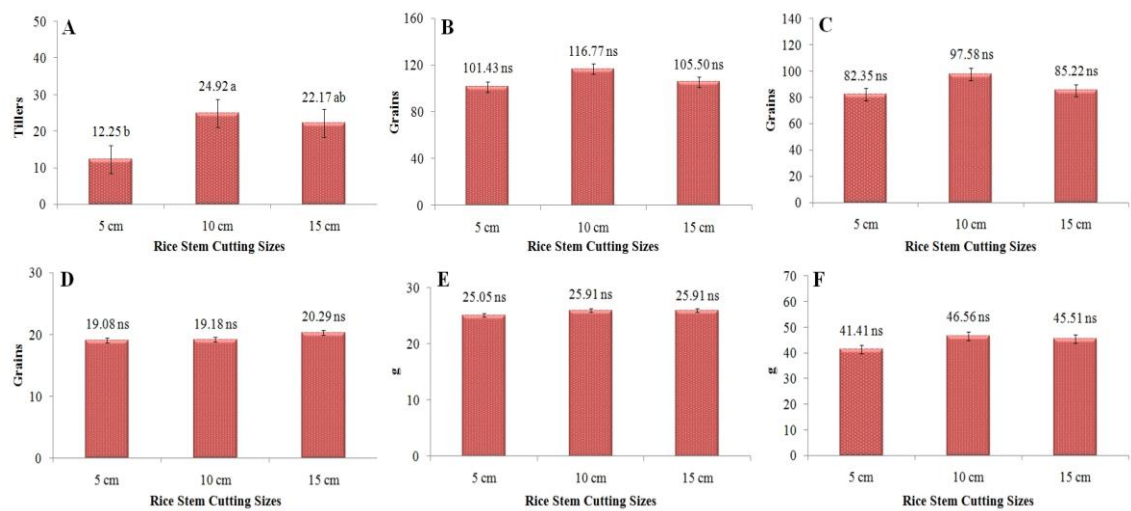


Figure 2. Effect of rice stem cutting sizes on the yield component (A= number of productive tillers; B= number of grains panicle<sup>-1</sup>; C= number of filled grains panicle<sup>-1</sup>; D= number of empty grains panicle<sup>-1</sup>; E= 1000-grains weight; F= yield hill<sup>-1</sup>) of ratoon rice. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE). ns= not significant.

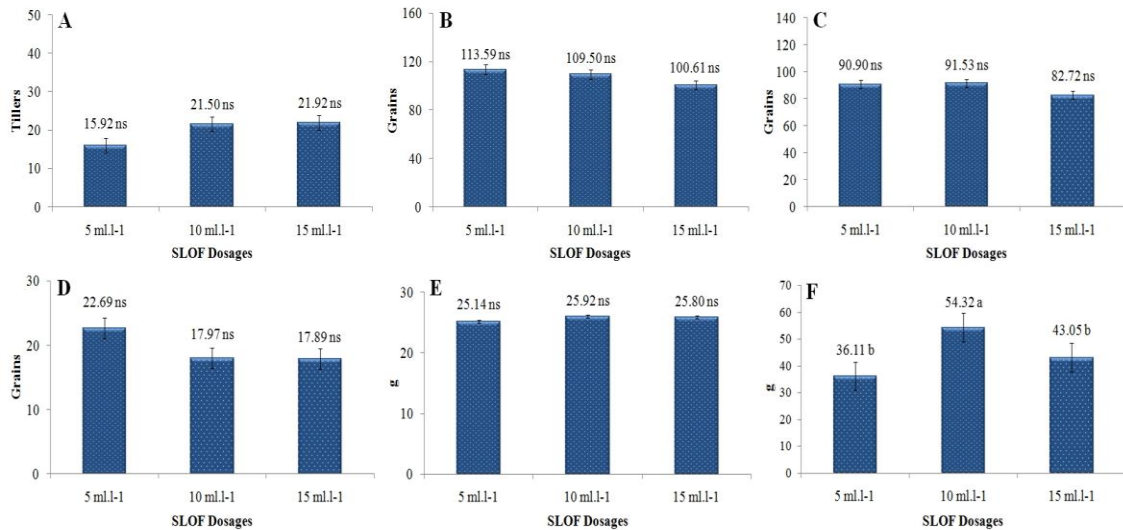


Figure 3. Effect of SLOF dosages on the yield component (A= number of productive tillers; B= number of grains panicle<sup>-1</sup>; C= number of filled grains panicle<sup>-1</sup>; D= number of empty grains panicle<sup>-1</sup>; E= 1000-grains weight; F= yield hill<sup>-1</sup>) of ratoon rice. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE). ns= not significant.

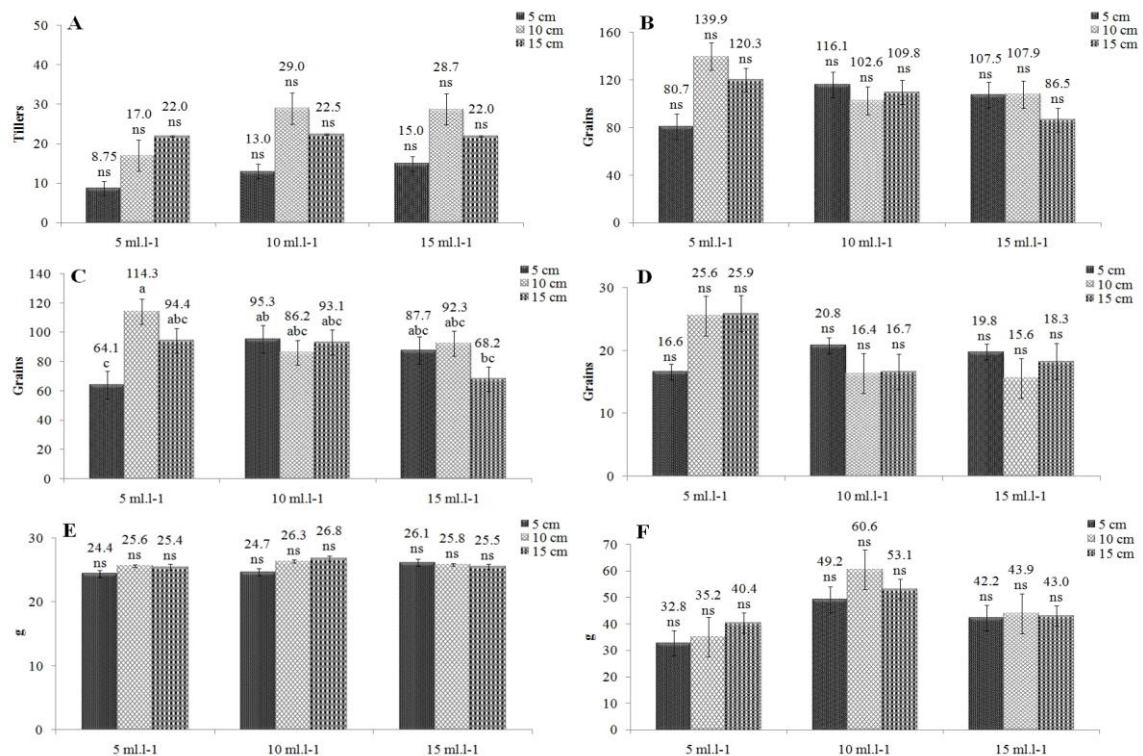
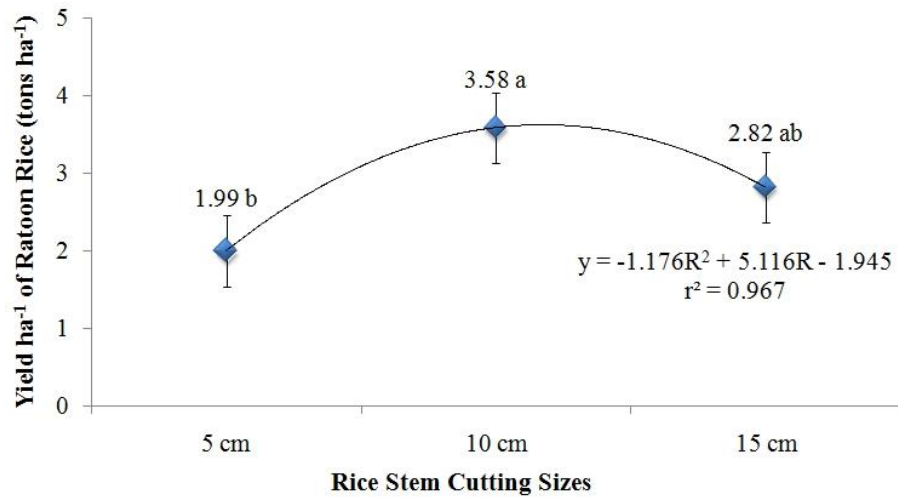


Figure 4. The combinations of stem cutting sizes and SLOF dosages on the yield component (A= number of productive tillers; B= number of grains panicle<sup>-1</sup>; C= number of filled grains panicle<sup>-1</sup>; D= number of empty grains panicle<sup>-1</sup>; E= 1000-grains weight; F= yield hill<sup>-1</sup>) of ratoon rice. Data followed by different letters on the same graph are significantly different according to



DMRT at 5% ± standard error (SE). ns= not significant.

Figure 5. Effect of rice stem cutting sizes on the yield ha<sup>-1</sup> of ratoon rice. Data followed by different letters on the same line are significantly different according to DMRT at 5% ± standard error (SE).

## #8724 Review

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### Submission

|         |                                                                                                                                                                                                  |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Authors | Alridiwersah Alridiwersah, Koko Tampubolon, Fransisca Natalia Sihombing, Andi Agus Suprianto, Zavandri Purba  |
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| Section | Plant Structure                                                                                                                                                                                  |
| Editor  | Marzena Parzymies                                                                                               |

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#### ORIGINAL RESEARCH PAPER in PLANT STRUCTURE

# Agronomic Character of Ratoon Rice: Stem Cutting Sizes and Seprint Liquid Organic Fertilizer

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## Abstract

This study aimed to identify the optimum rice stem cutting size combined with the application of Seprint liquid organic fertilizer (SLOF) to promote the growth and yield of ratoon rice. This research was conducted in a greenhouse at the Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, North Sumatra Province, Indonesia, from January to August 2018. The experiment was set up as a completely randomized design factorial with four replications. The first factor consisted of the cutting sizes of the rice stem (R1 = 5 cm, R2 = 10 cm, and R3 = 15 cm) and the second factor involved the SLOF dosage (S1 = 5 mL L<sup>-1</sup>, S2 = 10 mL L<sup>-1</sup>, and S3 = 15 mL L<sup>-1</sup>). The parameters were analyzed using analysis of variance (ANOVA), and the means were determined by Duncan's multiple range test (DMRT). The results showed that the R2 treatment significantly increased the ratoon rice height at 10 to 30 days after cutting (DAC), the number of tillers at 40 to 60 DAC, the number of productive tillers, and the yield per hectare. The S2 and S3 applications at significantly increased the yield per hill and ratoon rice height at 20 DAC. The R2S1 and R2S2 combination treatments significantly increased the number of filled grains per panicle and the ratoon rice height at 10 DAC. Cutting the stems at 10 cm combined with various dosages of SLOF resulted in greater growth and yield of ratoon rice for achieving an adequate food supply.

## Keywords

dosage; growth; yield

## 1. Introduction

Food is a basic human need, and adequate, nutritious, and safe food can lead to high-quality human resources. Grain (rice) is a major source of energy. According to United States Department of Agriculture (USDA) data, countries with the highest level of rice consumption worldwide from 2015 to 2019 are located in Asia, specifically in China (29.66%), India (20.39%), Indonesia (7.88%), Bangladesh (7.32%), and Vietnam (4.54%) (Ministry of Agriculture, 2019). In Indonesia, rice is the main food requirement for more than 90% of the population. The consumption of rice per capita has decreased, from 107.71 kg capita<sup>-1</sup> year<sup>-1</sup> in 2002 to 96.33 kg capita<sup>-1</sup> year<sup>-1</sup> in 2018 (Ministry of Agriculture, 2019). However, domestic rice yield continues to increase, although it is trending toward a slower growth rate. Indonesia's population growth increased linearly from 2005 to 2015 (226.71 to 258.16 million),

and the projected population until 2035 is estimated to be up to 305.65 million (Statistics Indonesia, 2019). The total domestic consumption of Indonesian rice continues to increase, even though the per capita consumption shows a decrease.

The increased domestic consumption of rice in Indonesia must be followed by a program to increase rice yield via intensification. One of the intensification programs that can be followed is system cultivation of ratoon rice. Mengel and Wilson (1981) stated that ratoon is a technique of harvesting production from tillers from the main plant stumps to increase grain yield without increasing land area. The ratoon technique has been used to shorten the age of the rice harvest. The maturing of hybrid rice varieties is required at 105–124 days after scattering or approximately 4 months (Indonesian Center for Rice Research, 2019). Therefore, in a year, there can only be two lots of rice planting until harvesting. The ratoon system can produce three to four lots of rice harvesting. The advantages of the ratoon system are the higher efficiency of resource use per unit area of land and unit per timing (Santos et al., 2003), reduction in land preparation, cost savings on planting seeds (Zandstra & Samson, 1979), and time saving of planting because of decreased growth time (Haque & Coffman, 1980). In addition, ratoon rice is preferred by farmers because of its high quality, including cooking and flavor, short growth period, reduced water and fertilizer costs, and decreased pest control (Yazdpour et al., 2012). Alizadeh and Habibi (2016) reported that the grain thickness and amylose content of ratoon rice were higher, ranging from 1.18% to 2.25% and 2.28% to 7.69%, respectively, compared to the main crop.

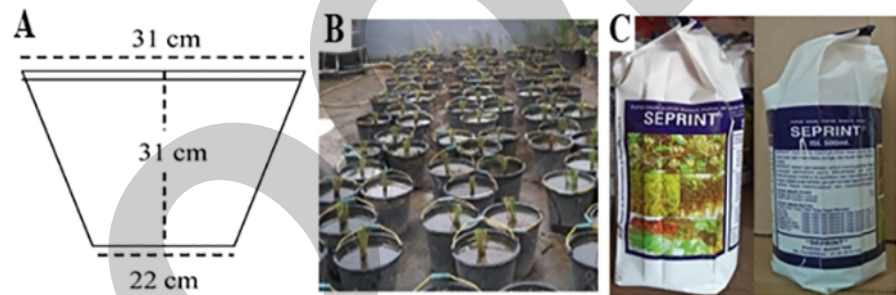
System cultivation of ratoon rice has been reported. Pratama et al. (2018) stated that the time of cutting the remaining stumps on day 10 of the rice harvest was significant for obtaining the largest root diameter of 0.89 mm with a stump cutting height of 4 cm above the soil surface and could increase grain productivity by 3.39 to 3.54 tons ha<sup>-1</sup>. Nuzul et al. (2018) stated that the highest yield components (e.g., the number and length of panicles, harvest age, grain number per panicle, filled grain, 1,000-grains weight, total dry weight, and harvest index), and rice yield (grain per hectare) were achieved in the cutting at harvest of a height 3 cm above the soil surface with a grain yield of 3.54 tons ha<sup>-1</sup>. Susilawati et al. (2012) stated that the cutting height of ratoon rice was related to the internode of the plant, and the nodes contained lateral shoots that produced ratoon shoots. Jichao and Xiaohui (1996) showed that the number of growing shoots was determined by the cutting height stems of the main plant; however, the condition was strongly influenced by residual assimilates as reserves in the stems that could be utilized for ratoon growth, and the vigor rate of the ratoon. The stem cutting height of the main plant can also affect the number of tillers and seed yield (Harrell et al., 2009) and trigger dormant shoot growth (Mahadevappa & Yogeesh, 1988).

However, in these studies, the rice cultivation system was not separated from fertilizer use to achieve the optimal yield. Islam et al. (2008) reported that fertilizer application of N = 130 kg ha<sup>-1</sup>, P<sub>2</sub>O<sub>5</sub> = 75 kg ha<sup>-1</sup>, K<sub>2</sub>O = 80 kg ha<sup>-1</sup>, S = 13 kg ha<sup>-1</sup>, and Zn = 4 kg ha<sup>-1</sup> significantly increased the yield of Boro rice ratoon by 1.42 tons ha<sup>-1</sup>. The high price of fertilizer with limited availability has resulted in the use of liquid organic fertilizer as an alternative to increase the availability and efficiency of irrigation rice nutrient uptake. The effect of liquid organic fertilizer on the growth and yield of irrigated rice has been widely reported (Ginting, 2019; Mahmoodi et al., 2020; Niis & Nik, 2017; Oh & Kim, 2013; Solihin et al., 2019); however, studies regarding the use of liquid organic fertilizer on the growth and yield of ratoon rice are limited. Thus, a special assessment of the influence of specific liquid organic fertilizers is required to increase the growth and yield of ratoon rice. The present study aimed to identify the optimum size of the rice stem cutting (ratoon) combined with the application of Seprint liquid organic fertilizer to promote growth and yield of ratoon in rice variety Inpari 30.

## 2. Material and Methods

### 2.1. Experiment I (Preliminary Research Stage)

The main plant included in the present study was the lowland rice variety Inpari 30. This variety was used because it has an average yield of up to 7.2 tons ha<sup>-1</sup> (Indonesian Agency for Agricultural Research and Development, 2020), which is higher than that of the Ciherang, Situ Bagendit, and Pepe varieties (Pramono et al., 2011). In addition, the taste of this rice variety is preferred by farmers in the Cicantayan subdistrict compared to the Inpari 22, Inpari 24, and Inpari 25 varieties (Putra & Haryati, 2018) from the Assessment Institute for Agricultural Technology Pasar Miring, Pagar Merbau subdistrict, Deli Serdang District, North Sumatra Province, Indonesia. The main plant was placed in a 20-L water bucket with an upper diameter of 31 cm, a lower diameter of 22 cm, and a height of 31 cm (Figure 1A). This experiment was conducted in a greenhouse at the Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, Indonesia, from January to August 2018. The bucket was filled with soil up to 5 cm from the surface. Two lowland rice seedlings were planted in the bucket and inundated with water until the vegetative phase of the main plant. The water in the bucket was then decreased to the bearing capacity for harvesting. The main plant was harvested 115 days after planting, followed by cutting the rice stem (Experiment II).



**Figure 1** Size of the bucket (A), design of the second experiment (B), and Seprint liquid organic fertilizer by Bunga Tani Products (C).

### 2.2. Experiment II (Main Research Stage)

After the main rice was harvested, it was cut from the rice stem base, as shown in Figure 1B. Seprint liquid organic fertilizer (SLOF) was applied 1 week after cutting the rice stems by dissolving in 1 L of water and pouring onto the soil surface. The nutrient content of SLOF was 11% N, 2% K<sub>2</sub>O, 0.17% P<sub>2</sub>O<sub>5</sub>, 0.49% Bioret, 8.98% boron (B), 5.35% cobalt (Co), 5.83% manganese (Mn), <0.01 ppm molybdenum (Mo), 18.16 ppm zinc (Zn), and 9.94 copper (Cu) (Figure 1C) (source: Bunga Tani Products). The bucket was inundated when cutting the rice stems until the end of the vegetative phase, and then the water was decreased to harvest the ratoon rice.

### 2.3. Research Design and Data Analysis

The present study was performed in a completely randomized design factorial with four replications. The first factor consisted of the cutting sizes of the rice stem (R1 = 5 cm, R2 = 10 cm, and R3 = 15 cm), and the second factor involved the SLOF dosage (S1 = 5 mL L<sup>-1</sup>, S2 = 10 mL L<sup>-1</sup>, and S3 = 15 mL L<sup>-1</sup>). The distance between the treatments was 50 × 50 cm. The parameters measured included the height and growth rate of the ratoon rice; the number of tillers at 10 to 60 days after cutting (DAC); the yield component of ratoon rice including the number of productive tillers, number of grains per panicle, number of filled grains per panicle, number of empty grains per panicle, 1,000-grains weight, yield per hill, and yield per hectare. The agronomic traits of ratoon rice are transformed in the form of natural logarithms (ln) due to the different units and then analyzed with the Pearson

correlation. The calculation of the growth rate and yield per hectare of the ratoon rice can be seen in Equation (1) and Equation (2):

$$\text{Growth rate (cm day}^{-1}\text{)} = \frac{\text{Average height of ratoon rice}}{\text{Days of cutting}} \quad (1)$$

$$\text{Yield (ha}^{-1}\text{)} = NP \times NPT \times NFGP \times 1,000 \text{ GW} \quad (2)$$

Notes:

- $NP$  – number population per hectare =  $\frac{\text{Land area (ha}^{-1}\text{)}}{\text{Plant spacing}} = \frac{10,000 \text{ m}^2}{0.5 \text{ m} \times 0.5 \text{ m}} = 40,000$  pop;
- $NPT$  – number of productive tillers;
- $NFGP$  – number of filled grains per panicle;
- 1,000 GW – 1,000-grains weight (g).

The parameters were analyzed using ANOVA, and the mean was determined by DMRT at 5% significance, and correlation analysis for agronomic traits of ratoon rice using IBM SPSS statistics v.20 software.

### 3. Results

#### 3.1. Height and Growth Rate of Ratoon Rice

Based on the ANOVA results, the cutting of the stems significantly increased the height of the ratoon rice at 10 to 30 DAC. In contrast, no significant increase was found at 40 and 60 DAC. SLOF application significantly increased the height of the ratoon rice at 20 DAC. In contrast, no significant increase was found at 10, 30, 40, and 60 DAC. The interaction of the cutting of the rice stems with SLOF application significantly increased the height of the ratoon rice at 10 DAC. However, no significant increase was found at 20 to 60 DAC (Table 1). The R2 treatment had the highest ratoon rice height at 10 to 60 DAC compared to the other cutting sizes, with significant increases from 10 to 30 DAC. The S3 application had the highest ratoon rice height at 10 to 40 DAC compared to the other doses, although it was significantly increased only at 20 DAC. The highest ratoon rice height was found in the S2 application at 60 DAC. The R2S2 and R2S3 combination treatments significantly increased the ratoon rice height to 27.98 cm and 25.55 cm, respectively, at 10 DAC. The highest ratoon rice heights were found in the R2S3 treatment at 20 to 60 DAC.

#### 3.2. Number of Tillers of Ratoon Rice

Based on the ANOVA results, the cutting of the rice stems significantly increased the number of tillers of ratoon rice at 40 and 60 DAC. In contrast, no significant increase was found at 10 to 30 DAC. The SLOF application and interaction with stem cutting did not significantly increase the number of tillers of ratoon rice (Table 2). The average number of tillers of lowland rice before becoming a ratoon ranged from 9.25 to 11.75 tillers. The R2 treatment had the highest number of tillers of ratoon rice at 10 to 60 DAC compared to the other cutting sizes, with significant increases at 40 to 60 DAC. The S2 application had the highest number of tillers of ratoon rice (25.33 tillers) at 60 DAC compared to the other doses. The R2S3 combination treatment had the highest number of tillers of ratoon rice at 36.25 tillers at 60 DAC compared to the other combinations.

#### 3.3. Yield Component of Ratoon Rice

Based on the ANOVA results, the cutting of the rice stems significantly affected the number of productive tillers. In contrast, the SLOF dosages and interactions with stem cuttings did not significantly increase the number of productive tillers of ratoon rice (Figure 2–Figure 4). The R2 treatment had the highest number of productive tillers (24.92 tillers) compared to the other rice stem cuttings.

Based on the ANOVA results, the cutting of the rice stems and SLOF dosages did not significantly affect the number of filled grains per panicle. In contrast, their interactions significantly increased the number of filled grains per panicle of ratoon rice (Figure 2–Figure 4). The R2S1 combination treatment significantly increased the

**Table 1** Effect of rice stem cutting and Seprint liquid organic fertilizer (SLOF) dosages on the ratoon rice height from 10 to 60 days after cutting (DAC).

| Treatment | Ratoon rice height (cm) |          |           | Average  | Growth rate<br>(cm day <sup>-1</sup> ) |
|-----------|-------------------------|----------|-----------|----------|----------------------------------------|
|           | S1                      | S2       | S3        |          |                                        |
|           | 10 days after cutting   |          |           |          |                                        |
| R1        | 9.46 d–h                | 7.05 h   | 10.33 c–h | 8.95 b   | 0.89                                   |
| R2        | 7.45 gh                 | 27.98 a  | 25.55 a   | 20.33 a  | 2.03                                   |
| R3        | 13.13 b–h               | 8.90 fgh | 9.45 e–h  | 10.49 b  | 1.05                                   |
| Average   | 10.01 ns                | 14.64 ns | 15.11 ns  |          |                                        |
|           | 20 days after cutting   |          |           |          |                                        |
| R1        | 15.53 ns                | 17.35 ns | 22.93 ns  | 18.60 b  | 0.93                                   |
| R2        | 15.25 ns                | 42.35ns  | 48.80 ns  | 35.47 a  | 1.77                                   |
| R3        | 27.90 ns                | 12.73 ns | 35.40 ns  | 25.34 ab | 1.27                                   |
| Average   | 19.56 b                 | 24.14 ab | 35.71 a   |          |                                        |
|           | 30 days after cutting   |          |           |          |                                        |
| R1        | 31.28 ns                | 39.95 ns | 36.88 ns  | 36.04 b  | 1.20                                   |
| R2        | 39.70 ns                | 58.33 ns | 63.63 ns  | 53.89 a  | 1.80                                   |
| R3        | 46.40 ns                | 38.13 ns | 49.93 ns  | 44.82 ab | 1.49                                   |
| Average   | 39.13 ns                | 45.47 ns | 50.15 ns  |          |                                        |
|           | 40 days after cutting   |          |           |          |                                        |
| R1        | 46.90 ns                | 52.98 ns | 50.73 ns  | 50.20 ns | 1.26                                   |
| R2        | 61.90 ns                | 63.93 ns | 75.23 ns  | 67.02 ns | 1.68                                   |
| R3        | 60.70 ns                | 54.28 ns | 55.83 ns  | 56.94 ns | 1.42                                   |
| Average   | 56.50 ns                | 57.06 ns | 60.60 ns  |          |                                        |
|           | 60 days after cutting   |          |           |          |                                        |
| R1        | 59.20 ns                | 65.80 ns | 58.18 ns  | 61.06 ns | 1.02                                   |
| R2        | 67.50 ns                | 70.38 ns | 77.53 ns  | 71.80 ns | 1.20                                   |
| R3        | 67.93 ns                | 66.28 ns | 64.63 ns  | 66.28 ns | 1.10                                   |
| Average   | 64.88 ns                | 67.49 ns | 66.78 ns  |          |                                        |

Note: Data followed by different letters in the same column and row are significantly different according to the DMRT at 5% significance. Size cutting of rice stems (R1 = 5 cm, R2 = 10 cm, and R3 = 15 cm). SLOF dosages (S1 = 5 mL L<sup>-1</sup>, S2 = 10 mL L<sup>-1</sup>, and S3 = 15 mL L<sup>-1</sup>). ns = not significant.

highest number of filled grains per panicle to 114.30 grains compared to the other combinations. The R2 treatment had the highest number of filled grains per panicle (97.58 grains) compared to the other cutting sizes. The S2 application had the highest number of filled grains per panicle (91.53 grains) compared to the other doses.

Based on the ANOVA results, the SLOF dosages significantly increased the yield per hill of ratoon rice. In contrast, the cutting of the rice stems and their interactions did not significantly increase the yield per hill of ratoon rice (Figure 2–Figure 4). The S2 application significantly had the highest yield per hill of ratoon rice of 54.32 g compared to the other doses. The R2 treatment had the highest yield per hill of ratoon rice of 46.56 g compared to the other cutting sizes. The R2S2 combination treatment had the highest yield per hill of ratoon rice of 60.63 g compared to the other combinations.

Based on the ANOVA results, the cutting of rice stems significantly increased the yield per hectare of ratoon rice. In contrast, the SLOF dosages and their interactions did not significantly increase the yield per hectare of ratoon rice (Figure 5). The R2 treatment had the highest yield per hectare of ratoon rice of 3.58 tons ha<sup>-1</sup> compared to the other cutting sizes. The S2 application had the highest yield per hectare of ratoon rice of 3.12 tons ha<sup>-1</sup> compared to the other dosages, whereas the R2S3 combination treatment had the highest yield per hectare of ratoon rice of 3.88 tons ha<sup>-1</sup> compared to the other combinations.

**Table 2** Number of tillers of ratoon rice after cutting the stems and Seprint liquid organic fertilizer (SLOF) dosages from 10 to 60 days after cutting (DAC).

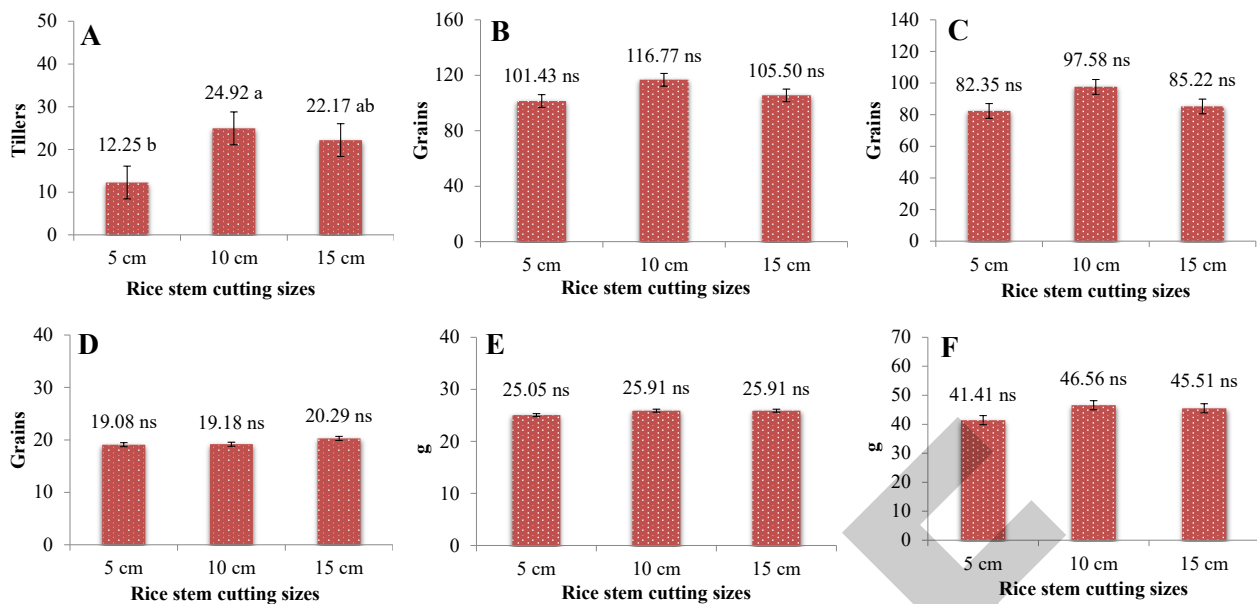
| Treatment             | Number of tillers of ratoon rice |          |          | Average  |
|-----------------------|----------------------------------|----------|----------|----------|
|                       | S1                               | S2       | S3       |          |
| 10 days after cutting |                                  |          |          |          |
| R1                    | 6.75 ns                          | 2.00 ns  | 3.75 ns  | 4.17 ns  |
| R2                    | 7.00 ns                          | 7.00 ns  | 6.00 ns  | 6.67 ns  |
| R3                    | 8.00 ns                          | 5.00 ns  | 4.50 ns  | 5.83 ns  |
| Average               | 7.25 ns                          | 4.67 ns  | 4.75 ns  |          |
| 20 days after cutting |                                  |          |          |          |
| R1                    | 8.75 ns                          | 4.25 ns  | 5.00 ns  | 6.00 ns  |
| R2                    | 8.25 ns                          | 14.50 ns | 15.25 ns | 12.67 ns |
| R3                    | 15.00 ns                         | 9.00 ns  | 8.75 ns  | 10.92 ns |
| Average               | 10.67 ns                         | 9.25 ns  | 9.67 ns  |          |
| 30 days after cutting |                                  |          |          |          |
| R1                    | 9.00 ns                          | 7.25 ns  | 8.00 ns  | 8.08 ns  |
| R2                    | 9.25 ns                          | 19.25 ns | 24.00 ns | 17.50 ns |
| R3                    | 20.00 ns                         | 12.75 ns | 15.00 ns | 15.92 ns |
| Average               | 12.75 ns                         | 13.08 ns | 15.67 ns |          |
| 40 days after cutting |                                  |          |          |          |
| R1                    | 10.75 ns                         | 12.00 ns | 10.50 ns | 11.08 b  |
| R2                    | 10.50 ns                         | 33.25 ns | 33.00 ns | 25.58 a  |
| R3                    | 22.75 ns                         | 23.00 ns | 19.50 ns | 21.75 ab |
| Average               | 14.67 ns                         | 22.75 ns | 21.00 ns |          |
| 60 days after cutting |                                  |          |          |          |
| R1                    | 13.00 ns                         | 13.25 ns | 13.25 ns | 13.17 b  |
| R2                    | 16.00 ns                         | 35.00 ns | 36.25 ns | 29.08 a  |
| R3                    | 24.00 ns                         | 27.75 ns | 23.50 ns | 25.08 a  |
| Average               | 17.67 ns                         | 25.33 ns | 24.33 ns |          |

Note: Data followed by different letters in the same column and row are significantly different according to the DMRT at 5%. Size cutting of rice stems (R1 = 5 cm, R2 = 10 cm, and R3 = 15 cm). SLOF dosages (S1 = 5 mL L<sup>-1</sup>, S2 = 10 mL L<sup>-1</sup>, and S3 = 15 mL L<sup>-1</sup>). ns = not significant.

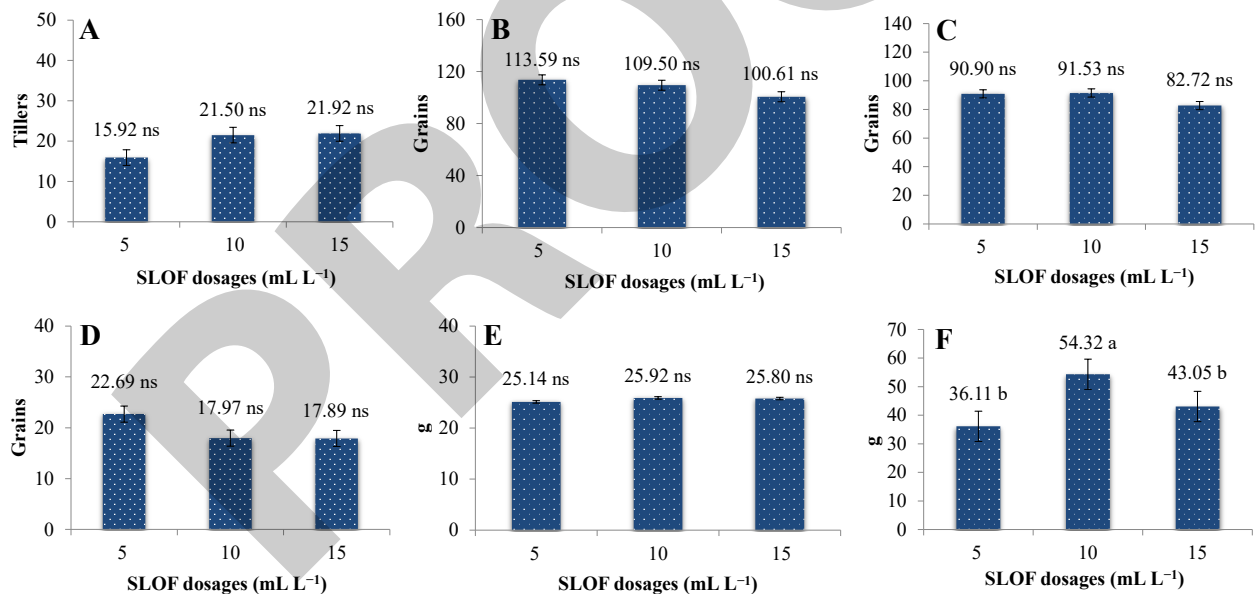
Based on the ANOVA results, the rice stem cutting sizes, SLOF dosages, and their interactions were insignificant on the yield components of ratoon rice (number of grains per panicle, number of empty grains per panicle, and 1,000-grains weight; Figure 2–Figure 4). The R2 treatment had the highest number of grains per panicle and 1,000-grains weight of 116.77 grains and 25.91 g, respectively, compared to the other cutting sizes. The R3 treatment had the highest number of empty grains per panicle (20.29 grains) compared to the other cutting sizes. The S1 application had the highest number of grains per panicle and number of empty grains per panicle of 113.59 and 22.69 grains, respectively, compared to the other doses. The S2 application had the highest 1,000-grains weight of 25.92 g compared to the other doses. The R2S1 combination treatment had the highest number of grains per panicle of 139.85 grains compared to the other combinations. The R3S1 and R3S2 combination treatments had the highest number of empty grains per panicle and 1,000-grains weight of 25.90 grains and 26.78 g, respectively, compared to the other combinations.

### 3.4. Correlations of Agronomic Traits of Ratoon Rice

The agronomic traits of ratoon rice include the plant height, number of tillers, number of productive tillers, number of grains per panicle, number of filled grains per panicle, 1,000-grains weight, and yield per hill significantly increase the yield per

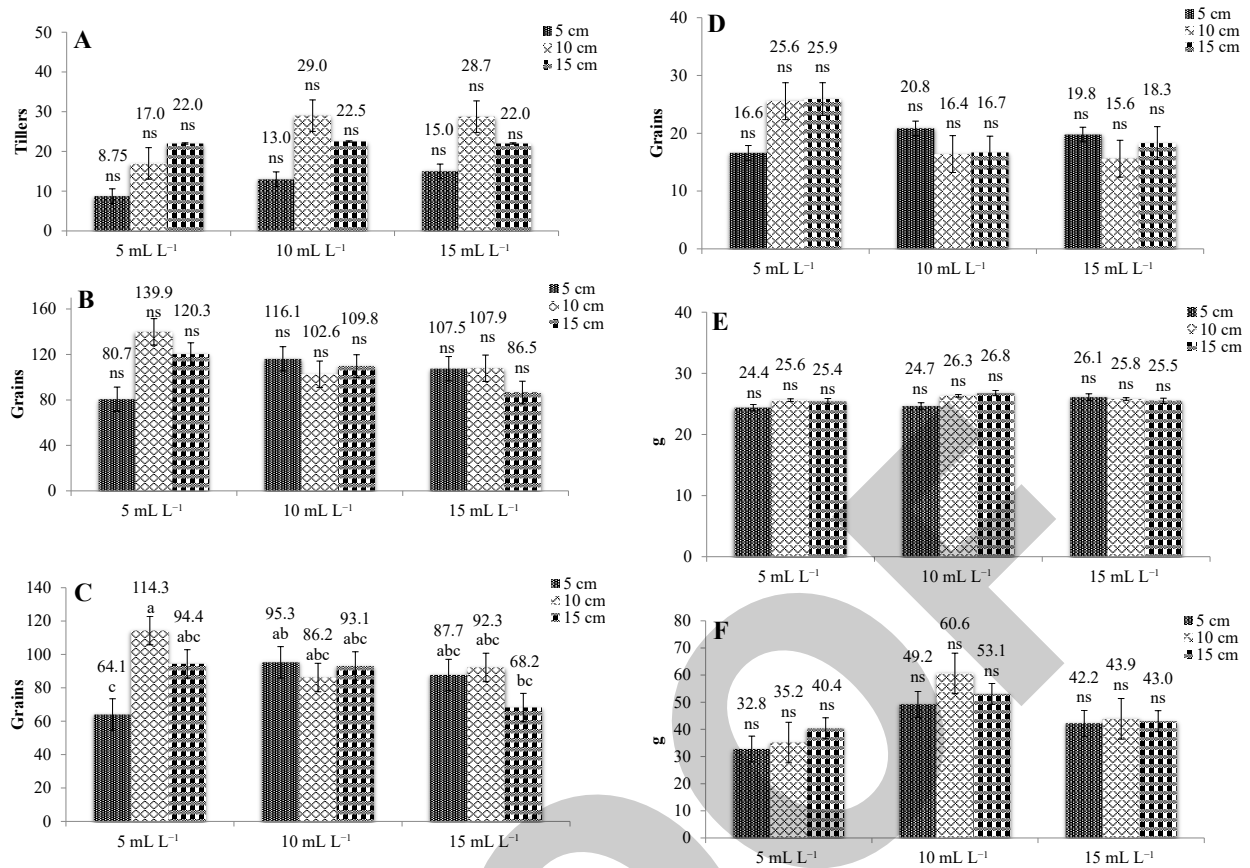


**Figure 2** Effect of rice stem cutting sizes on the yield component of ratoon rice: (A) number of productive tillers; (B) number of grains per panicle; (C) number of filled grains per panicle; (D) number of empty grains per panicle; (E) 1,000-grains weight; (F) yield per hill. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE).

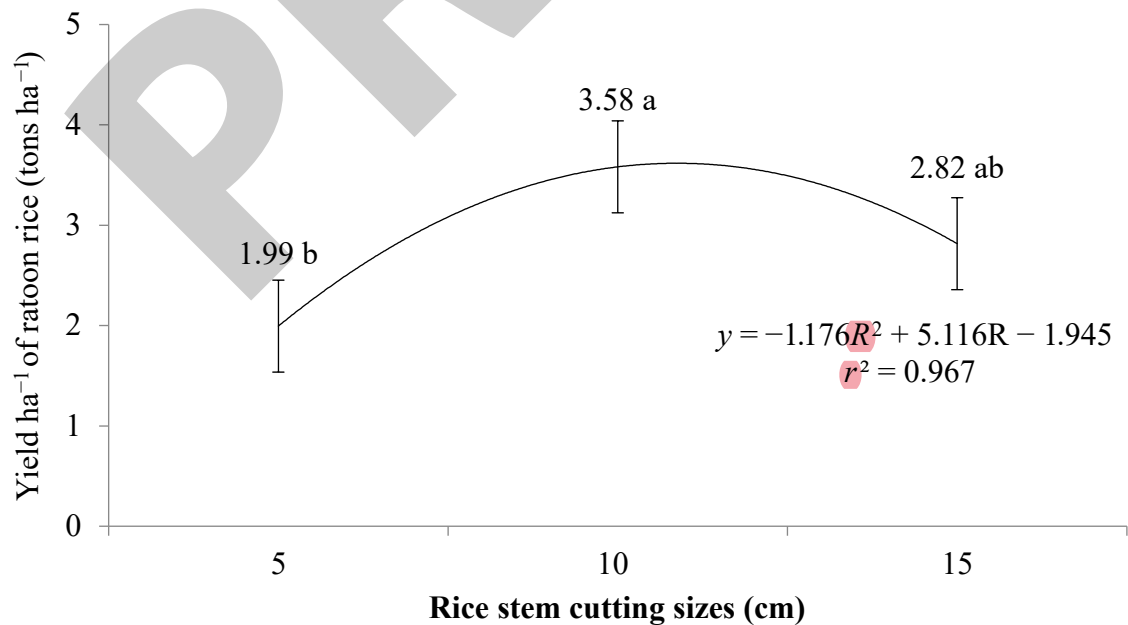


**Figure 3** Effect of Seprint liquid organic fertilizer (SLOF) dosages on the yield component of ratoon rice: (A) number of productive tillers; (B) number of grains per panicle; (C) number of filled grains per panicle; (D) number of empty grains per panicle; (E) 1,000-grains weight; (F) yield per hill. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE).

hectare of ratoon rice with the highest contribution was found in the number of productive tillers (correlation coefficient value of 0.885) (Table 3). The present study confirmed that an increase the yield per hectare of ratoon rice along with an increase in the number of productive tillers in the combination treatment of stem cutting with SLOF dosages.



**Figure 4** Combinations of stem cutting sizes and Seprint liquid organic fertilizer (SLOF) dosages on the yield component of ratoon rice: (A) number of productive tillers; (B) number of grains per panicle; (C) number of filled grains per panicle; (D) number of empty grains per panicle; (E) 1,000-grains weight; (F) yield per hill. Data followed by different letters on the same graph are significantly different according to DMRT at 5% ± standard error (SE).



**Figure 5** Effect of rice stem cutting sizes on the yield per hectare of ratoon rice. Data followed by different letters on the same line are significantly different according to DMRT at 5% ± standard error (SE).

**Table 3** Correlations of agronomic traits of ratoon rice in the treatment of stems cutting and Seprint liquid organic fertilizer (SLOF) dosages.

| Agronomic traits of ratoon rice | PH      | NT      | NPT     | NGP     | NFGP    | NEGP   | 1000-GW | YH     | Y |
|---------------------------------|---------|---------|---------|---------|---------|--------|---------|--------|---|
| PH                              | 1       |         |         |         |         |        |         |        |   |
| NT                              | 0.500** | 1       |         |         |         |        |         |        |   |
| NPT                             | 0.683** | 0.612** | 1       |         |         |        |         |        |   |
| NGP                             | -0.043  | -0.143  | 0.157   | 1       |         |        |         |        |   |
| NFGP                            | 0.104   | -0.051  | 0.217   | 0.927** | 1       |        |         |        |   |
| NEGP                            | -0.264  | -0.207  | 0.055   | 0.693** | 0.387*  | 1      |         |        |   |
| 1,000 GW                        | 0.167   | 0.243   | 0.271   | -0.085  | 0.090   | -0.311 | 1       |        |   |
| YH                              | 0.208   | 0.241   | 0.222   | 0.071   | 0.258   | -0.310 | 0.329*  | 1      |   |
| Y                               | 0.582** | 0.500** | 0.885** | 0.488** | 0.600** | 0.137  | 0.396*  | 0.360* | 1 |

Note: Correlation is significant at the \* 0.05 and \*\* 0.01 level (two-tailed). Agronomic traits: PH – plant height; NT – number of tillers; NPT – number of productive tillers; NGP – number of grains per panicle; NFGP – number of filled grains per panicle; NEGP – number of empty grains per panicle; 1,000 GW – 1,000-grains weight; YH – yield per hill; Y – yield per hectare.

#### 4. Discussion

Cutting 10 cm of the rice stem (R2 treatment) significantly increased the height of ratoon rice at 10 to 30 DAC and significantly increased the number of tillers of ratoon rice at 40 to 60 DAC and the number of productive tillers. The results were similar for the growth rate of ratoon rice, with the R2 treatment higher by 1.20 to 2.03 cm day<sup>-1</sup> compared to the R1 and R3 treatments that ranged from 0.89 to 1.26 cm day<sup>-1</sup> and 1.05 to 1.49 cm day<sup>-1</sup>, respectively. This was caused by an optimal carbohydrate supply from the emergence of the ratoon shoots that resulted in higher vegetative growth and was supported by the plant height, number of tillers, growth rate, and number of productive tillers on the R2 treatment being higher than the other cutting sizes (Table 1, Table 2 and Figure 2–Figure 4). The optimal cutting size of rice stems supports the growth and yield of ratoon rice. Santos et al. (2003) showed a decrease in yield ranging from 12% to 37% in <5 cm rice stem cuttings, whereas cuttings >20 cm of the rice stem produced tillers faster, and the number of grains was less than the optimal cutting size. Harrell et al. (2009) found that height cutting of the main plant stems affected the number of tillers and seed yield. Susilawati et al. (2012) stated that the height and number of productive tillers for ratoon rice in genotype IPB106-F-8-1 at a 10 cm cutting was higher than that at 20 cm and 30 cm cuttings. Mareza et al. (2016) stated that cutting 40 to 50 cm of the main rice stem was significant for the number of productive tillers, with the highest found at the 40 cm cutting (6.55 tillers) compared to the other cutting sizes.

The R2 treatment significantly increased the yield per hectare of ratoon rice to 3.58 tons ha<sup>-1</sup> compared to the other cutting sizes (Figure 5). The yield per hectare of ratoon rice in the study was smaller than that of the main plants (rice variety Inpari 30) where the initial planting was 5.08 tons ha<sup>-1</sup> and the yield decreased by 29.53% compared to the main plant. This resulted in a growth pattern (height and number of tillers) of ratoon rice that was higher in the R2 treatment compared to the other cutting sizes because photosynthesis caused the formation of assimilates and the production of filled grains. The number of productive tillers, number of filled grains per panicle, and 1,000-grains weight for the R2 treatment were also higher than the other cutting sizes (Figure 2–Figure 4). According to Harrell et al. (2009), the height of the cutting stems of the main plant affects the number of tillers and grains. Susilawati et al. (2012) showed that the yield per hectare of ratoon rice in genotype IPB106-F-8-1 for the 10 cm cutting was greater (2.1 tons ha<sup>-1</sup>) than that for the 20 and 30 cm cuttings (1.6 and 1.1 tons ha<sup>-1</sup>, respectively). Nuzul et al. (2018) found that the yield of ratoon rice decreased by 58.72% from that of the main plants.

The S3 treatment significantly increased the height of ratoon rice at 20 DAC (Table 1). SLOF has a main nutrient content of 11% N, which is higher than that of

K (2%). Therefore, a SLOF dose of 15 mL L<sup>-1</sup> could support the photosynthesis level and increase the vegetative phase of the ratoon rice. According to Surtinah (2009), liquid organic fertilizers are very efficient because plants easily absorb such fertilizers. Parman (2007) stated that liquid organic fertilizers improved soil physical, chemical, and biological properties, and increased the yield and quality of plants. Niis and Nik (2017) showed that the application of liquid organic fertilizer at a dose of 6 L ha<sup>-1</sup> significantly increased the highest number of seeds per panicle and the dry seed weight of rice by 107.38 seeds and 29.65 g, respectively, compared to doses of 2 and 4 L ha<sup>-1</sup>.

The S2 application significantly increased the yield per hill of ratoon rice by 54.32 g. SLOF contains 11% N and 2% K, which played an important role in improving the nutrient uptake and soil organic matter and increasing the availability of macro- and micronutrients for ratoon rice. Liquid organic fertilizers can play a role in cell division and increase assimilation, leading to increased biomass and yield of ratoon rice. According to Vidigal et al. (2002), the growth of onions increased progressively with an increased application of K fertilizer. El-Bassiony (2006) also stated that the application of K fertilizer increased the dry weight of onions. Martínez-Alcántara et al. (2016) stated that liquid organic fertilizers increased the uptake of macro- and micronutrients, and organic matter in soil compared to chemical fertilizers. Phibunwatthanawong and Riddech (2019) showed that liquid organic fertilizers contained micro- and supplementing nutrients, beneficial microorganisms such as plant growth-promoting rhizobacteria, and hormone indole acetic acid, which are not found in chemical fertilizers.

The R2S2 combination treatment significantly increased the ratoon rice height to 27.98 cm at 10 DAC. The R2S2 and R2S3 combination treatments had the highest ratoon rice height compared to the other combinations. This was caused by the main nutrients N and K in the S2 and S3 applications promoting the photosynthesis rate to form assimilates to stimulate ratoon rice growth, including the plant height, number of tillers, and number of productive tillers (Table 1, Table 2 and Figure 2–Figure 4). According to Nurhayati (2009), liquid organic fertilizer can promote metabolism in plants via the nutrient solubility process, and nutrient transport will occur from the roots to all parts of the plant. Hamzah (2014) stated that liquid organic fertilizer could increase plant height, and the number of branches and soybean pods.

The R2S1 combination treatment significantly increased the number of filled grains per panicle by 114.30 grains. This was because SLOF stimulated the metabolic process with the growth rate of ratoon rice, and photosynthesis formed assimilates and led to grain panicle production. According to Susilawati et al. (2012), the cutting of 10 cm of rice stem in genotype IPB106-F-8-1 significantly increased the number of grain per panicle, which was 108.0 grains higher than the 20 cm and 30 cm cuttings (78.5 and 71.1 grains, respectively). Mareza et al. (2016) stated that cutting 10 cm of the rice stems significantly improved the panicle length and the number of grains per panicle of ratoon rice by 14.93 cm and 47.05 grains, respectively, compared to the cuttings of 20 to 50 cm.

The correlations result confirmed that the number of productive tillers had a positive linear correlation (0.885) and was classified as very strong in increasing the yield per hectare of ratoon rice compared to another agronomic traits (Table 3). Similar results were reported by Sadeghi (2011); Ranawake et al. (2013) the number of productive tillers and the number of grains per panicle had a significant effect on grain yield per plant. Faruq et al. (2014) also reported that the number of productive tillers per hill has a correlated positively and significant increase the grain yield per plant of ratoon rice.

The application of ratoon rice technology combined with SLOF greatly encouraged rice yield to improve adequate food supply because a year of rice cultivation (main plants and ratoon technology) can produce an average yield of 8.66 tons ha<sup>-1</sup>. Thus, farmers will receive a double benefit by applying ratoon technology during a cycle of irrigated rice.

## 5. Conclusions

The R2 treatment significantly increased the ratoon rice height from 20.33 to 53.89 cm at 10 to 30 DAC, the number of tillers from 25.58 to 29.08 tillers at 40 to 60 DAC, the number of productive tillers to 24.92 tillers, and the yield per hectare of ratoon rice to 3.58 tons ha<sup>-1</sup>. The S3 application significantly increased the ratoon rice height to 35.71 cm at 20 DAC, and the S2 application significantly increased the yield per hill of ratoon rice to 54.32 g. The R2S2 combination treatment significantly increased the ratoon rice height to 27.98 cm at 10 DAC and the R2S1 combination treatment also significantly increased the number of filled grains per panicles of ratoon rice to 114.30 grains. The R2 treatment combined with various dosages of SLOF resulted in higher growth and yield of ratoon rice compared to the other cutting sizes.

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| <b>Nama Jurnal</b>      | <b>:</b> | <b>Acta Agrobotanica</b>                                                                                                                                                                                                                                                              |
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| <b>Skor Plagiarism</b>  | <b>:</b> | <b>15%</b>                                                                                                                                                                                                                                                                            |

**ORIGINAL RESEARCH PAPER**

**Agronomic Character of Ratoon Rice: Stem Cutting Sizes and Seprint Organic Liquid Fertilizer**

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**ABSTRAK**

The research aimed to identify the optimum size of rice stem cutting (ratoon) in combination with the application of Seprint liquid organic fertilizer (SLOF) in promoting the growth and production of the ratoon rice variety Inpari 30. This study used the rice variety Inpari 30 that was harvested 115 days after planting and then continued with the post-harvest cutting of the rice stems and SLOF application. This

research was conducted in the greenhouse, Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, North Sumatra Province, Indonesia from January until August 2018. Moreover, the study was set-up as a completely randomized factorial design with four replications. The first factor consisted of rice stem cutting (R1= 5 cm, R2= 10 cm, R3= 15 cm) and the second factor involved SLOF dosage (S1= 5 ml.l<sup>-1</sup>, S2= 10 ml.l<sup>-1</sup>, S3= 15 ml.l<sup>-1</sup>). The parameters were analyzed using the analysis of variance (ANOVA) and the mean was determined by Duncan's test at the using IBM SPSS statistics v.20 software. The results showed that cutting 10 cm of the rice stem significantly increased the height of the ratoon rice of 20.33 to 53.89 cm at 10 until 30 days after cutting (DAC), the number of tillers amounted to 25.58 to 29.08 tillers at 40 until 60 DAC and production.ha<sup>-1</sup> of 3.58 tons.ha<sup>-1</sup>. The giving of 10 ml.l<sup>-1</sup> and 15 ml.l<sup>-1</sup> SLOF significantly increased the production.hill<sup>-1</sup> and the height of ratoon rice amounted to 54.32 g and 35.71 cm at 20 DAC, respectively. The combination of cutting 10 cm of the rice stem with 5 ml.l<sup>-1</sup> and 10 ml.l<sup>-1</sup> SLOF significantly increased the number of filled grains.panicle<sup>-1</sup> and the height of ratoon rice amounted to 114.30 grains and 27.98 cm at 10 DAC, respectively.

**Keywords:** dosages; growth; production; ratoon rice; seprint liquid organic fertilizer.

## **Running Head : Growth and Production of Ratoon Rice**

## **INTRODUCTION**

Food is a basic human need and sufficient, nutritious and safe food can lead to quality human resources. One food that is a major source of energy is grain (rice). According to USDA data, the countries that have the highest level of rice consumption in the world are located in Asia. Countries with the highest level of rice consumption in

the World from 2015 until 2019 were China of 29.66%, India of 20.39%, Indonesia of 7.88%, Bangladesh of 7.32%, and Vietnam of 4.54% (USDA in Ministry of Agriculture, 2019). In Indonesia, rice is the main food needs of more than 90% of populations. Consumption rice per capita tends to decrease, from 107.71 kg.capita<sup>-1</sup>.year<sup>-1</sup> in 2002 to be 96.33 kg.capita<sup>-1</sup>.year<sup>-1</sup> in 2018 (Ministry of Agriculture, 2019). Domestic rice production from year to year continues to increase, although it had a trend towards a slower growth rate. Indonesia population growth had increased linearly from 2005 to 2015 (226.71 to 258.16 million) and the projected population until 2035 is estimated up to 305.65 million (Badan Pusat Statistik, 2019). The total domestic consumption of Indonesian rice will continue to increase even though per capita shown decreased.

Increased domestic consumption of rice in Indonesia must be followed by the program to increase rice production through intensification. One of the intensification programs that can be conducted by the system cultivation of ratoon rice. Mengel & Wilson, (1981) stated that the ratoon is a technique of harvesting production from tillers from main plant stumps that can increase grain yield without increasing land area. The ratoon technique is used to shorten the age of rice harvest. Maturing of hybrid rice varieties was needed at 105 until 124 days after scattering or around of 4 months (Balai Besar Penelitian Padi Kementerian Pertanian, 2019). Therefore, in a year can only be 2-fold the rice planting until harvesting. The ratoon system can produce 3- to 4-fold of rice harvesting. The advantages of the ratoon system are the higher efficiency of resource use per unit area of land and unit per timing (Santos et al., 2003), reducing land preparation, saving the cost of planting seeds (Zandstra & Samson, 1979), saving use of

machine, efficient use water (Prashar, 1970) and saving the time of planting because reduction in growth time (Haque & Coffman, 1980).

System cultivation of ratoon rice has been reported by researcher, Pratama et al., (2018) stated that the time of cutting the remaining stumps on 10 days of rice harvest was significantly on the largest root diameter of 0.89 mm with stump cutting height of 4 cm above the soil surface and could up to grain productivity of 3.39 to 3.54 tons.ha<sup>-1</sup>. Nuzul et al., (2018) stated that the highest yield component and yield of rice were achieved in the cutting at harvest with the height of 3 cm above the soil surface with grain yield of 3.54 tons.ha<sup>-1</sup>. Susilawati et al., (2012) stated that the cutting height of ratoon rice was related to the internode of plant, the nodes contain lateral shoots which will produce shoots of ratoon. Jichao & Xiaohui, (1996) stated that the number of growing shoots can be determined by the cutting height of the main plant stems, but the condition is strongly influenced by residual assimilates as reserves in the stems that can be utilized for ratoon growth, and the rate of ratoon vigor. The stem cutting height of the main plant can also affect the number of tillers and seed yields (Harrel et al., 2009) and triggers dormant shoots to grow (Mahadevappa & Yogeessa, 1988).

However, the system of rice cultivation cannot be separated from the use of fertilizer to achieve optimal production. Islam et al., (2008) reported that the fertilizer application of N= 130 kg.ha<sup>-1</sup>, P<sub>2</sub>O<sub>5</sub>= 75 kg.ha<sup>-1</sup>, K<sub>2</sub>O= 80 kg.ha<sup>-1</sup>, S= 13 kg.ha<sup>-1</sup>, Zn= 4 kg.ha<sup>-1</sup> significantly increased the yield of the Boro rice ratoon by 1.42 tons.ha<sup>-1</sup>. The high price of fertilizer with limited availability had resulted in the use of liquid organic fertilizer to be an alternative to increase the availability and efficiency of irrigation rice nutrient uptake. The effect of liquid organic fertilizer on the growth and yield of irrigation rice has been widely reported, but the use of liquid organic fertilizer on the

growth and production of ratoon rice is still relatively limited. Thus, a special assessment of the specific liquid organic fertilizers impact is needed to increase the growth and production of ratoon rice. The research aimed to identify the optimum size of rice stem cutting (ratoon) in combination with the Seprint liquid organic fertilizer (SLOF) application in promoting growth and production of the ratoon rice variety Inpari 30.

## **MATERIAL AND METHODS**

### **Experiment I (Preliminary Research Stage)**

The source of the main plant (rice variety Inpari 30) from Balai Pengkajian Teknologi Pertanian (BPTP) Pasar Miring, Pasar Miring Village, Pagar Merbau Sub-district, Deli Serdang District, North Sumatra Province, Indonesia. Planting was conducted in the water bucket of 20 l with an upper diameter of 31 cm, the lower diameter of 22 cm and the height of 31 cm (Figure 1). Planting was conducted at the greenhouse in the Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, Indonesia on January until August 2018. The water bucket is filled with soil from the Salemba area, Amplas, Medan City. The soil into the water bucket until less 5 cm from the water bucket surface. The water bucket was inundated with water up to the vegetative phase of the main plant, then the water in the bucket was reduced to the bearing capacity toward harvesting. The main plant was harvested at 115 days after planting then cutting of the rice stem (experiment II).

### **Experiment II (Main Research Stage)**

Experiment II continues the experiment I. After the rice was harvested, stem rice was conducted with cutting based on the size of treatment (Figure 2). The water bucket

was inundated when cutting rice stems until the vegetative phase was done. Then reduce the water toward the harvesting of ratoon rice plants. The giving of Seprint Liquid Organic Fertiliser (SLOF) was conducted at a week after cutting of rice stems. The main nutrient content of SLOF is 11% N, and 2% K<sub>2</sub>O (Source: Bunga Tani Products).

#### **Design Research and Data Analyzed**

This research was used in the Completely Randomized factorial Design with four replications. The first factor consisted of rice stem cutting (R1= 5 cm, R2= 10 cm, R3= 15 cm), and the second factor involved SLOF dosage (S1= 5 ml.l<sup>-1</sup>, S2= 10 ml.l<sup>-1</sup>, S3= 15 ml.l<sup>-1</sup>). The distance between treatments of 50 cm x 50 cm. The parameters of this research were the height and the growth quickness of ratoon rice, the number of tillers at 10 to 60 Days After Cutting (DAC), the yield component of ratoon rice (the number of the productive tillers, the number of grains.penicle<sup>-1</sup>, the number of filled grains.penicle<sup>-1</sup>, the number of empty grains.penicle<sup>-1</sup>, 1000 grains weight, the production.hill<sup>-1</sup>, and the production.ha<sup>-1</sup>). The calculation of the growth quickness and production.ha<sup>-1</sup> of ratoon rice can be seen in equations 1 and 2.

$$\text{Growth quickness (cm.day}^{-1}\text{)} = \frac{\text{Average height of ratoon rice}}{\text{days of cutting}} \quad (1)$$

$$\text{Production.ha}^{-1} = \text{NP} \times \text{NPT} \times \text{NFGP} \times 1000\text{-GW} \quad (2)$$

Note :

$$\text{NP} = \text{number population.ha}^{-1} = \frac{\text{land area.ha}^{-1}}{\text{plant spacing}} = \frac{10,000 \text{ m}^2}{0.5 \text{ m} \times 0.5 \text{ m}} = 40,000 \text{ populations.}$$

NPT = number of productive tillers

NFGP = number of filled grains.penicle<sup>-1</sup>

1000-GW = 1000 grains weight (g)

The parameters were analyzed using the analysis of variance (ANOVA) and the mean was determined by DMRT at the level of 5% using IBM SPSS statistics v.20 software.

## **RESULTS**

### **Height and Growth Quickness of Ratoon Rice**

Based on the ANOVA showed that cutting stems significantly increased the height of ratoon rice at 10 to 30 DAC, in contrast not significantly at 40 to 60 DAC. The giving of SLOF significantly increased the height of the ratoon rice at 20 DAC, in contrast not significantly at 10, 30, 40, and 60 DAC. Interaction of the cutting of rice stems with SLOF showed significantly increased the height of ratoon rice at 10 DAC, in contrast, not significant at 20 until 60 DAC (Table 1). The results showed that the cutting 10 cm of the rice stem was increased the highest of the height of ratoon rice at 10-60 DAC compared to other cutting sizes, although it has significantly at 10-30 DAC. The giving of 15 ml.l<sup>-1</sup> SLOF was increased the highest of the height of ratoon rice at 10-40 DAC compared to other doses, although it was significant only at 20 DAC. The highest of the height of ratoon rice was found in the given 10 ml.l<sup>-1</sup> SLOF at 60 DAC. Interaction of the cutting 10 cm of rice stem with 10 ml.l<sup>-1</sup> SLOF (R2S2) is the combination significantly increased the height of ratoon rice amounted to 27.98 cm at 10 DAC. Whereas the highest of the height of ratoon rice was found in the combination cutting 10 cm of the rice stem with 15 ml.l<sup>-1</sup> SLOF (R2S3) at 20 until 60 DAC.

### **Number of Ratoon Rice Tillers**

Based on the ANOVA showed that the cutting of rice stems significantly increased the number of ratoon rice tillers at 40-60 DAC, in contrast not significantly at

10-30 DAC. The giving SLOF and their interactions showed not significantly increased the number of ratoon rice tillers (Table 2). The results showed that the cutting 10 cm of the rice stem can impact in increasing the highest of the number of ratoon rice tillers at 10-60 DAC compared to other cutting sizes, although significantly was found in 40 until 60 DAC. The giving of 10 ml.l<sup>-1</sup> SLOF (S2) was given the highest of the number of ratoon rice tillers of 25.33 tillers until the end observation (60 DAC) compared to other doses. The combination cutting 10 cm of the rice stem with 15 ml.l<sup>-1</sup> SLOF (R2S3) was given the highest of the number of ratoon rice tillers of 36.25 tillers at 60 DAC compared to other combinations.

#### **Yield Component of Ratoon Rice**

Based on the ANOVA showed that the cutting of rice stems, SLOF dosages, and their interactions not significantly on the yield component of ratoon rice (the number of productive tillers, the number of grains.panicle<sup>-1</sup>, the number of empty grains.panicle<sup>-1</sup>, and 1000 grains weight) (Figure 3-5). The results showed that the cutting 10 cm of the rice stem (R2) was given the highest of the number of productive tillers, the number of grains.panicle<sup>-1</sup>, the number of empty grains.panicle<sup>-1</sup>, and 1000 grains weight amounted to 35.75 tillers, 116.77 grains, 19.08 grains, and 25.91 g, respectively compared to other cutting sizes. The giving 10 ml.l<sup>-1</sup>, 5 ml.l<sup>-1</sup>, 15 ml.l<sup>-1</sup> of SLOF also given the highest of the number of productive tillers, 1000 grains weight, the number of grains.panicle<sup>-1</sup>, and the number of empty grains.panicle<sup>-1</sup> amounted to 32.75 tillers, 25.92 g, 113.59 grains, and 17.89 grains, respectively compared to other doses. The combination cutting 10 cm of the rice stem with 10 ml.l<sup>-1</sup>, 5 ml.l<sup>-1</sup>, 15 ml.l<sup>-1</sup> of SLOF was given the highest of the number of productive tillers, 1000 grains weight, the number of grains.panicle<sup>-1</sup>, and the

number of empty grains.panicle<sup>-1</sup> amounted to 41.50 tillers, 26.78 g, 139.85 grains, and 15.60 grains, respectively compared to other combinations.

Based on the ANOVA showed that the cutting of rice stems and SLOF dosages not significantly on the number of filled grains.panicle<sup>-1</sup>, in contrast, their interactions significantly increased the number of filled grains.panicle<sup>-1</sup> of ratoon rice (Figure 3-5). The results showed that cutting 10 cm of the rice stem (R2) was given the highest of the number of filled grains.panicle<sup>-1</sup> of 97.58 grains compared to other cutting sizes. The giving of 10 ml.l<sup>-1</sup> SLOF (S2) was given the highest of the number of filled grains.panicle<sup>-1</sup> of 91.53 grains compared to other doses. The combination cutting 10 cm of the rice stem with 5 ml.l<sup>-1</sup> SLOF (R2S1) significantly increased the highest of the number of filled grains.panicle<sup>-1</sup> of 114.30 grains compared to other combinations.

Based on the ANOVA showed that the SLOF dosages significantly increased the production.hill<sup>-1</sup> of ratoon rice, in contrast, the cutting of the rice stems and their interactions not significantly increased the production.hill<sup>-1</sup> of ratoon rice (Figure 3-5). The results showed that the giving of 10 ml.l<sup>-1</sup> SLOF (S2) significantly increased in the highest of the production.hill<sup>-1</sup> of ratoon rice amounted to 54.32 g compared to other doses. The cutting 10 cm of the rice stem (R2) was given the highest of the production.hill<sup>-1</sup> of ratoon rice of 46.56 g compared to other cutting sizes. The combination cutting 10 cm of the rice stem with 10 ml.l<sup>-1</sup> SLOF (R2S2) was given the highest of the production.hill<sup>-1</sup> of ratoon rice amounted to 60.63 g compared to other combinations.

Based on the ANOVA showed that the cutting of rice stems significantly increased the production.ha<sup>-1</sup> of ratoon rice, in contrast, the SLOF dosages and their interactions not significantly increased the production.ha<sup>-1</sup> of ratoon rice (Figure 6). The

results showed that the cutting 10 cm of the rice stem (R2) significantly increased the highest of the production.ha<sup>-1</sup> of ratoon rice amounted to 3.58 tons.ha<sup>-1</sup> compared to other cutting sizes. The giving of 10 ml.l<sup>-1</sup> SLOF was given the highest of the production.ha<sup>-1</sup> of ratoon rice amounted to 3.12 tons.ha<sup>-1</sup> compared to other dosages, whereas the combination cutting 10 cm of rice stem with 15 ml.l<sup>-1</sup> SLOF (R2S3) was given the highest of the production.ha<sup>-1</sup> of ratoon rice amounted to 3.88 tons.ha<sup>-1</sup> compared to other combinations.

## DISCUSSION

The cutting 10 cm of the rice stem significantly increased the highest of the height of ratoon rice at 10-30 DAC. The result similar to the growth quickness of ratoon rice on the cutting 10 cm was higher (1.20 to 2.03 cm.day<sup>-1</sup>) compared to the cutting 5 cm and 15 cm, ranging from 0.89 to 1.26 cm.day<sup>-1</sup> and 1.05 to 1.49 cm.day<sup>-1</sup>, respectively. This is caused by the optimal carbohydrates supply that the emergence of ratoon shoots. The results of this research were authenticated that the higher or smaller of the ratoon rice variety Inpari 30 does not show the higher of the height growth compared to cutting 10 cm. This is consistent with the height and the number of ratoon rice tillers at cutting 10 cm was higher compared to other sizes (Table 1-2). The optimal cutting size of rice stems will support the growth and production of ratoon rice. According to Vergara et al., (1988) stated that the optimal cutting height of ratoon rice ranged from 15-20 cm with leaving 2 to 3 internode able to increased vigor and seed production on panicles of ratoon. Santos et al., (2003) stated that a decrease in yield ranging from 12-37% in the cutting < 5 cm of rice stem, while the cutting > 20 cm of rice stem can be produced tillers faster emerge in contrast the number of grains was fewer compared to the optimal cutting size. Susilawati et al., (2012) stated that the

height of the ratoon rice genotype IPB106-F-8-1 at the cutting 10 cm was higher compared to the cutting 20 cm and 30 cm.

The giving of 15 ml.l<sup>-1</sup> SLOF significantly increased the highest of the height of ratoon rice at 20 DAC. This is caused by the SLOF have the main nutrient content of 11% N more higher compared to K nutrient (2%) with the result that the dose of 15 ml.l<sup>-1</sup> SLOF can support the photosynthesis level and have an impact on increasing the vegetative phase of ratoon rice. This is linear with the height of ratoon rice at the dose 15 ml.l<sup>-1</sup> SLOF was higher compared to other dosages at 20 DAC (Table 1). According to Gardner et al., (1985) stated that nitrogen is a structural component of important organic compounds, such as amino acids, proteins, nucleoproteins, various enzymes, purines, and pyrimidines. Nitrogen is needed by plants in cell division and enlargement that the optimum giving of nitrogen will increase the plant's vegetative phase. Engelstad, (1997) stated that the optimal giving of N nutrients can support plant growth, increased protein synthesis, increased chlorophyll formation and increased the plant root shoot ratio.

The combination cutting 10 cm of rice stem with 10 ml.l<sup>-1</sup> SLOF (R2S2) significantly increased the height of the ratoon rice amounted to 27.98 cm at 10 DAC. This authenticates the combination of cutting 10 cm of rice stem with 10-15 ml.l<sup>-1</sup> SLOF was showed the highest of the height of ratoon rice compared to other combinations. This is caused to the main nutrients N and K in the 10 to 15 ml.l<sup>-1</sup> of SLOF dosages can be promoted the photosynthesis rate in forming assimilates at cutting 10 cm as to stimulate the growth process of the ratoon rice, such as plant height, number of tillers, and the number of productive tillers (Table 1-2, Figure 3-5). According to Nurhayati, (2009) stated that the application of liquid organic fertilizer can be promoted

the process of metabolism in plants through the process of nutrient solubility, that nutrient transport will be going well from the roots to all parts of the plant. Hamzah, (2014) stated that the use of liquid organic fertilizer can an increase plant height, the number of branches, and the number of soybean pods.

The cutting 10 cm of rice stem significantly increased the highest of the number of ratoon rice tillers at 40-60 DAC. This is caused by that result assimilate in the optimal cutting of ratoon can be produced well vegetative growth. This is can be seen from the growth quickness of ratoon rice on cutting 10 cm was higher compared to other cutting sizes (Table 1). This is supported by the number of ratoon rice productive tillers on cutting 10 cm higher compared to other cutting sizes (Figure 3-5 ). According to Harrel et al., (2009) stated that the height cutting of the main plant stems can also affect the number of tillers and seed yields. Susilawati et al., (2012) stated that the number of ratoon rice productive tillers on genotypes IPB106-F-8-1 in the cutting 10 cm was higher compared to the cutting 20 cm and 30 cm.

The combination cutting 10 cm of rice stem with 5 ml.l<sup>-1</sup> SLOF (R2S1) significantly increased the highest of the number of filled grains.panicle<sup>-1</sup> amounted to 114.30 grains. This is caused by the giving of SLOF that can be stimulated the metabolic process with growth quickness of ratoon rice on cutting 10 cm that the results of photosynthesis will form assimilates and lead to production grain.panicle<sup>-1</sup>. According to Nurhayati, (2009) stated that the application of liquid organic fertilizer can be supporting the process of metabolism in plants through the process of nutrient solubility, that nutrient transport going well from the roots to all parts of the plant. Susilawati et al., (2012) stated that the cutting 10 cm of the IPB106-F-8-1 genotype rice stem significantly increased the number of grain.panicle<sup>-1</sup> and was higher of 108.0

grains compared to cutting 20 cm of rice stem amounted to 78.5 grains and the cutting 30 cm of rice stem amounted to 71.1 grains. Mareza et al., (2016) stated that the cutting 10 cm of rice stem significantly improved the length of the panicle (14.93 cm) and the number of grains.panicle<sup>-1</sup> of ratoon rice (47.05 grains) compared to cutting 20 until 50 cm of rice stem.

The giving of 10 ml.l<sup>-1</sup> SLOF (S2) significantly increased the highest of the production.hill<sup>-1</sup> of ratoon rice amounted to 54.32 g. This is caused the main nutrient content in SLOF (N= 11% and K= 2%) had an important role in cell division and increases assimilation has an impact on increasing biomass and production of ratoon rice. According to Gardner et al., (1985) stated that nitrogen nutrient was needed by plants in cell division and enlargement that the giving of optimum nitrogen will increase the plant's vegetative phase. Vachhani & Patel, (1996) stated that the application of K fertilizer can increase the vegetative growth of the onion plant. Vidigal et al., (2002) stated that the growth of onion was increased progressively with the increasing application of K fertilizer. El-Bassiony, (2006) stated that K fertilizer was affected by increasing the dry weight of the onion plant.

The cutting 10 cm of stem rice (R2) can significantly increased the highest of the production.ha<sup>-1</sup> of ratoon rice amounted to 3.58 tons.ha<sup>-1</sup> compared to other cutting sizes. The production.ha<sup>-1</sup> of ratoon rice on the research was smaller compared to the production.ha<sup>-1</sup> of main plants (rice variety Inpari 30) when the initial planting up to 5.08 tons.ha<sup>-1</sup>, or the production was reduced by 29.53% of the main plant. This is caused the growth pattern (the height and number of tillers) of ratoon rice were higher in cutting 10 cm compared to other cutting sizes that the results of photosynthesis produced will be distributed in the assimilates form and produce filled grains. This is

linear with the number of productive tillers, the number of filled grains.panicle<sup>-1</sup> and 1000 grains weight on the cutting 10 cm was higher compared to other cutting sizes (Figure 3-5). According to Harrel et al., (2009) stated that the height cutting stems of the main plant can affect the number of tillers and grains production. Susilawati et al., (2012) stated that the production.ha<sup>-1</sup> ratoon rice genotype IPB106-F-8-1 on the cutting of 10 cm was greater of 2.1 tons.ha<sup>-1</sup> compared to the cutting 20 cm of 1.6 tons.ha<sup>-1</sup> and the cutting 30 cm of 1.1 tons.ha<sup>-1</sup>. Nuzul et al., (2018) also stated that the yield of ratoon rice was decreased from 6.54 tons.ha<sup>-1</sup> to 2.70 tons.ha<sup>-1</sup> or amounted to 58.72% of main plants.

The application of ratoon rice technology combine with the SLOF greatly encourages of rice production in achieving food sufficiency, because in a year of rice cultivation (main plants and ratoon technology) can produce an average production of 8.66 tons.ha<sup>-1</sup>. Thus, farmers will get a double benefit by applying ratoon technology in a cycle of irrigation rice.

## CONCLUSIONS

The cutting 10 cm of rice stem significantly increased the height of ratoon rice ranging from 20.33 to 53.89 cm at 10 until 30 DAC, the number of tillers ranging from 25.58 to 29.08 tillers at 40 until 60 DAC and the production.ha<sup>-1</sup> of ratoon rice amounted to 3.58 tons.ha<sup>-1</sup>. The giving of 15 ml.l<sup>-1</sup> SLOF significantly increased the height of ratoon rice amounted to 35.71 cm at 20 DAC, and the 10 ml.l<sup>-1</sup> SLOF also significantly increased the production.hill<sup>-1</sup> of ratoon rice amounted to 54.32 g. The combination cutting 10 cm of rice stem with 10 ml.l<sup>-1</sup> SLOF significantly increased the height of ratoon rice amounted to 27.98 cm at 10 DAC and the combination cutting 10 cm of rice stem with 5 ml.l<sup>-1</sup> SLOF also significantly increased the number of filled

grains.panicle<sup>-1</sup> of ratoon rice amounted to 114.30 grains. The application cutting 10 cm of rice stem combined with various dosages of SLOF showed that the higher growth and production of ratoon rice compared to other cutting sizes.

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## TABLES

Table 1. Effect of rice stems cutting and SLOF on the height of ratoon rice at 10 until 60 days after cutting (DAC).

| Treatment             | Height of Ratoon Rice (cm) |          |           | average  | Growth quickness (cm.day <sup>-1</sup> ) |
|-----------------------|----------------------------|----------|-----------|----------|------------------------------------------|
|                       | S1                         | S2       | S3        |          |                                          |
| 10 Days After Cutting |                            |          |           |          |                                          |
| R1                    | 9.46 d-h                   | 7.05 h   | 10.33 c-h | 8.95 b   | 0.89                                     |
| R2                    | 7.45 gh                    | 27.98 a  | 25.55 a   | 20.33 a  | 2.03                                     |
| R3                    | 13.13 b-h                  | 8.90 fgh | 9.45 e-h  | 10.49 b  | 1.05                                     |
| average               | 10.01                      | 14.64    | 15.11     |          |                                          |
| 20 Days After Cutting |                            |          |           |          |                                          |
| R1                    | 15.53                      | 17.35    | 22.93     | 18.60 b  | 0.93                                     |
| R2                    | 15.25                      | 42.35    | 48.80     | 35.47 a  | 1.77                                     |
| R3                    | 27.90                      | 12.73    | 35.40     | 25.34 ab | 1.27                                     |
| average               | 19.56 b                    | 24.14 ab | 35.71 a   |          |                                          |
| 30 Days After Cutting |                            |          |           |          |                                          |
| R1                    | 31.28                      | 39.95    | 36.88     | 36.04 b  | 1.20                                     |
| R2                    | 39.70                      | 58.33    | 63.63     | 53.89 a  | 1.80                                     |
| R3                    | 46.40                      | 38.13    | 49.93     | 44.82 ab | 1.49                                     |
| average               | 39.13                      | 45.47    | 50.15     |          |                                          |
| 40 Days After Cutting |                            |          |           |          |                                          |
| R1                    | 46.90                      | 52.98    | 50.73     | 50.20    | 1.26                                     |
| R2                    | 61.90                      | 63.93    | 75.23     | 67.02    | 1.68                                     |
| R3                    | 60.70                      | 54.28    | 55.83     | 56.94    | 1.42                                     |
| average               | 56.50                      | 57.06    | 60.60     |          |                                          |
| 60 Days After Cutting |                            |          |           |          |                                          |
| R1                    | 59.20                      | 65.80    | 58.18     | 61.06    | 1.02                                     |
| R2                    | 67.50                      | 70.38    | 77.53     | 71.80    | 1.20                                     |
| R3                    | 67.93                      | 66.28    | 64.63     | 66.28    | 1.10                                     |
| average               | 64.88                      | 67.49    | 66.78     |          |                                          |

Note: Data was followed by different letters on the same line show significantly different based on the DMRT test at the level 5%. Size cutting of rice stems (R1= 5 cm; R2= 10 cm; R3= 15 cm). SLOF dosages (S1= 5 ml.l<sup>-1</sup>; S2= 10 ml.l<sup>-1</sup>; S3= 15 ml.l<sup>-1</sup>).

Table 2. Effect of rice stems cutting and SLOF on the number of ratoon rice tillers at 10 until 60 DAC.

| Treatment             | Number of Ratoon Rice Tillers |       |       | average  |
|-----------------------|-------------------------------|-------|-------|----------|
|                       | S1                            | S2    | S3    |          |
| 10 Days After Cutting |                               |       |       |          |
| R1                    | 6.75                          | 2.00  | 3.75  | 4.17     |
| R2                    | 7.00                          | 7.00  | 6.00  | 6.67     |
| R3                    | 8.00                          | 5.00  | 4.50  | 5.83     |
| average               | 7.25                          | 4.67  | 4.75  |          |
| 20 Days After Cutting |                               |       |       |          |
| R1                    | 8.75                          | 4.25  | 5.00  | 6.00     |
| R2                    | 8.25                          | 14.50 | 15.25 | 12.67    |
| R3                    | 15.00                         | 9.00  | 8.75  | 10.92    |
| average               | 10.67                         | 9.25  | 9.67  |          |
| 30 Days After Cutting |                               |       |       |          |
| R1                    | 9.00                          | 7.25  | 8.00  | 8.08     |
| R2                    | 9.25                          | 19.25 | 24.00 | 17.50    |
| R3                    | 20.00                         | 12.75 | 15.00 | 15.92    |
| average               | 12.75                         | 13.08 | 15.67 |          |
| 40 Days After Cutting |                               |       |       |          |
| R1                    | 10.75                         | 12.00 | 10.50 | 11.08 b  |
| R2                    | 10.50                         | 33.25 | 33.00 | 25.58 a  |
| R3                    | 22.75                         | 23.00 | 19.50 | 21.75 ab |
| average               | 14.67                         | 22.75 | 21.00 |          |
| 60 Days After Cutting |                               |       |       |          |
| R1                    | 13.00                         | 13.25 | 13.25 | 13.17 b  |
| R2                    | 16.00                         | 35.00 | 36.25 | 29.08 a  |
| R3                    | 24.00                         | 27.75 | 23.50 | 25.08 a  |
| average               | 17.67                         | 25.33 | 24.33 |          |

Note: Data was followed by different letters on the same line show significantly different based on the DMRT test at the level 5%. Size cutting of rice stems (R1= 5 cm; R2= 10 cm; R3= 15 cm). SLOF dosages (S1= 5 ml.l<sup>-1</sup>; S2= 10 ml.l<sup>-1</sup>; S3= 15 ml.l<sup>-1</sup>).

## FIGURES

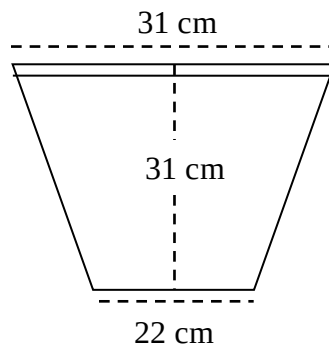


Figure 1. The size of the water bucket.



Figure 2. Design experiment II.

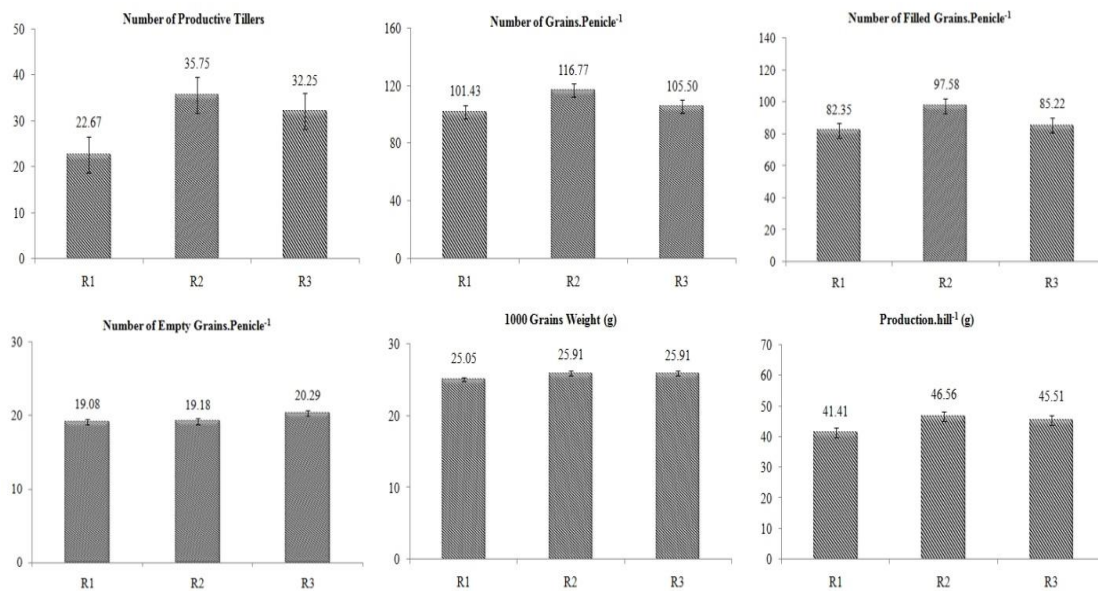


Figure 3. Effect of rice stem cutting sizes (R1= 5 cm; R2= 10 cm; R3= 15 cm) on the yield component of ratoon rice. Data followed by different letters on the same line show significantly different based on the DMRT test at the level of 5%  $\pm$  SE.

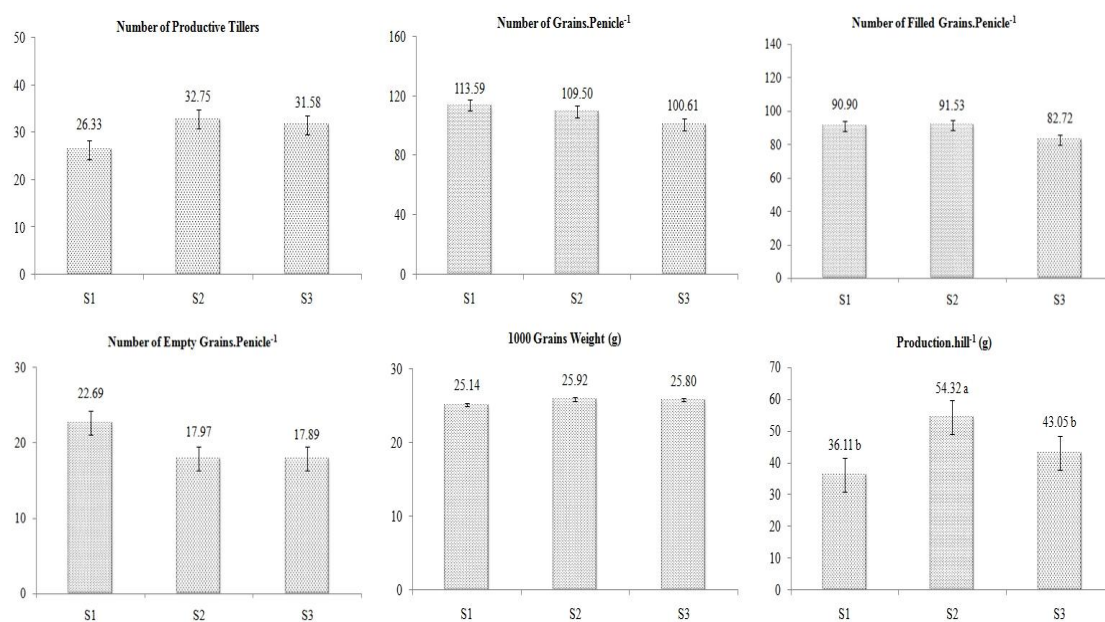


Figure 4. Effect of SLOF dosages (S1= 5 ml.l<sup>-1</sup>; S2= 10 ml.l<sup>-1</sup>; S3= 15 ml.l<sup>-1</sup>) on the yield component of ratoon rice. Data followed by different letters on the same line show significantly different based on the DMRT test at the level of 5%  $\pm$  SE.

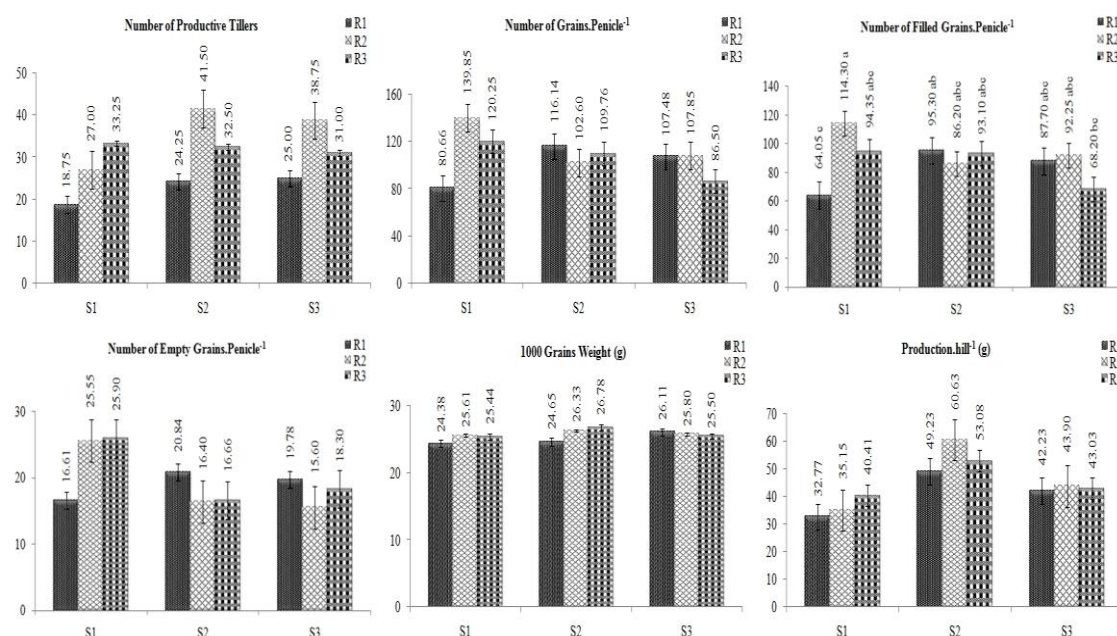


Figure 5. The combinations of stem cutting sizes (R1 = 5 cm; R2 = 10 cm; R3 = 15 cm) and SLOF dosages (S1= 5 ml.l<sup>-1</sup>; S2= 10 ml.l<sup>-1</sup>; S3= 15 ml.l<sup>-1</sup>) on the yield component of ratoon rice. Data followed by different letters on the same line show significantly different based on the DMRT test at the level 5%  $\pm$  SE.

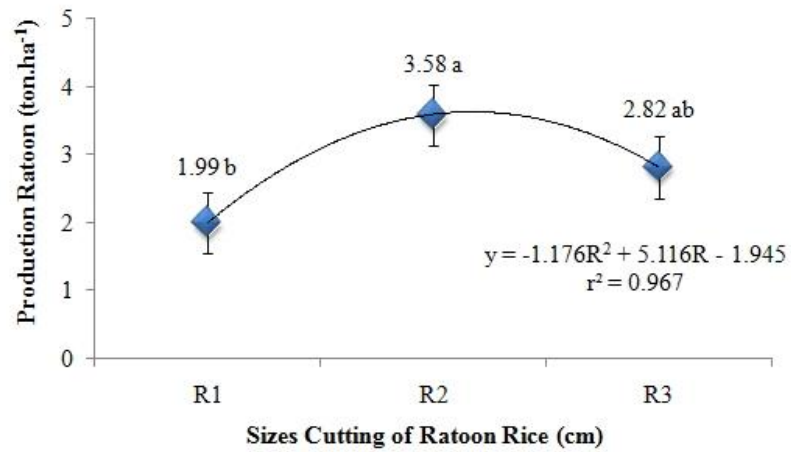


Figure 6. Effect of rice stem cutting sizes (R1= 5 cm; R2= 10 cm; R3= 15 cm) on the production.ha<sup>-1</sup> of ratoon rice. Data followed by different letters on the same line show significantly different based on the DMRT test at the level of 5% ± SE.

# Alridiwirsah et al., 2021

*by* Koko Tampubolon

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1    **ORIGINAL RESEARCH PAPER**

2

3    **Agronomic Character of Ratoon Rice: Stem Cutting Sizes and Seprint Liquid**  
4    **Organic Fertilizer**

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19    **ABSTRACT**

20        The research aimed to identify the optimum size of rice stem cutting (ratoon) in  
21        combination with the application of Seprint liquid organic fertilizer (SLOF) in  
22        promoting the growth and yield of the ratoon rice. This research was conducted in the  
23        greenhouse, Faculty of Agriculture, University of Muhammadiyah Sumatera Utara,  
24        North Sumatra Province, Indonesia from January to August 2018. The research was set-  
25        up as completely randomized design factorial within four replications. The first factor

involved the cutting sizes of the rice stem (R1= 5 cm, R2= 10 cm, R3= 15 cm) and the second factor involved SLOF dosages, including S1= 5 ml l<sup>-1</sup>, S2= 10 ml l<sup>-1</sup>, S3= 15 ml l<sup>-1</sup>. Parameters were analyzed using the ANOVA and the means was determined by Duncan Multiple Range Test (DMRT) at 5% using IBM SPSS statistics v.20 software. The results showed that cutting 10 cm of the rice stem significantly increased the ratoon rice height at 10 until 30 days after cutting (DAC), number of tillers at 40 until 60 DAC and yield ha<sup>-1</sup>. The SLOF at the dose of 10 and 15 ml l<sup>-1</sup> significantly increased the yield hill<sup>-1</sup> and the ratoon rice height at 20 DAC. The combination of cutting 10 cm of the rice stem with SLOF at the dose of 5 and 10 ml l<sup>-1</sup> significantly increased the number of filled grains panicle<sup>-1</sup> and the ratoon rice height at 10 DAC. Application cutting steem at 10 cm combined with various dosages of SLOF resulted the greater growth and yield of ratoon rice in achieving food sufficiency.

**Keywords:** dosage; growth; yield; ratoon rice; seprint liquid organic fertilizer.

**Running Head : Growth and Yield of Ratoon Rice**

## INTRODUCTION

Food is a basic human need and sufficient, nutritious and safe food can lead to quality human resources. One food that is a major source of energy is grain (rice). According to USDA data, the countries that have the highest level of rice consumption in the world are located in Asia. Countries with the highest level of rice consumption found in China by 29.66%, India by 20.39%, Indonesia by 7.88%, Bangladesh by 7.32%, and Vietnam by 4.54% of the world from 2015 to 2019 (USDA in Ministry of Agriculture, 2019). In Indonesia, rice is the main food needs of more than 90% of populations. Consumption rice capita<sup>-1</sup> tends to decrease, from 107.71 kg capita<sup>-1</sup> year<sup>-1</sup>

40  
50 in 2002 to be 96.33 kg capita<sup>-1</sup> year<sup>-1</sup> in 2018 (Ministry of Agriculture, 2019). Domestic  
51 rice yield from year to year continues to increase, although it had a trend towards a  
52 slower growth rate. Indonesia population growth had increased linearly from 2005 to  
53 2015 at 226.71 until 258.16 million and the projected population until 2035 is estimated  
54 up to 305.65 million (Statistics of Indonesia, 2019). The total domestic consumption of  
55 Indonesian rice will continue to increase even though per capita shown decreased.

56 Increased domestic consumption of rice in Indonesia must be followed by the  
57 program to increase rice yield through intensification. One of the intensification  
58 programs that can be conducted by the system cultivation of ratoon rice. Mengel &  
59 Wilson, (1981) stated that the ratoon is a technique of harvesting production from tillers  
60 from main plant stumps that can increase grain yield without increasing land area. The  
61 ratoon technique is used to shorten the age of rice harvest. Maturing of hybrid rice  
62 varieties was needed at 105 until 124 days after scattering or around of 4 months  
63 (Indonesian Center for Rice Research, 2019). Therefore, in a year can only be 2-fold the  
64 rice planting until harvesting. The ratoon system can produce 3- until 4-fold of rice  
65 harvesting. The advantages of the ratoon system are the higher efficiency of resource  
66 use per unit area of land and unit per timing (Santos et al., 2003), reducing land  
67 preparation, saving the cost of planting seeds (Zandstra & Samson, 1979), and saving  
68 the time of planting because reduction in growth time (Haque & Coffman, 1980). In  
69 addition, the ratoon rice is considered by farmers because of its high quality including  
70 12 cooking, flavor, short growing, reduce the cost of water, fertilizer and pest control  
71 (Yazdpour et al., 2012). Alizadeh & Habibi, (2016) also reported that the grain  
72 thickness and amylose content for ratoon rice was higher ranged of 1.18 to 2.25% and  
73 2.28 to 7.69% compared to the main crop.

74 System cultivation of ratoon rice has been reported, Pratama et al., (2018) stated  
75 that the time of cutting the remaining stumps on 10 days of rice harvest was  
76 significantly on the largest root diameter of 0.89 mm with stump <sup>38</sup>cutting height of 4 cm  
77 above the soil surface and could up to grain productivity of 3.39 to 3.54 ton ha<sup>-1</sup>. Nuzul  
78 et al., (2018) stated that the highest yield component (number and length of panicle,  
79 harvest age, grain number panicle<sup>-1</sup>, filled grain, 1000-grains weight, total dry weight,  
80 harvest indeks) and yield (grain ha<sup>-1</sup>) of rice were achieved in the cutting at harvest with  
81 <sup>21</sup>the height of 3 cm above the soil surface with the grain yield of 3.54 ton ha<sup>-1</sup>. <sup>11</sup>Susilawati  
82 et al., (2012) stated that the cutting height of ratoon rice was related to the internode of  
83 plant, the nodes contain lateral shoots which will produce shoots of ratoon. Jichao &  
84 Xiaohui, (1996) stated that the number of growing shoots can be determined by the  
85 cutting height stems of the main plant, but the condition is strongly influenced by  
86 residual assimilates as reserves in the stems that can be utilized for ratoon growth, and  
87 the rate vigor of ratoon. The stem cutting height of the main plant can also affect the  
88 number of tillers and seed yields (Harrel et al., 2009) and triggers dormant shoots to  
89 grow (Mahadevappa & Yogeasha, 1988).

90 However, the system of rice cultivation did not be separated from the use of  
91 fertilizer to achieve optimal <sup>37</sup>yield. Islam et al., (2008) reported that the fertilizer  
92 <sup>7</sup>application of N= 130 kg ha<sup>-1</sup>, P<sub>2</sub>O<sub>5</sub>= 75 kg ha<sup>-1</sup>, K<sub>2</sub>O= 80 kg ha<sup>-1</sup>, S= 13 kg ha<sup>-1</sup>, Zn= 4  
93 kg ha<sup>-1</sup> significantly increased the yield of the Boro rice ratoon by 1.42 ton ha<sup>-1</sup>. The  
94 high price of fertilizer with limited availability had resulted in the use of liquid organic  
95 <sup>5</sup>fertilizer to be an alternative to increase the availability and efficiency of irrigation rice  
96 nutrient uptake. The effect of liquid organic fertilizer on the growth and yield of  
97 irrigation rice has been widely reported (Oh & Kim, 2013; Niis & Nik, 2017; Ginting,

2019; Solihin et al., 2019; Mahmoodi et al., 2020), but the use of liquid organic fertilizer on the growth and yield of ratoon rice is still relatively limited. Thus, a special assessment of the specific liquid organic fertilizers impact is needed to increase the growth and yield of ratoon rice. The research was aimed to identify the optimum size of rice stem cutting (ratoon) in combination with the application of Seprint liquid organic fertilizer (SLOF) in promoting growth and yield of the ratoon rice in variety Inpari 30.

104

## 105 MATERIAL AND METHODS

### 106 Experiment I (Preliminary Research Stage)

107 The source of the main plant of lowland rice variety Inpari 30 because it has an  
108 average yield up to 7.2 ton ha<sup>-1</sup> (Ministry of Agriculture, 2020) and the higher compared  
109 to Ciherang, Situ Bagendit and Pepe varieties (Pramono et al., 2011) as well as the taste  
110 of rice preferred by farmers in Cicantayan sub-District compared to Inpari 22, Inpari 24  
111 and Inpari 25 (Putra & Haryati, 2018) from Assessment Institute for Agricultural  
112 Technology (AIAT) Pasar Miring, Pagar Merbau sub-District, Deli Serdang District,  
113 North Sumatra Province, Indonesia. The main plant was conducted in the water bucket  
114 of 20 l with an upper diameter of 31 cm, the lower diameter of 22 cm and the height of  
115 31 cm (Figure 1A). This research was conducted at the greenhouse in the Faculty of  
116 Agriculture, University of Muhammadiyah Sumatera Utara, Indonesia from January to  
117 August 2018. The bucket was filled with soil until 5 cm from the surface. Planted two  
118 seedling of lowland rice in the bucket and was inundated with water up to the vegetative  
119 phase of the main plant, then the water in the bucket was reduced to the bearing  
120 capacity toward harvesting. The main plant was harvested at 115 days after planting  
121 then cutting of the rice stem (experiment II).

## 122 Experiment II (Main Research Stage)

123 After the main rice was harvested, it was cut from the base of rice stem as shown  
124 in Figure 1B. The giving of Seprint Liquid Organic Fertilizer (SLOF) only conducted at  
125 one week after cutting of rice stems by dissolving in 1 liter of water based on the  
126 treatment and then applied by pour on the surface soil. The nutrient content of SLOF  
127 consists of 11% N; 2% K<sub>2</sub>O; 0.17% P<sub>2</sub>O<sub>5</sub>; 0.49% Bioret; 8.98% Boron (B); 5.35%  
128 Cobalt (Co); 5.83% Manganese (Mn); <0.01 ppm Molybdenum (Mo); 18.16 ppm Zinc  
129 (Zn); and 9.94 ppm Copper (Cu) could be presented in Figure 1C (Source: Bunga Tani  
130 Products). The bucket was inundated when cutting rice stems until the end of vegetative  
131 phase, then reduce the water toward the harvesting of ratoon rice.

## 132 Design Research and Data Analyzed

133 This research was used in the Completely Randomized Design factorial with  
134 four replications. The first factor consisted of rice stem cutting (R<sub>1</sub>= 5 cm, R<sub>2</sub>= 10 cm,  
135 R<sub>3</sub>= 15 cm), and the second factor involved SLOF dosage (S<sub>1</sub>= 5 ml l<sup>-1</sup>; S<sub>2</sub>= 10 ml l<sup>-1</sup>;  
136 S<sub>3</sub>= 15 ml l<sup>-1</sup>). The distance between treatments were 50 cm x 50 cm. The parameters  
137 including the height and the growth quickness of ratoon rice, the number of tillers at 10  
138 to 60 Days After Cutting (DAC), the yield component of ratoon rice including number  
139 of productive tillers; number of grains penicle<sup>-1</sup>; number of filled grains penicle<sup>-1</sup>;  
140 number of empty grains penicle<sup>-1</sup>; 1000-grains weight, yield hill<sup>-1</sup>; and yield ha<sup>-1</sup>. The  
141 calculation of the growth quickness and yield ha<sup>-1</sup> of ratoon rice can be seen in equations  
142 1 and 2.

$$143 \quad \text{Growth quickness (cm day}^{-1}\text{)} = \frac{\text{Average height of ratoon rice}}{\text{days of cutting}} \quad (1)$$

$$144 \quad \text{Yield ha}^{-1} = \text{NP} \times \text{NPT} \times \text{NFGP} \times 1000\text{-GW} \quad (2)$$

145 Note :

146 NP = number population ha<sup>-1</sup> =  $\frac{\text{land area ha}^{-1}}{\text{plant spacing}} = \frac{10,000 \text{ m}^2}{0.5 \text{ m} \times 0.5 \text{ m}} = 40,000$  populations.

147 NPT = number of productive tillers

148 NFGP = <sup>28</sup> number of filled grains penicle<sup>-1</sup>

149 1000-GW = 1000-grains weight (g)

150 The parameters were analyzed using the <sup>22</sup> analysis of variance (ANOVA) and the  
151 mean was determined by DMRT at 5% using IBM SPSS statistics v.20 software.

152

## 153 RESULTS

### 154 Height and Growth Quickness of Ratoon Rice

155 Based on the ANOVA showed that cutting stems significantly increased the  
156 height of ratoon rice at 10 to 30 DAC. In contrast, it was insignificant at 40 to 60 DAC.  
157 The SLOF significantly increased the height of the ratoon rice at 20 DAC. In contrast, it  
158 was insignificant at 10, 30, 40, and 60 DAC. The interaction of the cutting of rice stems  
159 with SLOF significantly increased the height of ratoon rice at 10 DAC. However, it was  
160 insignificant at 20 until 60 DAC (Table 1). <sup>19</sup> The results showed that the cutting 10 cm of  
161 the rice stem increased the highest height of ratoon rice at 10 until 60 DAC compared to  
162 other cutting sizes, although it had significantly at 10 until 30 DAC. The giving SLOF  
163 at the dose of 15 ml l<sup>-1</sup> increased the highest height of ratoon rice at 10 until 40 DAC  
164 compared to other doses, although it had significantly only at 20 DAC. The highest  
165 height of ratoon rice was found in 10 ml l<sup>-1</sup> SLOF at 60 DAC. The interaction of the rice  
166 stem cutting of 10 cm with 10 and 15 ml l<sup>-1</sup> of SLOF (R2S2 and R2S3) significantly  
167 increased the height of ratoon rice by 27.98 cm and 25.55 cm, respectively at 10 DAC.  
168 The highest height of ratoon rice was found in the combination cutting 10 cm of the rice  
169 stem with 15 ml l<sup>-1</sup> SLOF (R2S3) at 20 until 60 DAC.

170 **Number Tillers of Ratoon Rice**

171 Based on the ANOVA showed that the cutting of rice stems significantly  
172 increased the number tillers of ratoon rice at 40 to 60 DAC. In contrast, it was  
173 insignificant at 10 until 30 DAC. The SLOF and their interactions insignificant  
174 increased the number tillers of ratoon rice (Table 2). The average number tillers of  
175 lowland rice before becoming a ratoon ranged from 9.25 to 11.75 tillers. The cutting 10  
176 cm can impact in increasing the highest number tillers of ratoon rice at 10 until 60 DAC  
177 compared to other cutting sizes, although it had significantly affected at 40 until 60  
178 DAC. The giving SLOF of 10 ml l<sup>-1</sup> (S2) given the highest number tillers of ratoon rice  
179 at 25.33 tillers until 60 DAC compared to other doses. The combination cutting 10 cm  
180 of the rice stem with 15 ml l<sup>-1</sup> SLOF (R2S3) showed the highest number tillers of ratoon  
181 rice by 36.25 tillers at 60 DAC compared to other combinations.

182 **Yield Component of Ratoon Rice**

183 Based on the ANOVA showed that the cutting of rice stems and SLOF dosages  
184 were insignificant on the number of filled grains panicle<sup>-1</sup>. In contrast, their interactions  
185 significantly increased number of filled grains panicle<sup>-1</sup> of ratoon rice (Figures 2 to 4).  
186 The combination cutting 10 cm of the rice stem with 5 ml.l<sup>-1</sup> SLOF (R2S1) significantly  
187 increased the highest number of filled grains panicle<sup>-1</sup> of 114.30 grains compared to  
188 other combinations. The cutting 10 cm of the rice stem (R2) had the highest number of  
189 filled grains panicle<sup>-1</sup> of 97.58 grains compared to other cutting sizes. The giving of 10  
190 ml.l<sup>-1</sup> SLOF (S2) had also the highest number of filled grains panicle<sup>-1</sup> of 91.53 grains  
191 compared to other doses.

192 Based on the ANOVA showed that the SLOF dosages significantly increased the  
193 yield hill<sup>-1</sup> of ratoon rice. In contrast, the cutting of the rice stems and their interactions

194 were insignificant increased the yield  $\text{hill}^{-1}$  of ratoon rice (Figures 2 to 4). The SLOF at  
195 the dose of  $10 \text{ ml l}^{-1}$  (S2) significantly increased the highest yield  $\text{hill}^{-1}$  of ratoon rice by  
196 54.32 g compared to other doses. The cutting 10 cm of the rice stem (R2) had the  
197 highest yield  $\text{hill}^{-1}$  of ratoon rice by 46.56 g compared to other cutting sizes. The  
198 combination cutting 10 cm of the rice stem with  $10 \text{ ml l}^{-1}$  SLOF (R2S2) had the highest  
199 yield  $\text{hill}^{-1}$  of ratoon rice by 60.63 g compared to other combinations.

200 Based on the ANOVA showed that the cutting of rice stems significantly  
201 increased the yield  $\text{ha}^{-1}$  of ratoon rice. In contrast, the SLOF dosages and their  
202 interactions were insignificant increased the yield  $\text{ha}^{-1}$  of ratoon rice (Figure 5). The  
203 cutting 10 cm of the rice stem (R2) significantly increased the highest yield  $\text{ha}^{-1}$  of  
204 ratoon rice by 3.58 tons  $\text{ha}^{-1}$  compared to other cutting sizes. The SLOF at the dose of  
205  $10 \text{ ml l}^{-1}$  had the highest yield  $\text{ha}^{-1}$  of ratoon rice by 3.12 tons  $\text{ha}^{-1}$  compared to other  
206 dosages, whereas the combination cutting 10 cm of rice stem with  $15 \text{ ml l}^{-1}$  SLOF  
207 (R2S3) had the highest yield  $\text{ha}^{-1}$  of ratoon rice by 3.88 tons  $\text{ha}^{-1}$  compared to other  
208 combinations.

209 Based on the ANOVA showed that the rice stem cutting sizes, SLOF dosages,  
210 and their interactions were insignificant on the yield component of ratoon rice (number  
211 of productive tillers; number of grains panicle $^{-1}$ ; number of empty grains panicle $^{-1}$  and  
212 1000-grains weight) are presented in Figures 2 to 4. The cutting 10 cm of the rice stem  
213 (R2) had the highest number of productive tillers; number of grains panicle $^{-1}$  and 1000-  
214 grains weight of 35.75 tillers; 116.77 grains and 25.91 g, respectively compared to other  
215 cutting sizes. The cutting 15 cm of the rice stem (R3) had the highest number of empty  
216 grains panicle $^{-1}$  of 20.29 g compared to other cutting sizes. The giving SLOF of  $5 \text{ ml l}^{-1}$   
217 (S1) had the highest number of grains panicle $^{-1}$  and number of empty grains panicle $^{-1}$  of

113.59 grains and 22.69 grains, respectively compared to other doses. The giving SLOF of 10 ml l<sup>-1</sup> (S2) had the highest number of productive tillers and 1000-grains weight of 32.75 tillers and 25.92 grains, respectively compared to other doses. The combination cutting 10 cm of the rice stem with SLOF of 5 ml l<sup>-1</sup> and 10 ml l<sup>-1</sup> (R2S1 and R2S2) had the highest number of grains panicle<sup>-1</sup> and number of productive tillers of 139.85 grains and 41.50 tillers, respectively compared to other combinations. The combination cutting 15 cm of the rice stem with SLOF of 5 ml l<sup>-1</sup> and 10 ml l<sup>-1</sup> (R3S1 and R3S2) had the highest number of empty grains panicle<sup>-1</sup> and 1000-grains weight of 25.90 grains and 26.78 g, respectively compared to other combinations.

227

## 228 DISCUSSION

229 The cutting 10 cm of the rice stem significantly increased the highest height of  
230 ratoon rice at 10 until 30 DAC and also significantly increased the highest number  
231 tillers of ratoon rice at 40 until 60 DAC. The result similar to the growth quickness of  
232 ratoon rice on the cutting 10 cm was higher of 1.20 to 2.03 cm day<sup>-1</sup> compared to the  
233 cutting 5 cm and 15 cm, ranged of 0.89 to 1.26 cm day<sup>-1</sup> and 1.05 to 1.49 cm day<sup>-1</sup>,  
234 respectively. It was caused by the optimal carbohydrates supply that the emergence of  
235 ratoon shoots and result in greater vegetative growth. It was supported by the height,  
236 number of tillers, growth quickness and number of productive tillers for ratoon rice on  
237 cutting 10 cm was higher compared to other cutting sizes (Tables 1-2 and Figures 2-4).  
238 The optimal cutting size of rice stems will support the growth and yield of ratoon rice.  
239 According to Santos et al., (2003) the decrease in yield ranging from 12 until 37% in the  
240 cutting < 5 cm of rice stem, while the cutting >20 cm of rice stem can be produced  
241 tillers faster emerge in contrast the number of grains was fewer compared to the optimal

242 cutting size. Harrel et al., (2009) the height cutting of the main plant stems can also  
243 <sup>11</sup> affect the number of tillers and seeds yield. Susilawati et al., (2012) stated that the  
244 height and number of productive tillers for ratoon rice in genotype IPB106-F-8-1 at the  
245 cutting 10 cm was higher compared to the cutting 20 cm and 30 cm. Mareza et al.,  
246 (2016) stated that the cutting 40 until 50 cm of the main stem of rice was significant for <sup>5</sup>  
247 the number of productive tillers and the highest was found in 40 cm of 6.55 tillers  
248 compared to other cutting sizes.

249 The cutting 10 cm of stem rice (R2) significantly increased the highest yield ha<sup>-1</sup>  
250 of ratoon rice by 3.58 tons ha<sup>-1</sup> compared to other cutting sizes. The yield ha<sup>-1</sup> of ratoon  
251 rice on the research was smaller compared to the yield ha<sup>-1</sup> of main plants (rice variety  
252 Inpari 30) when the initial planting until 5.08 tons ha<sup>-1</sup>, or the yield was decreased of  
253 29.53% of the main plant. It was caused the growth pattern (the <sup>11</sup> height and number of  
254 tillers) of ratoon rice were higher in cutting 10 cm compared to other cutting sizes that  
255 the results of photosynthesis produced will be distributed in the assimilates form and  
256 produce filled grains. It was linear with the <sup>6</sup> number of productive tillers, number of  
257 filled grains panicle<sup>-1</sup>, and 1000-grains weight on cutting 10 cm was higher compared to  
258 other cutting sizes (Figures 2-4). According to Harrel et al., (2009) the height cutting  
259 stems of the main plant can affect the number of tillers and grains. <sup>7</sup> Susilawati et al.,  
260 (2012) stated that the yield ha<sup>-1</sup> for ratoon rice in genotype IPB106-F-8-1 on cutting 10  
261 cm was greater of 2.1 tons ha<sup>-1</sup> compared to the cutting 20 cm and 30 cm of 1.6 <sup>27</sup> tons ha<sup>-1</sup>  
262 and 1.1 tons ha<sup>-1</sup>, respectively. Nuzul et al., (2018) also added that the yield of ratoon  
263 rice was decreased by 58.72% from the main plants.

264 <sup>44</sup> The giving SLOF of 15 ml l<sup>-1</sup> significantly increased the highest height of ratoon  
265 rice at 20 DAC. It was caused by the SLOF had the main nutrient content of 11% N

266 more higher compared to K nutrient only 2% with the result that the dose of 15 ml l<sup>-1</sup>  
267 SLOF can support the photosynthesis level and have an impact on increasing the  
268 vegetative phase of ratoon rice. It was linear with the height of ratoon rice at the dose 15  
269 ml l<sup>-1</sup> SLOF was higher compared to other dosages at 20 DAC (Table 1). According to  
270 Surtinah, (2009) the application of liquid organic fertilizers is very efficient causes it is  
271 easily absorbed by plants. Parman, (2007) stated that the liquid organic fertilizers can  
272 improve soil physical, chemical, and biological properties, also increase the yield, and  
273 quality of plant. Niss & Nik, (2017) stated that the application of liquid organic fertilizer  
274 at the dose of 6 l ha<sup>-1</sup> significantly increased the highest number of seeds panicle<sup>-1</sup> and  
275 the dry seeds weight of rice by 107.38 seeds and 29.65 g compared to the dose of 2 and  
276 4 l ha<sup>-1</sup>.

277 The giving SLOF of 10 ml l<sup>-1</sup> (S2) significantly increased the highest yield hill<sup>-1</sup>  
278 of ratoon rice by 54.32 g. It was caused the SLOF had 11% N and 2% K along an  
279 important role in improve nutrient uptake and soil organic matter resulted the macro-  
280 and micro-nutrients be available to be absorbed by ratoon rice. The liquid organic  
281 fertilizers also had a role in cell division and increase assimilation which leads to  
282 increased biomass and yield of ratoon rice. According to Vidigal et al., (2002) stated  
283 that the growth of onion was increased progressively with the increasing application of  
284 K fertilizer. El-Bassiony, (2006) stated that K fertilizer was affected by increasing the  
285 dry weight of onion. Martínez-Alcántara et al., (2016) stated that the liquid organic  
286 fertilizers increases uptake of macro- and micro-nutrient, as well as organic matter in  
287 soil compared to chemical fertilizers. Phibunwatthanawong & Riddech, (2019) also  
288 added the liquid organic fertilizers had the micro and supplement nutrient, beneficial  
289 microorganisms such as plant growth-promoting rhizobacteria (PGPR), and hormone

290 Indole Acetic Acid (IAA) which are not found in chemical fertilizers.

291 The combination cutting 10 cm of rice stem with 10 ml l<sup>-1</sup> SLOF (R2S2)  
292 significantly increased the ratoon rice height of 27.98 cm at 10 DAC. It is authenticates  
293 the combination of cutting 10 cm with SLOF at the dose of 10 and 15 ml l<sup>-1</sup> had the  
294 highest of the ratoon rice height compared to other combinations. It was caused to the  
295 main nutrients N and K in the 10 and 15 ml l<sup>-1</sup> of SLOF dosages could be promoted the  
296 photosynthesis rate in forming assimilates at cutting 10 cm as to stimulate the growth  
297 process of the ratoon rice, such as the <sup>16</sup> plant height, number of tillers, and number of  
298 <sup>16</sup> productive tillers (Tables 1-2 and Figures 2-4). According to Nurhayati, (2009) the  
299 application of liquid organic fertilizer can be promoted the process of metabolism in  
300 plants through the process of nutrient solubility, that nutrient transport will be going  
301 well from the roots to all parts of the plant. Hamzah, (2014) <sup>21</sup> stated that the use of liquid  
302 <sup>34</sup> organic fertilizer can an increase the plant height, number of branches, and the number  
303 of soybean pods.

304 The combination cutting 10 cm of rice stem with SLOF at the dose of 5 ml l<sup>-1</sup>  
305 <sup>22</sup> (R2S1) significantly increased the highest number of filled grains panicle<sup>-1</sup> by 114.30  
306 grains. It was caused by the SLOF could be stimulated the metabolic process with the  
307 growth quickness of ratoon rice on cutting 10 cm that the results of photosynthesis will  
308 form assimilates and lead to be produced grains panicle<sup>-1</sup>. According to <sup>7</sup> Susilawati et al.,  
309 <sup>24</sup> (2012) stated that the cutting 10 cm of rice stem in genotype IPB106-F-8-1 significantly  
310 increased the number of grain panicle<sup>-1</sup> and was higher of 108.0 grains compared to  
311 cutting 20 cm and 30 cm of 78.5 and 71.1 grains, respectively. Mareza et al., (2016)  
312 <sup>33</sup> stated that the cutting 10 cm of rice stem significantly improved the panicle length and  
313 number of grains panicle<sup>-1</sup> of ratoon rice by 14.93 cm and 47.05 grains, respectively

314 compared to cutting 20 until 50 cm.

315 The application of ratoon rice technology combine with the SLOF greatly  
316 encourages of rice yield in achieving food sufficiency, because in a year of rice  
317 cultivation (main plants and ratoon technology) can be produce an average yield of 8.66  
318 ton ha<sup>-1</sup>. Thus, farmers will get a double benefit by applying ratoon technology in a  
319 cycle of irrigation rice.

320

## 321 CONCLUSIONS

322 The cutting 10 cm of rice stem significantly increased the ratoon rice height  
323 ranged of 20.33 to 53.89 cm at 10 until 30 DAC, number of tillers ranged of 25.58 to  
324 29.08 tillers at 40 until 60 DAC and the yield ha<sup>-1</sup> of ratoon rice by 3.58 tons ha<sup>-1</sup>. The  
325 SLOF at the dose of 15 ml l<sup>-1</sup> significantly increased the ratoon rice height of 35.71 cm  
326 at 20 DAC, and the dose of 10 ml l<sup>-1</sup> SLOF also significantly increased the yield hill<sup>-1</sup> of  
327 ratoon rice by 54.32 g. The combination cutting 10 cm of rice stem with SLOF at the  
328 dose of 10 ml.l<sup>-1</sup> significantly increased the ratoon rice height of 27.98 cm at 10 DAC  
329 and the combination cutting 10 cm of rice stem with 5 ml l<sup>-1</sup> SLOF also significantly  
330 increased the number of filled grains panicle<sup>-1</sup> of ratoon rice by 114.30 grains. The  
331 application cutting 10 cm of rice stem combined with various dosages of SLOF showed  
332 that the higher growth and yield of ratoon rice compared to other cutting sizes.

333

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337

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## TABLES

Table 1. Effect of rice stems cutting and SLOF dosages on the ratoon rice height at 10 until 60 days after cutting (DAC).

| Treatment             | Ratoon Rice Height (cm) |          |           | average  | Growth quickness (cm.day <sup>-1</sup> ) |
|-----------------------|-------------------------|----------|-----------|----------|------------------------------------------|
|                       | S1                      | S2       | S3        |          |                                          |
| 10 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 9.46 d-h                | 7.05 h   | 10.33 c-h | 8.95 b   | 0.89                                     |
| R2                    | 7.45 gh                 | 27.98 a  | 25.55 a   | 20.33 a  | 2.03                                     |
| R3                    | 13.13 b-h               | 8.90 fgh | 9.45 e-h  | 10.49 b  | 1.05                                     |
| average               | 10.01 ns                | 14.64 ns | 15.11 ns  |          |                                          |
| 20 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 15.53 ns                | 17.35 ns | 22.93 ns  | 18.60 b  | 0.93                                     |
| R2                    | 15.25 ns                | 42.35ns  | 48.80 ns  | 35.47 a  | 1.77                                     |
| R3                    | 27.90 ns                | 12.73 ns | 35.40 ns  | 25.34 ab | 1.27                                     |
| average               | 19.56 b                 | 24.14 ab | 35.71 a   |          |                                          |
| 30 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 31.28 ns                | 39.95 ns | 36.88 ns  | 36.04 b  | 1.20                                     |
| R2                    | 39.70 ns                | 58.33 ns | 63.63 ns  | 53.89 a  | 1.80                                     |
| R3                    | 46.40 ns                | 38.13 ns | 49.93 ns  | 44.82 ab | 1.49                                     |
| average               | 39.13 ns                | 45.47 ns | 50.15 ns  |          |                                          |
| 40 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 46.90 ns                | 52.98 ns | 50.73 ns  | 50.20 ns | 1.26                                     |
| R2                    | 61.90 ns                | 63.93 ns | 75.23 ns  | 67.02 ns | 1.68                                     |
| R3                    | 60.70 ns                | 54.28 ns | 55.83 ns  | 56.94 ns | 1.42                                     |
| average               | 56.50 ns                | 57.06 ns | 60.60 ns  |          |                                          |
| 60 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 59.20 ns                | 65.80 ns | 58.18 ns  | 61.06 ns | 1.02                                     |
| R2                    | 67.50 ns                | 70.38 ns | 77.53 ns  | 71.80 ns | 1.20                                     |
| R3                    | 67.93 ns                | 66.28 ns | 64.63 ns  | 66.28 ns | 1.10                                     |
| average               | 64.88 ns                | 67.49 ns | 66.78 ns  |          |                                          |

Note: Data followed by different letters on the same column and row are significantly different according to DMRT at 5%. Size cutting of rice stems (R1= 5 cm; R2= 10 cm; R3= 15 cm). SLOF dosages (S1= 5 ml l<sup>-1</sup>; S2= 10 ml l<sup>-1</sup>; S3= 15 ml l<sup>-1</sup>). ns= not significant.

Table 2. The increase in the number tillers of ratoon rice after cutting the stems and SLOF dosages at 10 until 60 DAC.

| Treatment             | Number Tillers of Ratoon Rice |          |          | average  |
|-----------------------|-------------------------------|----------|----------|----------|
|                       | S1                            | S2       | S3       |          |
| 10 Days After Cutting |                               |          |          |          |
| R1                    | 6.75 <sup>32</sup> ns         | 2.00 ns  | 3.75 ns  | 4.17 ns  |
| R2                    | 7.00 ns                       | 7.00 ns  | 6.00 ns  | 6.67 ns  |
| R3                    | 8.00 ns                       | 5.00 ns  | 4.50 ns  | 5.83 ns  |
| average               | 7.25 ns                       | 4.67 ns  | 4.75 ns  |          |
| 20 Days After Cutting |                               |          |          |          |
| R1                    | 8.75 ns                       | 4.25 ns  | 5.00 ns  | 6.00 ns  |
| R2                    | 8.25 ns                       | 14.50 ns | 15.25 ns | 12.67 ns |
| R3                    | 15.00 ns                      | 9.00 ns  | 8.75 ns  | 10.92 ns |
| average               | 10.67 ns                      | 9.25 ns  | 9.67 ns  |          |
| 30 Days After Cutting |                               |          |          |          |
| R1                    | 9.00 <sup>2</sup> ns          | 7.25 ns  | 8.00 ns  | 8.08 ns  |
| R2                    | 9.25 ns                       | 19.25 ns | 24.00 ns | 17.50 ns |
| R3                    | 20.00 ns                      | 12.75 ns | 15.00 ns | 15.92 ns |
| average               | 12.75 ns                      | 13.08 ns | 15.67 ns |          |
| 40 Days After Cutting |                               |          |          |          |
| R1                    | 10.75 ns                      | 12.00 ns | 10.50 ns | 11.08 b  |
| R2                    | 10.50 ns                      | 33.25 ns | 33.00 ns | 25.58 a  |
| R3                    | 22.75 ns                      | 23.00 ns | 19.50 ns | 21.75 ab |
| average               | 14.67 ns                      | 22.75 ns | 21.00 ns |          |
| 60 Days After Cutting |                               |          |          |          |
| R1                    | 13.00 ns                      | 13.25 ns | 13.25 ns | 13.17 b  |
| R2                    | 16.00 ns                      | 35.00 ns | 36.25 ns | 29.08 a  |
| R3                    | 24.00 ns                      | 27.75 ns | 23.50 ns | 25.08 a  |
| average <sup>9</sup>  | 17.67 ns                      | 25.33 ns | 24.33 ns |          |

Note: Data followed by different letters on the same column and row are significantly different according to DMRT at 5%. Size cutting of rice stems (R1= 5 cm; R2= 10 cm; R3= 15 cm). SLOF dosages (S1= 5 ml l<sup>-1</sup>; S2= 10 ml l<sup>-1</sup>; S3= 15 ml l<sup>-1</sup>). ns= not significant.

## FIGURES



Figure 1. The size of the bucket (A); design of the second experiment (B); and seprint liquid organic fertilizer by bunga tani products (C).

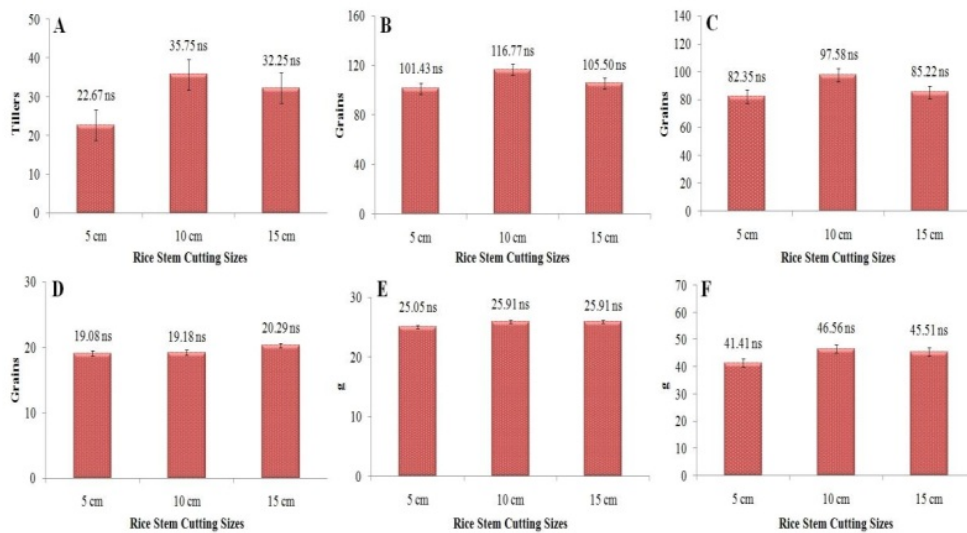


Figure 2. Effect of rice stem cutting sizes on the yield component (A= number of productive tillers; B= number of grains panicle<sup>-1</sup>; C= number of filled grains panicle<sup>-1</sup>; D= number of empty grains panicle<sup>-1</sup>; E= 1000-grains weight; F= yield hill<sup>-1</sup>) of ratoon rice. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE). ns= not significant.

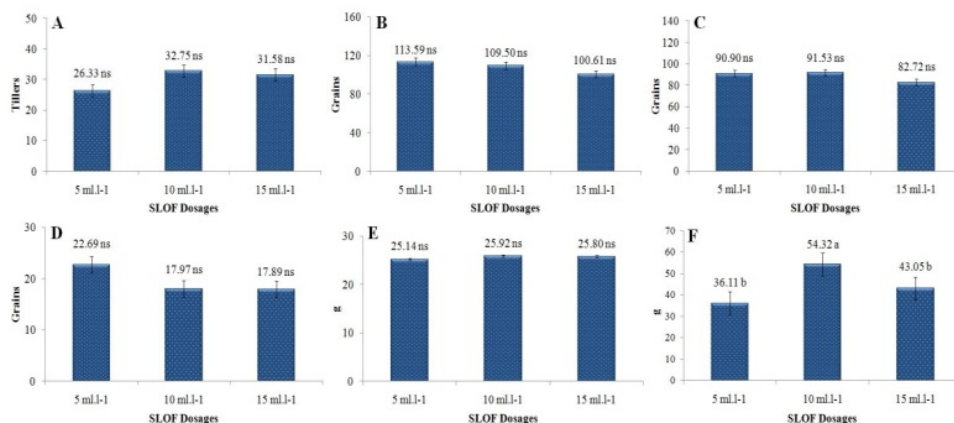


Figure 3. Effect of SLOF dosages on the yield component (A= number of productive tillers; B= number of grains panicle<sup>-1</sup>; C= number of filled grains panicle<sup>-1</sup>; D= number of empty grains panicle<sup>-1</sup>; E= 1000-grains weight; F= yield hill<sup>-1</sup>) of ratoon rice. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE). ns= not significant.

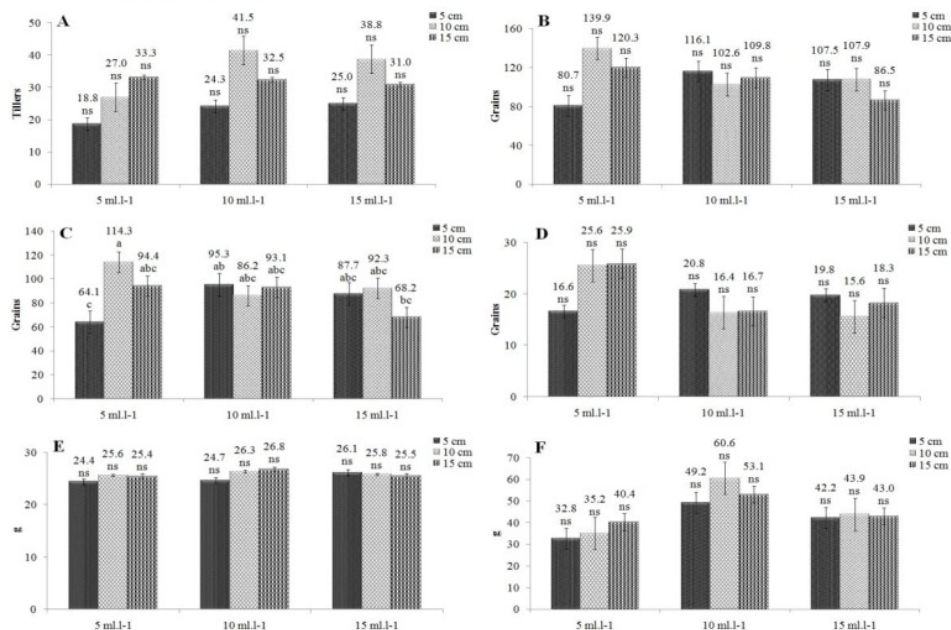


Figure 4. The combinations of stem cutting sizes and SLOF dosages on the yield component (A= number of productive tillers; B= number of grains panicle<sup>-1</sup>; C= number of filled grains panicle<sup>-1</sup>; D= number of empty grains panicle<sup>-1</sup>; E= 1000-grains weight; F= yield hill<sup>-1</sup>) of ratoon rice. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE). ns= not significant.

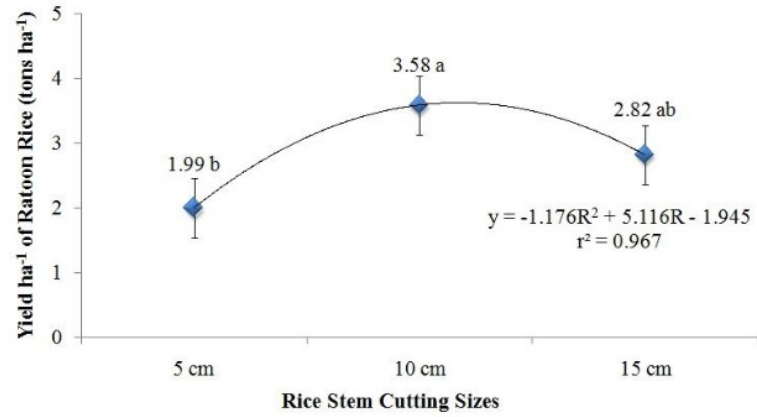


Figure 5. Effect of rice stem cutting sizes on the yield ha<sup>-1</sup> of ratoon rice. Data followed by different letters on the same line are significantly different according to DMRT at 5% ± standard error (SE).

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Our decision is to: accept the submission after revision.

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Reviewer B:

Does the title accurately reflect the content of the article?:

Yes

Are the current state of knowledge and the aim of the study presented properly?:

No

Has the authors used appropriate and coherent research methods?:

No

Were the results correctly interpreted and the conclusions well justified?:

No

Are the figures, tables and photos appropriate and necessary?:

No

Is the article grammatically and stylistically correct?:

No

What is scientific significance of the paper?:

Should not be published in this journal

Other comments::

First of all, English was very poor thus it was hard to understand. Authors did not make a clear argument and raise the probleme and weak explanation of why they tested this particular organic liquid fertiliser in the introduction. In M&M, authors should have explained why they used this particular genotype of rice and the fertiliser they used. the explanations were missing. Statistic analysis was confusing, hard to understand.

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Reviewer D:

Does the title accurately reflect the content of the article?:

Yes

Are the current state of knowledge and the aim of the study presented properly?:

Yes

Has the authors used appropriate and coherent research methods?:

Yes

Were the results correctly interpreted and the conclusions well justified?:

No

Are the figures, tables and photos appropriate and necessary?:

Yes

Is the article grammatically and stylistically correct?:

Yes

What is scientific significance of the paper?:

Important in some respect

Other comments::

The reviewed article presents new content and interesting research. However, doubts are raised by the presentation, discussion and methodology. The comments are presented below and collected in the points:

1. There is no information about chemical composition of the water and the soil in which rice was grown. In studies where fertilization was a factor, this element is necessary for the correct interpretation of the obtained results.
2. No Seprint Liquid Organic Fertilizer (SLOF) performance. What was the form of nitrogen in this fertilizer? The potassium content is given once as K and as K<sub>2</sub>O. If the fertilizer contained 2% of K<sub>2</sub>O converted to K it would be only 1.66%. This error appears throughout the work. Does this fertilizer contain phosphorus, which is responsible for plant tillering? Is it a fertilizer without micronutrients?
3. The specified units are incorrect. Tons per kg, liters per dm<sup>-3</sup> should be changed according to the SI system. The entries ml.l<sup>-1</sup> are incorrect, it should be ml · dm<sup>-3</sup>
4. Discussions should be extended with new items of literature because the work is mostly based on the literature from 1980-1990.
5. In the discussion, lines 294 and 246 contain the same informations. Information on the influence of nitrogen and potassium on the yielding should be extended.
6. Poor quality of figure 5, no statistics in the figures.

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**ORIGINAL RESEARCH PAPER**

**Agronomic Character of Ratoon Rice: Stem Cutting Sizes and Seprint Liquid Organic Fertilizer**

**ABSTRACT**

The research aimed to identify the optimum size of rice stem cutting (ratoon) in combination with the application of Seprint liquid organic fertilizer (SLOF) in promoting the growth and yield of the ratoon rice. This research was conducted in the greenhouse, Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, North Sumatra Province, Indonesia from January to August 2018. The research was set-up as completely randomized design factorial within four replications. The first factor

involved the cutting sizes of the rice stem (R1= 5 cm, R2= 10 cm, R3= 15 cm) and the second factor involved SLOF dosages, including S1= 5 ml l<sup>-1</sup>, S2= 10 ml l<sup>-1</sup>, S3= 15 ml l<sup>-1</sup>. Parameters were analyzed using the ANOVA and the means was determined by Duncan Multiple Range Test (DMRT) at 5% using IBM SPSS statistics v.20 software. The results showed that cutting 10 cm of the rice stem significantly increased the ratoon rice height at 10 until 30 days after cutting (DAC), number of tillers at 40 until 60 DAC, the number of productive tillers, and the yield ha<sup>-1</sup>. The SLOF at the dose of 10 and 15 ml l<sup>-1</sup> significantly increased the yield hill<sup>-1</sup> and the ratoon rice height at 20 DAC. The combination of cutting 10 cm of the rice stem with SLOF at the dose of 5 and 10 ml l<sup>-1</sup> significantly increased the number of filled grains panicle<sup>-1</sup> and the ratoon rice height at 10 DAC. Application cutting steem at 10 cm combined with various dosages of SLOF resulted the greater growth and yield of ratoon rice in achieving food sufficiency.

**Keywords:** dosage; growth; yield; ratoon rice; seprint liquid organic fertilizer.

## **Running Head : Growth and Yield of Ratoon Rice**

## **INTRODUCTION**

Food is a basic human need and sufficient, nutritious and safe food can lead to quality human resources. One food that is a major source of energy is grain (rice). According to USDA data, the countries that have the highest level of rice consumption in the world are located in Asia. Countries with the highest level of rice consumption found in China by 29.66%, India by 20.39%, Indonesia by 7.88%, Bangladesh by 7.32%, and Vietnam by 4.54% of the world from 2015 to 2019 (USDA in Ministry of Agriculture, 2019). In Indonesia, rice is the main food needs of more than 90% of populations. Consumption rice capita<sup>-1</sup> tends to decrease, from 107.71 kg capita<sup>-1</sup> year<sup>-1</sup>

in 2002 to be 96.33 kg capita<sup>-1</sup> year<sup>-1</sup> in 2018 (Ministry of Agriculture, 2019). Domestic rice yield from year to year continues to increase, although it had a trend towards a slower growth rate. Indonesia population growth had increased linearly from 2005 to 2015 at 226.71 until 258.16 million and the projected population until 2035 is estimated up to 305.65 million (Statistics of Indonesia, 2019). The total domestic consumption of Indonesian rice will continue to increase even though per capita shown decreased.

Increased domestic consumption of rice in Indonesia must be followed by the program to increase rice yield through intensification. One of the intensification programs that can be conducted by the system cultivation of ratoon rice. Mengel & Wilson, (1981) stated that the ratoon is a technique of harvesting production from tillers from main plant stumps that can increase grain yield without increasing land area. The ratoon technique is used to shorten the age of rice harvest. Maturing of hybrid rice varieties was needed at 105 until 124 days after scattering or around of 4 months (Indonesian Center for Rice Research, 2019). Therefore, in a year can only be 2-fold the rice planting until harvesting. The ratoon system can produce 3- until 4-fold of rice harvesting. The advantages of the ratoon system are the higher efficiency of resource use per unit area of land and unit per timing (Santos et al., 2003), reducing land preparation, saving the cost of planting seeds (Zandstra & Samson, 1979), and saving the time of planting because reduction in growth time (Haque & Coffman, 1980). In addition, the ratoon rice is considered by farmers because of its high quality including cooking, flavor, short growing, reduce the cost of water, fertilizer and pest control (Yazdpour et al., 2012). Alizadeh & Habibi, (2016) also reported that the grain thickness and amylose content for ratoon rice was higher ranged of 1.18 to 2.25% and 2.28 to 7.69% compared to the main crop.

System cultivation of ratoon rice has been reported, Pratama et al., (2018) stated that the time of cutting the remaining stumps on 10 days of rice harvest was significantly on the largest root diameter of 0.89 mm with stump cutting height of 4 cm above the soil surface and could up to grain productivity of 3.39 to 3.54 ton ha<sup>-1</sup>. Nuzul et al., (2018) stated that the highest yield component (number and length of panicle, harvest age, grain number panicle<sup>-1</sup>, filled grain, 1000-grains weight, total dry weight, harvest indeks) and yield (grain ha<sup>-1</sup>) of rice were achieved in the cutting at harvest with the height of 3 cm above the soil surface with the grain yield of 3.54 ton ha<sup>-1</sup>. Susilawati et al., (2012) stated that the cutting height of ratoon rice was related to the internode of plant, the nodes contain lateral shoots which will produce shoots of ratoon. Jichao & Xiaohui, (1996) stated that the number of growing shoots can be determined by the cutting height stems of the main plant, but the condition is strongly influenced by residual assimilates as reserves in the stems that can be utilized for ratoon growth, and the rate vigor of ratoon. The stem cutting height of the main plant can also affect the number of tillers and seed yields (Harrel et al., 2009) and triggers dormant shoots to grow (Mahadevappa & Yogeeshha, 1988).

However, the system of rice cultivation did not be separated from the use of fertilizer to achieve optimal yield. Islam et al., (2008) reported that the fertilizer application of N= 130 kg ha<sup>-1</sup>, P<sub>2</sub>O<sub>5</sub>= 75 kg ha<sup>-1</sup>, K<sub>2</sub>O= 80 kg ha<sup>-1</sup>, S= 13 kg ha<sup>-1</sup>, Zn= 4 kg ha<sup>-1</sup> significantly increased the yield of the Boro rice ratoon by 1.42 ton ha<sup>-1</sup>. The high price of fertilizer with limited availability had resulted in the use of liquid organic fertilizer to be an alternative to increase the availability and efficiency of irrigation rice nutrient uptake. The effect of liquid organic fertilizer on the growth and yield of irrigation rice has been widely reported (Oh & Kim, 2013; Niis & Nik, 2017; Ginting,

2019; Solihin et al., 2019; Mahmoodi et al., 2020), but the use of liquid organic fertilizer on the growth and yield of ratoon rice is still relatively limited. Thus, a special assessment of the specific liquid organic fertilizers impact is needed to increase the growth and yield of ratoon rice. The research was aimed to identify the optimum size of rice stem cutting (ratoon) in combination with the application of Seprint liquid organic fertilizer (SLOF) in promoting growth and yield of the ratoon rice in variety Inpari 30.

## MATERIAL AND METHODS

### Experiment I (Preliminary Research Stage)

The source of the main plant of lowland rice variety Inpari 30 because it has an average yield up to 7.2 ton ha<sup>-1</sup> (Ministry of Agriculture, 2020) and the higher compared to Ciherang, Situ Bagendit and Pepe varieties (Pramono et al., 2011) as well as the taste of rice preferred by farmers in Cicantayan sub-District compared to Inpari 22, Inpari 24 and Inpari 25 (Putra & Haryati, 2018) from Assessment Institute for Agricultural Technology (AIAT) Pasar Miring, Pagar Merbau sub-District, Deli Serdang District, North Sumatra Province, Indonesia. The main plant was conducted in the water bucket of 20 l with an upper diameter of 31 cm, the lower diameter of 22 cm and the height of 31 cm (Figure 1A). This research was conducted at the greenhouse in the Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, Indonesia from January to August 2018. The bucket was filled with soil until 5 cm from the surface. Planted two seedling of lowland rice in the bucket and was inundated with water up to the vegetative phase of the main plant, then the water in the bucket was reduced to the bearing capacity toward harvesting. The main plant was harvested at 115 days after planting then cutting of the rice stem (experiment II).

## Experiment II (Main Research Stage)

After the main rice was harvested, it was cut from the base of rice stem as shown in Figure 1B. The giving of **Seprint** Liquid Organic Fertilizer (SLOF) **only conducted at one week after cutting of rice stems by** dissolving in 1 liter of water based on the treatment and then applied by pour on the surface soil. The nutrient content of SLOF **consists of** 11% N; 2% K<sub>2</sub>O; 0.17% P<sub>2</sub>O<sub>5</sub>; 0.49% Bioret; 8.98% Boron (B); 5.35% Cobalt (Co); 5.83% Manganese (Mn); <0.01 ppm Molybdenum (Mo); 18.16 ppm Zinc (Zn); and 9.94 ppm Copper (Cu) **could be presented in Figure 1C** (Source: Bunga Tani Products). **The bucket was inundated when cutting rice stems until the end of vegetative phase, then reduce the water toward the harvesting of ratoon rice.**

## Design Research and Data Analyzed

This research was used in the Completely Randomized Design factorial with four replications. The first factor consisted of rice stem cutting (R1= 5 cm, R2= 10 cm, R3= 15 cm), and the second factor involved SLOF dosage (S1= 5 ml l<sup>-1</sup>; S2= 10 ml l<sup>-1</sup>; S3= 15 ml l<sup>-1</sup>). The distance between treatments were 50 cm x 50 cm. The parameters including the height and the growth quickness of ratoon rice, the number of tillers at 10 to 60 Days After Cutting (DAC), the yield component of ratoon rice including number of productive tillers; number of grains penicle<sup>-1</sup>; number of filled grains penicle<sup>-1</sup>; number of empty grains penicle<sup>-1</sup>; 1000-grains weight, yield hill<sup>-1</sup>; and yield ha<sup>-1</sup>. The calculation of the growth quickness and yield ha<sup>-1</sup> of ratoon rice can be seen in equations 1 and 2.

$$\text{Growth quickness (cm day}^{-1}\text{)} = \frac{\text{Average height of ratoon rice}}{\text{days of cutting}} \quad (1)$$

$$\text{Yield ha}^{-1} = \text{NP} \times \text{NPT} \times \text{NFGP} \times 1000\text{-GW} \quad (2)$$

Note :

NP = number population ha<sup>-1</sup> =  $\frac{\text{land area ha}^{-1}}{\text{plant spacing}}$  =  $\frac{100,000 \text{ m}^2}{2.5 \times 10^3 \text{ m}^2}$  = 40,000 populations.

NPT = number of productive tillers

NFGP = number of filled grains penicle<sup>-1</sup>

1000-GW = 1000-grains weight (g)

The parameters were analyzed using the analysis of variance (ANOVA) and the mean was determined by DMRT at 5% using IBM SPSS statistics v.20 software.

## RESULTS

### Height and Growth Quickness of Ratoon Rice

Based on the ANOVA showed that cutting stems significantly increased the height of ratoon rice at 10 to 30 DAC. In contrast, it was insignificant at 40 to 60 DAC. The SLOF significantly increased the height of the ratoon rice at 20 DAC. In contrast, it was insignificant at 10, 30, 40, and 60 DAC. The interaction of the cutting of rice stems with SLOF significantly increased the height of ratoon rice at 10 DAC. However, it was insignificant at 20 until 60 DAC (Table 1). The results showed that the cutting 10 cm of the rice stem increased the highest height of ratoon rice at 10 until 60 DAC compared to other cutting sizes, although it had significantly at 10 until 30 DAC. The giving SLOF at the dose of 15 ml l<sup>-1</sup> increased the highest height of ratoon rice at 10 until 40 DAC compared to other doses, although it had significantly only at 20 DAC. The highest height of ratoon rice was found in 10 ml l<sup>-1</sup> SLOF at 60 DAC. The interaction of the rice stem cutting of 10 cm with 10 and 15 ml l<sup>-1</sup> of SLOF (R2S2 and R2S3) significantly increased the height of ratoon rice by 27.98 cm and 25.55 cm, respectively at 10 DAC. The highest height of ratoon rice was found in the combination cutting 10 cm of the rice stem with 15 ml l<sup>-1</sup> SLOF (R2S3) at 20 until 60 DAC.

## Number Tillers of Ratoon Rice

Based on the ANOVA showed that the cutting of rice stems significantly increased the number tillers of ratoon rice at 40 to 60 DAC. In contrast, it was insignificant at 10 until 30 DAC. The SLOF and their interactions insignificant increased the number tillers of ratoon rice (Table 2). The average number tillers of lowland rice before becoming a ratoon ranged from 9.25 to 11.75 tillers. The cutting 10 cm can impact in increasing the highest number tillers of ratoon rice at 10 until 60 DAC compared to other cutting sizes, although it had significantly affected at 40 until 60 DAC. The giving SLOF of 10 ml l<sup>-1</sup> (S2) given the highest number tillers of ratoon rice at 25.33 tillers until 60 DAC compared to other doses. The combination cutting 10 cm of the rice stem with 15 ml l<sup>-1</sup> SLOF (R2S3) showed the highest number tillers of ratoon rice by 36.25 tillers at 60 DAC compared to other combinations.

## Yield Component of Ratoon Rice

Based on the ANOVA showed that the cutting of rice stems was significantly on the number of productive tillers. In contrast, the SLOF dosages and their interactions insignificantly increased number of productive tillers of ratoon rice (Figures 2 to 4). The cutting 10 cm of the rice stem significantly increased the highest number of productive tillers by 24.92 tillers compared to other cutting of rice stems.

Based on the ANOVA showed that the cutting of rice stems and SLOF dosages were insignificant on the number of filled grains panicle<sup>-1</sup>. In contrast, their interactions significantly increased number of filled grains panicle<sup>-1</sup> of ratoon rice (Figures 2 to 4). The combination cutting 10 cm of the rice stem with 5 ml.l<sup>-1</sup> SLOF (R2S1) significantly increased the highest number of filled grains panicle<sup>-1</sup> of 114.30 grains compared to other combinations. The cutting 10 cm of the rice stem (R2) had the highest number of

filled grains panicle<sup>-1</sup> of 97.58 grains compared to other cutting sizes. The giving of 10 ml.l<sup>-1</sup> SLOF (S2) had also the highest number of filled grains panicle<sup>-1</sup> of 91.53 grains compared to other doses.

Based on the ANOVA showed that the SLOF dosages significantly increased the yield hill<sup>-1</sup> of ratoon rice. In contrast, the cutting of the rice stems and their interactions were insignificant increased the yield hill<sup>-1</sup> of ratoon rice (Figures 2 to 4). The SLOF at the dose of 10 ml.l<sup>-1</sup> (S2) significantly increased the highest yield hill<sup>-1</sup> of ratoon rice by 54.32 g compared to other doses. The cutting 10 cm of the rice stem (R2) had the highest yield hill<sup>-1</sup> of ratoon rice by 46.56 g compared to other cutting sizes. The combination cutting 10 cm of the rice stem with 10 ml l<sup>-1</sup> SLOF (R2S2) had the highest yield hill<sup>-1</sup> of ratoon rice by 60.63 g compared to other combinations.

Based on the ANOVA showed that the cutting of rice stems significantly increased the yield ha<sup>-1</sup> of ratoon rice. In contrast, the SLOF dosages and their interactions were insignificant increased the yield ha<sup>-1</sup> of ratoon rice (Figure 5). The cutting 10 cm of the rice stem (R2) significantly increased the highest yield ha<sup>-1</sup> of ratoon rice by 3.58 tons ha<sup>-1</sup> compared to other cutting sizes. The SLOF at the dose of 10 ml l<sup>-1</sup> had the highest yield ha<sup>-1</sup> of ratoon rice by 3.12 tons ha<sup>-1</sup> compared to other dosages, whereas the combination cutting 10 cm of rice stem with 15 ml l<sup>-1</sup> SLOF (R2S3) had the highest yield ha<sup>-1</sup> of ratoon rice by 3.88 tons ha<sup>-1</sup> compared to other combinations.

Based on the ANOVA showed that the rice stem cutting sizes, SLOF dosages, and their interactions were insignificant on the yield component of ratoon rice (number of grains panicle<sup>-1</sup>; number of empty grains panicle<sup>-1</sup> and 1000-grains weight) are presented in Figures 2 to 4. The cutting 10 cm of the rice stem (R2) had the highest

number of grains panicle<sup>-1</sup> and 1000-grains weight of 116.77 grains and 25.91 g, respectively compared to other cutting sizes. The cutting 15 cm of the rice stem (R3) had the highest number of empty grains panicle<sup>-1</sup> of 20.29 g compared to other cutting sizes. The giving SLOF of 5 ml l<sup>-1</sup> (S1) had the highest number of grains panicle<sup>-1</sup> and number of empty grains panicle<sup>-1</sup> of 113.59 and 22.69 grains, respectively compared to other doses. The giving SLOF of 10 ml l<sup>-1</sup> (S2) had the highest in 1000-grains weight of 25.92 grains compared to other doses. The combination cutting 10 cm of the rice stem with SLOF at 5 ml l<sup>-1</sup> (R2S1) had the highest number of grains panicle<sup>-1</sup> by 139.85 grains compared to other combinations. The combination cutting 15 cm of the rice stem with SLOF of 5 ml l<sup>-1</sup> and 10 ml l<sup>-1</sup> (R3S1 and R3S2) had the highest number of empty grains panicle<sup>-1</sup> and 1000-grains weight of 25.90 grains and 26.78 g, respectively compared to other combinations.

## DISCUSSION

The cutting 10 cm of the rice stem significantly increased the highest height of ratoon rice at 10 until 30 DAC and also significantly increased the highest number tillers of ratoon rice at 40 until 60 DAC, as well as the number of productive tillers. The result similar to the growth quickness of ratoon rice on the cutting 10 cm was higher of 1.20 to 2.03 cm day<sup>-1</sup> compared to the cutting 5 cm and 15 cm, ranged of 0.89 to 1.26 cm day<sup>-1</sup> and 1.05 to 1.49 cm day<sup>-1</sup>, respectively. It was caused by the optimal carbohydrates supply that the emergence of ratoon shoots and result in greater vegetative growth. It was supported by the plant height, number of tillers, growth quickness and number of productive tillers for ratoon rice on cutting 10 cm was higher compared to other cutting sizes (Tables 1-2 and Figures 2-4). The optimal cutting size

of rice stems will support the growth and yield of ratoon rice. According to Santos et al., (2003) the decrease in yield ranging from 12 until 37% in the cutting < 5 cm of rice stem, while the cutting >20 cm of rice stem can be produced tillers faster emerge in contrast the number of grains was fewer compared to the optimal cutting size. Harrel et al., (2009) the height cutting of the main plant stems can also affect the number of tillers and seeds yield. Susilawati et al., (2012) stated that the height and number of productive tillers for ratoon rice in genotype IPB106-F-8-1 at the cutting 10 cm was higher compared to the cutting 20 cm and 30 cm. Mareza et al., (2016) stated that the cutting 40 until 50 cm of the main stem of rice was significant for the number of productive tillers and the highest was found in 40 cm of 6.55 tillers compared to other cutting sizes.

The cutting 10 cm of stem rice (R2) significantly increased the highest yield  $\text{ha}^{-1}$  of ratoon rice by 3.58 tons  $\text{ha}^{-1}$  compared to other cutting sizes. The yield  $\text{ha}^{-1}$  of ratoon rice on the research was smaller compared to the yield  $\text{ha}^{-1}$  of main plants (rice variety Inpari 30) when the initial planting until 5.08 tons  $\text{ha}^{-1}$ , or the yield was decreased of 29.53% of the main plant. It was caused the growth pattern (the height and number of tillers) of ratoon rice were higher in cutting 10 cm compared to other cutting sizes that the results of photosynthesis produced will be distributed in the assimilates form and produce filled grains. It was linear with the number of productive tillers, number of filled grains panicle<sup>-1</sup>, and 1000-grains weight on cutting 10 cm was higher compared to other cutting sizes (Figures 2-4). According to Harrel et al., (2009) the height cutting stems of the main plant can affect the number of tillers and grains. Susilawati et al., (2012) stated that the yield  $\text{ha}^{-1}$  for ratoon rice in genotype IPB106-F-8-1 on cutting 10 cm was greater of 2.1 tons  $\text{ha}^{-1}$  compared to the cutting 20 cm and 30 cm of 1.6 tons  $\text{ha}^{-1}$  and 1.1 tons  $\text{ha}^{-1}$ , respectively. Nuzul et al., (2018) also added that the yield of ratoon

rice was decreased by 58.72% from the main plants.

The giving SLOF of 15 ml l<sup>-1</sup> significantly increased the highest height of ratoon rice at 20 DAC. It was caused by the SLOF had the main nutrient content of 11% N more higher compared to K nutrient only 2% with the result that the dose of 15 ml l<sup>-1</sup> SLOF can support the photosynthesis level and have an impact on increasing the vegetative phase of ratoon rice. It was linear with the height of ratoon rice at the dose 15 ml l<sup>-1</sup> SLOF was higher compared to other dosages at 20 DAC (Table 1). According to Surtinah, (2009) the application of liquid organic fertilizers is very efficient causes it is easily absorbed by plants. Parman, (2007) stated that the liquid organic fertilizers can improve soil physical, chemical, and biological properties, also increase the yield, and quality of plant. Niss & Nik, (2017) stated that the application of liquid organic fertilizer at the dose of 6 l ha<sup>-1</sup> significantly increased the highest number of seeds panicle<sup>-1</sup> and the dry seeds weight of rice by 107.38 seeds and 29.65 g compared to the dose of 2 and 4 l ha<sup>-1</sup>.

The giving SLOF of 10 ml l<sup>-1</sup> (S2) significantly increased the highest in yield hill<sup>-1</sup> of ratoon rice by 54.32 g. It was caused the SLOF had 11% N and 2% K along an important role in improve nutrient uptake and soil organic matter resulted the macro- and micro-nutrients be available to be absorbed by ratoon rice. The liquid organic fertilizers also had a role in cell division and increase assimilation which leads to increased biomass and yield of ratoon rice. According to Vidigal et al., (2002) stated that the growth of onion was increased progressively with the increasing application of K fertilizer. El-Bassiony, (2006) stated that K fertilizer was affected by increasing the dry weight of onion. Martínez-Alcántara et al., (2016) stated that the liquid organic fertilizers increases uptake of macro- and micro-nutrient, as well as organic matter in

soil compared to chemical fertilizers. Phibunwatthanawong & Riddech, (2019) also added the liquid organic fertilizers had the micro and supplement nutrient, beneficial microorganisms such as plant growth-promoting rhizobacteria (PGPR), and hormone Indole Acetic Acid (IAA) which are not found in chemical fertilizers.

The combination cutting 10 cm of rice stem with 10 ml l<sup>-1</sup> SLOF (R2S2) significantly increased the ratoon rice height of 27.98 cm at 10 DAC. It is authenticates the combination of cutting 10 cm with SLOF at the dose of 10 and 15 ml l<sup>-1</sup> had the highest of the ratoon rice height compared to other combinations. It was caused to the main nutrients N and K in the 10 and 15 ml l<sup>-1</sup> of SLOF dosages could be promoted the photosynthesis rate in forming assimilates at cutting 10 cm as to stimulate the growth process of the ratoon rice, such as the plant height, number of tillers, and number of productive tillers (Tables 1-2 and Figures 2-4). According to Nurhayati, (2009) the application of liquid organic fertilizer can be promoted the process of metabolism in plants through the process of nutrient solubility, that nutrient transport will be going well from the roots to all parts of the plant. Hamzah, (2014) stated that the use of liquid organic fertilizer can an increase the plant height, number of branches, and the number of soybean pods.

The combination cutting 10 cm of rice stem with SLOF at the dose of 5 ml l<sup>-1</sup> (R2S1) significantly increased the highest number of filled grains panicle<sup>-1</sup> by 114.30 grains. It was caused by the SLOF could be stimulated the metabolic process with the growth quickness of ratoon rice on cutting 10 cm that the results of photosynthesis will form assimilates and lead to be produced grains panicle<sup>-1</sup>. According to Susilawati et al., (2012) stated that the cutting 10 cm of rice stem in genotype IPB106-F-8-1 significantly increased the number of grain panicle<sup>-1</sup> and was higher of 108.0 grains compared to

cutting 20 cm and 30 cm of 78.5 and 71.1 grains, respectively. Mareza et al., (2016) stated that the cutting 10 cm of rice stem significantly improved the panicle length and number of grains panicle<sup>-1</sup> of ratoon rice by 14.93 cm and 47.05 grains, respectively compared to cutting 20 until 50 cm.

The application of ratoon rice technology combine with the SLOF greatly encourages of rice yield in achieving food sufficiency, because in a year of rice cultivation (main plants and ratoon technology) can be produce an average yield of 8.66 ton ha<sup>-1</sup>. Thus, farmers will get a double benefit by applying ratoon technology in a cycle of irrigation rice.

## CONCLUSIONS

The cutting 10 cm of rice stem significantly increased the ratoon rice height ranged of 20.33 to 53.89 cm at 10 until 30 DAC, number of tillers ranged of 25.58 to 29.08 tillers at 40 until 60 DAC, the number of productive tillers by 24.92 tillers, and the yield ha<sup>-1</sup> of ratoon rice by 3.58 tons ha<sup>-1</sup>. The SLOF at the dose of 15 ml l<sup>-1</sup> significantly increased the ratoon rice height of 35.71 cm at 20 DAC, and the dose of 10 ml l<sup>-1</sup> SLOF also significantly increased the yield hill<sup>-1</sup> of ratoon rice by 54.32 g. The combination cutting 10 cm of rice stem with SLOF at the dose of 10 ml.l<sup>-1</sup> significantly increased the ratoon rice height of 27.98 cm at 10 DAC and the combination cutting 10 cm of rice stem with 5 ml l<sup>-1</sup> SLOF also significantly increased the number of filled grains panicle<sup>-1</sup> of ratoon rice by 114.30 grains. The application cutting 10 cm of rice stem combined with various dosages of SLOF showed that the higher growth and yield of ratoon rice compared to other cutting sizes.

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## TABLES

Table 1. Effect of rice stems cutting and SLOF dosages on the ratoon rice height at 10 until 60 days after cutting (DAC).

| Treatment             | Ratoon Rice Height (cm) |          |           | average  | Growth quickness (cm.day <sup>-1</sup> ) |
|-----------------------|-------------------------|----------|-----------|----------|------------------------------------------|
|                       | S1                      | S2       | S3        |          |                                          |
| 10 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 9.46 d-h                | 7.05 h   | 10.33 c-h | 8.95 b   | 0.89                                     |
| R2                    | 7.45 gh                 | 27.98 a  | 25.55 a   | 20.33 a  | 2.03                                     |
| R3                    | 13.13 b-h               | 8.90 fgh | 9.45 e-h  | 10.49 b  | 1.05                                     |
| average               | 10.01 ns                | 14.64 ns | 15.11 ns  |          |                                          |
| 20 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 15.53 ns                | 17.35 ns | 22.93 ns  | 18.60 b  | 0.93                                     |
| R2                    | 15.25 ns                | 42.35ns  | 48.80 ns  | 35.47 a  | 1.77                                     |
| R3                    | 27.90 ns                | 12.73 ns | 35.40 ns  | 25.34 ab | 1.27                                     |
| average               | 19.56 b                 | 24.14 ab | 35.71 a   |          |                                          |
| 30 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 31.28 ns                | 39.95 ns | 36.88 ns  | 36.04 b  | 1.20                                     |
| R2                    | 39.70 ns                | 58.33 ns | 63.63 ns  | 53.89 a  | 1.80                                     |
| R3                    | 46.40 ns                | 38.13 ns | 49.93 ns  | 44.82 ab | 1.49                                     |
| average               | 39.13 ns                | 45.47 ns | 50.15 ns  |          |                                          |
| 40 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 46.90 ns                | 52.98 ns | 50.73 ns  | 50.20 ns | 1.26                                     |
| R2                    | 61.90 ns                | 63.93 ns | 75.23 ns  | 67.02 ns | 1.68                                     |
| R3                    | 60.70 ns                | 54.28 ns | 55.83 ns  | 56.94 ns | 1.42                                     |
| average               | 56.50 ns                | 57.06 ns | 60.60 ns  |          |                                          |
| 60 Days After Cutting |                         |          |           |          |                                          |
| R1                    | 59.20 ns                | 65.80 ns | 58.18 ns  | 61.06 ns | 1.02                                     |
| R2                    | 67.50 ns                | 70.38 ns | 77.53 ns  | 71.80 ns | 1.20                                     |
| R3                    | 67.93 ns                | 66.28 ns | 64.63 ns  | 66.28 ns | 1.10                                     |
| average               | 64.88 ns                | 67.49 ns | 66.78 ns  |          |                                          |

Note: Data followed by different letters on the same column and row are significantly different according to DMRT at 5%. Size cutting of rice stems (R1= 5 cm; R2= 10 cm; R3= 15 cm). SLOF dosages (S1= 5 ml l<sup>-1</sup>; S2= 10 ml l<sup>-1</sup>; S3= 15 ml l<sup>-1</sup>). ns= not significant.

Table 2. The increase in the number tillers of ratoon rice after cutting the stems and SLOF dosages at 10 until 60 DAC.

| Treatment             | Number Tillers of Ratoon Rice |          |          | average  |
|-----------------------|-------------------------------|----------|----------|----------|
|                       | S1                            | S2       | S3       |          |
| 10 Days After Cutting |                               |          |          |          |
| R1                    | 6.75 ns                       | 2.00 ns  | 3.75 ns  | 4.17 ns  |
| R2                    | 7.00 ns                       | 7.00 ns  | 6.00 ns  | 6.67 ns  |
| R3                    | 8.00 ns                       | 5.00 ns  | 4.50 ns  | 5.83 ns  |
| average               | 7.25 ns                       | 4.67 ns  | 4.75 ns  |          |
| 20 Days After Cutting |                               |          |          |          |
| R1                    | 8.75 ns                       | 4.25 ns  | 5.00 ns  | 6.00 ns  |
| R2                    | 8.25 ns                       | 14.50 ns | 15.25 ns | 12.67 ns |
| R3                    | 15.00 ns                      | 9.00 ns  | 8.75 ns  | 10.92 ns |
| average               | 10.67 ns                      | 9.25 ns  | 9.67 ns  |          |
| 30 Days After Cutting |                               |          |          |          |
| R1                    | 9.00 ns                       | 7.25 ns  | 8.00 ns  | 8.08 ns  |
| R2                    | 9.25 ns                       | 19.25 ns | 24.00 ns | 17.50 ns |
| R3                    | 20.00 ns                      | 12.75 ns | 15.00 ns | 15.92 ns |
| average               | 12.75 ns                      | 13.08 ns | 15.67 ns |          |
| 40 Days After Cutting |                               |          |          |          |
| R1                    | 10.75 ns                      | 12.00 ns | 10.50 ns | 11.08 b  |
| R2                    | 10.50 ns                      | 33.25 ns | 33.00 ns | 25.58 a  |
| R3                    | 22.75 ns                      | 23.00 ns | 19.50 ns | 21.75 ab |
| average               | 14.67 ns                      | 22.75 ns | 21.00 ns |          |
| 60 Days After Cutting |                               |          |          |          |
| R1                    | 13.00 ns                      | 13.25 ns | 13.25 ns | 13.17 b  |
| R2                    | 16.00 ns                      | 35.00 ns | 36.25 ns | 29.08 a  |
| R3                    | 24.00 ns                      | 27.75 ns | 23.50 ns | 25.08 a  |
| average               | 17.67 ns                      | 25.33 ns | 24.33 ns |          |

Note: Data followed by different letters on the same column and row are significantly different according to DMRT at 5%. Size cutting of rice stems (R1= 5 cm; R2= 10 cm; R3= 15 cm). SLOF dosages (S1= 5 ml l<sup>-1</sup>; S2= 10 ml l<sup>-1</sup>; S3= 15 ml l<sup>-1</sup>). ns= not significant.

FIGURES

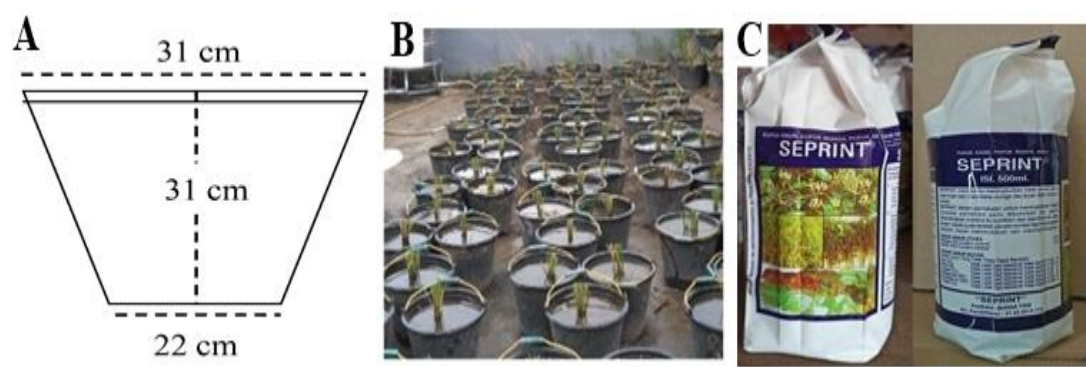


Figure 1. The size of the bucket (A); design of the second experiment (B); and seprint liquid organic fertilizer by bunga tani products (C).

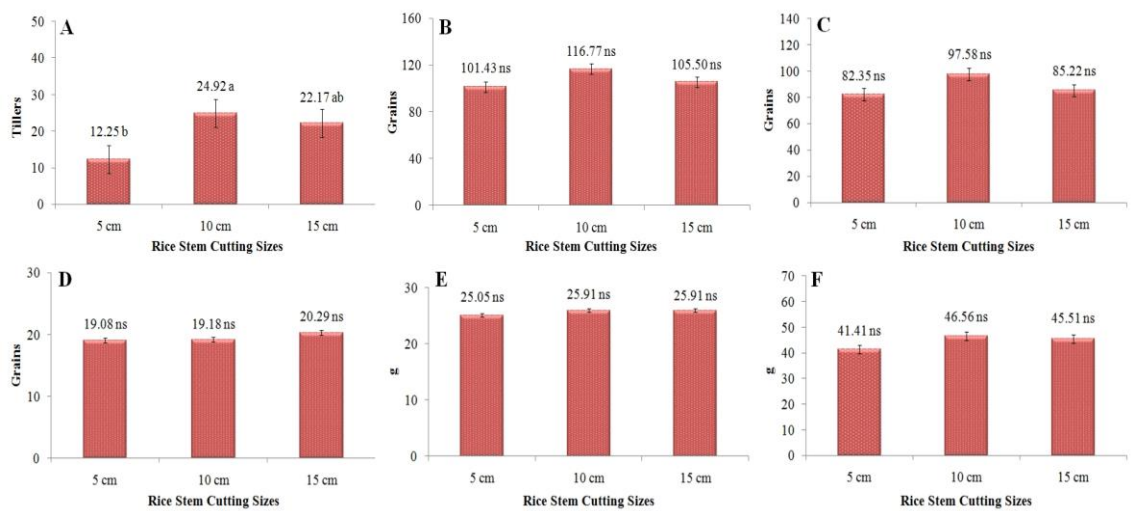


Figure 2. Effect of rice stem cutting sizes on the yield component (A= number of productive tillers; B= number of grains panicle<sup>-1</sup>; C= number of filled grains panicle<sup>-1</sup>; D= number of empty grains panicle<sup>-1</sup>; E= 1000-grains weight; F= yield hill<sup>-1</sup>) of ratoon rice. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE). ns= not significant.

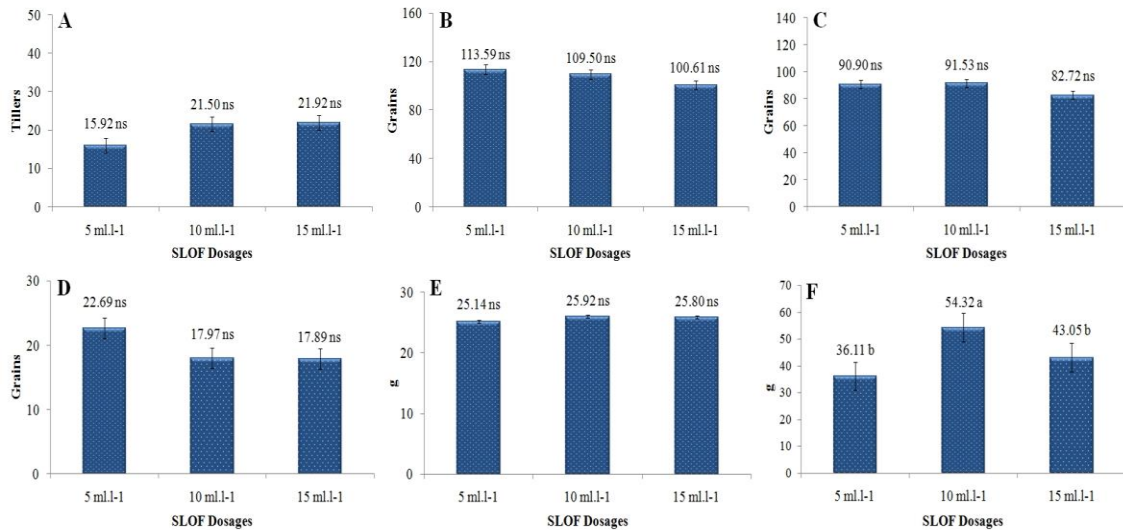


Figure 3. Effect of SLOF dosages on the yield component (A= number of productive tillers; B= number of grains panicle<sup>-1</sup>; C= number of filled grains panicle<sup>-1</sup>; D= number of empty grains panicle<sup>-1</sup>; E= 1000-grains weight; F= yield hill<sup>-1</sup>) of ratoon rice. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE). ns= not significant.

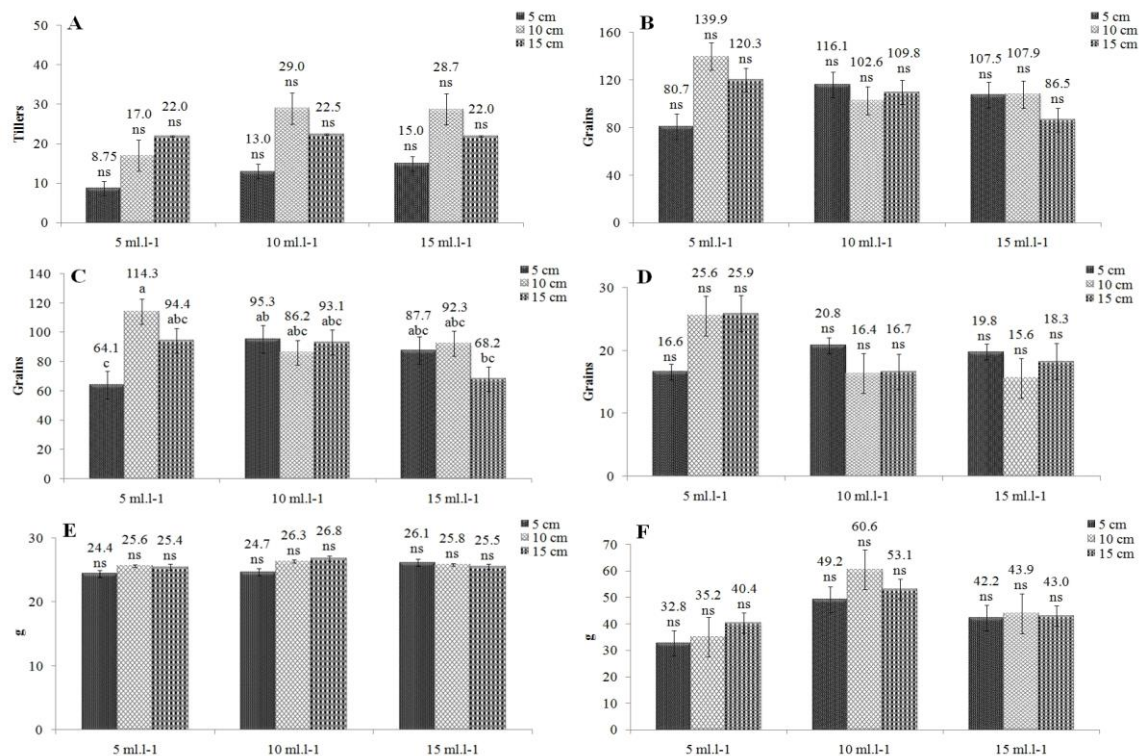
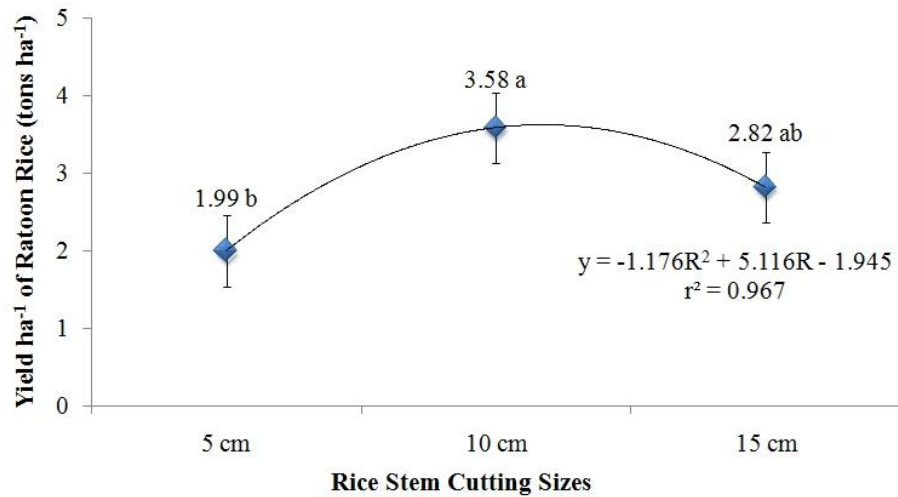


Figure 4. The combinations of stem cutting sizes and SLOF dosages on the yield component (A= number of productive tillers; B= number of grains panicle<sup>-1</sup>; C= number of filled grains panicle<sup>-1</sup>; D= number of empty grains panicle<sup>-1</sup>; E= 1000-grains weight; F= yield hill<sup>-1</sup>) of ratoon rice. Data followed by different letters on the same graph are significantly different according to



DMRT at 5% ± standard error (SE). ns= not significant.

Figure 5. Effect of rice stem cutting sizes on the yield ha<sup>-1</sup> of ratoon rice. Data followed by different letters on the same line are significantly different according to DMRT at 5% ± standard error (SE).

## #8724 Review

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### Submission

|         |                                                                                                                                                                                                  |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Authors | Alridiwersah Alridiwersah, Koko Tampubolon, Fransisca Natalia Sihombing, Andi Agus Suprianto, Zavandri Purba  |
| Title   | Agronomic Character of Ratoon Rice: Stem Cutting Sizes and Seprint Liquid Organic Fertilizer                                                                                                     |
| Section | Plant Structure                                                                                                                                                                                  |
| Editor  | Marzena Parzymies                                                                                               |

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#### ORIGINAL RESEARCH PAPER in PLANT STRUCTURE

# Agronomic Character of Ratoon Rice: Stem Cutting Sizes and Seprint Liquid Organic Fertilizer

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## Abstract

This study aimed to identify the optimum rice stem cutting size combined with the application of Seprint liquid organic fertilizer (SLOF) to promote the growth and yield of ratoon rice. This research was conducted in a greenhouse at the Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, North Sumatra Province, Indonesia, from January to August 2018. The experiment was set up as a completely randomized design factorial with four replications. The first factor consisted of the cutting sizes of the rice stem (R1 = 5 cm, R2 = 10 cm, and R3 = 15 cm) and the second factor involved the SLOF dosage (S1 = 5 mL L<sup>-1</sup>, S2 = 10 mL L<sup>-1</sup>, and S3 = 15 mL L<sup>-1</sup>). The parameters were analyzed using analysis of variance (ANOVA), and the means were determined by Duncan's multiple range test (DMRT). The results showed that the R2 treatment significantly increased the ratoon rice height at 10 to 30 days after cutting (DAC), the number of tillers at 40 to 60 DAC, the number of productive tillers, and the yield per hectare. The S2 and S3 applications at significantly increased the yield per hill and ratoon rice height at 20 DAC. The R2S1 and R2S2 combination treatments significantly increased the number of filled grains per panicle and the ratoon rice height at 10 DAC. Cutting the stems at 10 cm combined with various dosages of SLOF resulted in greater growth and yield of ratoon rice for achieving an adequate food supply.

## Keywords

dosage; growth; yield

## 1. Introduction

Food is a basic human need, and adequate, nutritious, and safe food can lead to high-quality human resources. Grain (rice) is a major source of energy. According to United States Department of Agriculture (USDA) data, countries with the highest level of rice consumption worldwide from 2015 to 2019 are located in Asia, specifically in China (29.66%), India (20.39%), Indonesia (7.88%), Bangladesh (7.32%), and Vietnam (4.54%) (Ministry of Agriculture, 2019). In Indonesia, rice is the main food requirement for more than 90% of the population. The consumption of rice per capita has decreased, from 107.71 kg capita<sup>-1</sup> year<sup>-1</sup> in 2002 to 96.33 kg capita<sup>-1</sup> year<sup>-1</sup> in 2018 (Ministry of Agriculture, 2019). However, domestic rice yield continues to increase, although it is trending toward a slower growth rate. Indonesia's population growth increased linearly from 2005 to 2015 (226.71 to 258.16 million),

and the projected population until 2035 is estimated to be up to 305.65 million (Statistics Indonesia, 2019). The total domestic consumption of Indonesian rice continues to increase, even though the per capita consumption shows a decrease.

The increased domestic consumption of rice in Indonesia must be followed by a program to increase rice yield via intensification. One of the intensification programs that can be followed is system cultivation of ratoon rice. Mengel and Wilson (1981) stated that ratoon is a technique of harvesting production from tillers from the main plant stumps to increase grain yield without increasing land area. The ratoon technique has been used to shorten the age of the rice harvest. The maturing of hybrid rice varieties is required at 105–124 days after scattering or approximately 4 months (Indonesian Center for Rice Research, 2019). Therefore, in a year, there can only be two lots of rice planting until harvesting. The ratoon system can produce three to four lots of rice harvesting. The advantages of the ratoon system are the higher efficiency of resource use per unit area of land and unit per timing (Santos et al., 2003), reduction in land preparation, cost savings on planting seeds (Zandstra & Samson, 1979), and time saving of planting because of decreased growth time (Haque & Coffman, 1980). In addition, ratoon rice is preferred by farmers because of its high quality, including cooking and flavor, short growth period, reduced water and fertilizer costs, and decreased pest control (Yazdpour et al., 2012). Alizadeh and Habibi (2016) reported that the grain thickness and amylose content of ratoon rice were higher, ranging from 1.18% to 2.25% and 2.28% to 7.69%, respectively, compared to the main crop.

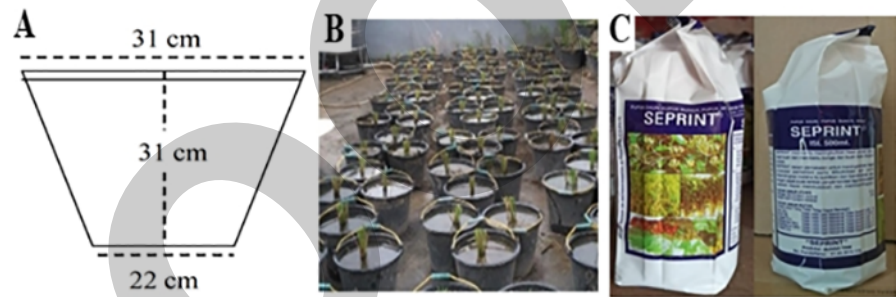
System cultivation of ratoon rice has been reported. Pratama et al. (2018) stated that the time of cutting the remaining stumps on day 10 of the rice harvest was significant for obtaining the largest root diameter of 0.89 mm with a stump cutting height of 4 cm above the soil surface and could increase grain productivity by 3.39 to 3.54 tons ha<sup>-1</sup>. Nuzul et al. (2018) stated that the highest yield components (e.g., the number and length of panicles, harvest age, grain number per panicle, filled grain, 1,000-grains weight, total dry weight, and harvest index), and rice yield (grain per hectare) were achieved in the cutting at harvest of a height 3 cm above the soil surface with a grain yield of 3.54 tons ha<sup>-1</sup>. Susilawati et al. (2012) stated that the cutting height of ratoon rice was related to the internode of the plant, and the nodes contained lateral shoots that produced ratoon shoots. Jichao and Xiaohui (1996) showed that the number of growing shoots was determined by the cutting height stems of the main plant; however, the condition was strongly influenced by residual assimilates as reserves in the stems that could be utilized for ratoon growth, and the vigor rate of the ratoon. The stem cutting height of the main plant can also affect the number of tillers and seed yield (Harrell et al., 2009) and trigger dormant shoot growth (Mahadevappa & Yogeesh, 1988).

However, in these studies, the rice cultivation system was not separated from fertilizer use to achieve the optimal yield. Islam et al. (2008) reported that fertilizer application of N = 130 kg ha<sup>-1</sup>, P<sub>2</sub>O<sub>5</sub> = 75 kg ha<sup>-1</sup>, K<sub>2</sub>O = 80 kg ha<sup>-1</sup>, S = 13 kg ha<sup>-1</sup>, and Zn = 4 kg ha<sup>-1</sup> significantly increased the yield of Boro rice ratoon by 1.42 tons ha<sup>-1</sup>. The high price of fertilizer with limited availability has resulted in the use of liquid organic fertilizer as an alternative to increase the availability and efficiency of irrigation rice nutrient uptake. The effect of liquid organic fertilizer on the growth and yield of irrigated rice has been widely reported (Ginting, 2019; Mahmoodi et al., 2020; Niis & Nik, 2017; Oh & Kim, 2013; Solihin et al., 2019); however, studies regarding the use of liquid organic fertilizer on the growth and yield of ratoon rice are limited. Thus, a special assessment of the influence of specific liquid organic fertilizers is required to increase the growth and yield of ratoon rice. The present study aimed to identify the optimum size of the rice stem cutting (ratoon) combined with the application of Seprint liquid organic fertilizer to promote growth and yield of ratoon in rice variety Inpari 30.

## 2. Material and Methods

### 2.1. Experiment I (Preliminary Research Stage)

The main plant included in the present study was the lowland rice variety Inpari 30. This variety was used because it has an average yield of up to 7.2 tons ha<sup>-1</sup> (Indonesian Agency for Agricultural Research and Development, 2020), which is higher than that of the Ciherang, Situ Bagendit, and Pepe varieties (Pramono et al., 2011). In addition, the taste of this rice variety is preferred by farmers in the Cicantayan subdistrict compared to the Inpari 22, Inpari 24, and Inpari 25 varieties (Putra & Haryati, 2018) from the Assessment Institute for Agricultural Technology Pasar Miring, Pagar Merbau subdistrict, Deli Serdang District, North Sumatra Province, Indonesia. The main plant was placed in a 20-L water bucket with an upper diameter of 31 cm, a lower diameter of 22 cm, and a height of 31 cm (Figure 1A). This experiment was conducted in a greenhouse at the Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, Indonesia, from January to August 2018. The bucket was filled with soil up to 5 cm from the surface. Two lowland rice seedlings were planted in the bucket and inundated with water until the vegetative phase of the main plant. The water in the bucket was then decreased to the bearing capacity for harvesting. The main plant was harvested 115 days after planting, followed by cutting the rice stem (Experiment II).



**Figure 1** Size of the bucket (A), design of the second experiment (B), and Seprint liquid organic fertilizer by Bunga Tani Products (C).

### 2.2. Experiment II (Main Research Stage)

After the main rice was harvested, it was cut from the rice stem base, as shown in Figure 1B. Seprint liquid organic fertilizer (SLOF) was applied 1 week after cutting the rice stems by dissolving in 1 L of water and pouring onto the soil surface. The nutrient content of SLOF was 11% N, 2% K<sub>2</sub>O, 0.17% P<sub>2</sub>O<sub>5</sub>, 0.49% Bioret, 8.98% boron (B), 5.35% cobalt (Co), 5.83% manganese (Mn), <0.01 ppm molybdenum (Mo), 18.16 ppm zinc (Zn), and 9.94 copper (Cu) (Figure 1C) (source: Bunga Tani Products). The bucket was inundated when cutting the rice stems until the end of the vegetative phase, and then the water was decreased to harvest the ratoon rice.

### 2.3. Research Design and Data Analysis

The present study was performed in a completely randomized design factorial with four replications. The first factor consisted of the cutting sizes of the rice stem (R1 = 5 cm, R2 = 10 cm, and R3 = 15 cm), and the second factor involved the SLOF dosage (S1 = 5 mL L<sup>-1</sup>, S2 = 10 mL L<sup>-1</sup>, and S3 = 15 mL L<sup>-1</sup>). The distance between the treatments was 50 × 50 cm. The parameters measured included the height and growth rate of the ratoon rice; the number of tillers at 10 to 60 days after cutting (DAC); the yield component of ratoon rice including the number of productive tillers, number of grains per panicle, number of filled grains per panicle, number of empty grains per panicle, 1,000-grains weight, yield per hill, and yield per hectare. The agronomic traits of ratoon rice are transformed in the form of natural logarithms (ln) due to the different units and then analyzed with the Pearson

correlation. The calculation of the growth rate and yield per hectare of the ratoon rice can be seen in Equation (1) and Equation (2):

$$\text{Growth rate (cm day}^{-1}\text{)} = \frac{\text{Average height of ratoon rice}}{\text{Days of cutting}} \quad (1)$$

$$\text{Yield (ha}^{-1}\text{)} = NP \times NPT \times NFGP \times 1,000 \text{ GW} \quad (2)$$

Notes:

- $NP$  – number population per hectare =  $\frac{\text{Land area (ha}^{-1}\text{)}}{\text{Plant spacing}} = \frac{10,000 \text{ m}^2}{0.5 \text{ m} \times 0.5 \text{ m}} = 40,000$  pop;
- $NPT$  – number of productive tillers;
- $NFGP$  – number of filled grains per panicle;
- 1,000 GW – 1,000-grains weight (g).

The parameters were analyzed using ANOVA, and the mean was determined by DMRT at 5% significance, and correlation analysis for agronomic traits of ratoon rice using IBM SPSS statistics v.20 software.

### 3. Results

#### 3.1. Height and Growth Rate of Ratoon Rice

Based on the ANOVA results, the cutting of the stems significantly increased the height of the ratoon rice at 10 to 30 DAC. In contrast, no significant increase was found at 40 and 60 DAC. SLOF application significantly increased the height of the ratoon rice at 20 DAC. In contrast, no significant increase was found at 10, 30, 40, and 60 DAC. The interaction of the cutting of the rice stems with SLOF application significantly increased the height of the ratoon rice at 10 DAC. However, no significant increase was found at 20 to 60 DAC (Table 1). The R2 treatment had the highest ratoon rice height at 10 to 60 DAC compared to the other cutting sizes, with significant increases from 10 to 30 DAC. The S3 application had the highest ratoon rice height at 10 to 40 DAC compared to the other doses, although it was significantly increased only at 20 DAC. The highest ratoon rice height was found in the S2 application at 60 DAC. The R2S2 and R2S3 combination treatments significantly increased the ratoon rice height to 27.98 cm and 25.55 cm, respectively, at 10 DAC. The highest ratoon rice heights were found in the R2S3 treatment at 20 to 60 DAC.

#### 3.2. Number of Tillers of Ratoon Rice

Based on the ANOVA results, the cutting of the rice stems significantly increased the number of tillers of ratoon rice at 40 and 60 DAC. In contrast, no significant increase was found at 10 to 30 DAC. The SLOF application and interaction with stem cutting did not significantly increase the number of tillers of ratoon rice (Table 2). The average number of tillers of lowland rice before becoming a ratoon ranged from 9.25 to 11.75 tillers. The R2 treatment had the highest number of tillers of ratoon rice at 10 to 60 DAC compared to the other cutting sizes, with significant increases at 40 to 60 DAC. The S2 application had the highest number of tillers of ratoon rice (25.33 tillers) at 60 DAC compared to the other doses. The R2S3 combination treatment had the highest number of tillers of ratoon rice at 36.25 tillers at 60 DAC compared to the other combinations.

#### 3.3. Yield Component of Ratoon Rice

Based on the ANOVA results, the cutting of the rice stems significantly affected the number of productive tillers. In contrast, the SLOF dosages and interactions with stem cuttings did not significantly increase the number of productive tillers of ratoon rice (Figure 2–Figure 4). The R2 treatment had the highest number of productive tillers (24.92 tillers) compared to the other rice stem cuttings.

Based on the ANOVA results, the cutting of the rice stems and SLOF dosages did not significantly affect the number of filled grains per panicle. In contrast, their interactions significantly increased the number of filled grains per panicle of ratoon rice (Figure 2–Figure 4). The R2S1 combination treatment significantly increased the

**Table 1** Effect of rice stem cutting and Seprint liquid organic fertilizer (SLOF) dosages on the ratoon rice height from 10 to 60 days after cutting (DAC).

| Treatment | Ratoon rice height (cm) |          |           | Average  | Growth rate<br>(cm day <sup>-1</sup> ) |
|-----------|-------------------------|----------|-----------|----------|----------------------------------------|
|           | S1                      | S2       | S3        |          |                                        |
|           | 10 days after cutting   |          |           |          |                                        |
| R1        | 9.46 d–h                | 7.05 h   | 10.33 c–h | 8.95 b   | 0.89                                   |
| R2        | 7.45 gh                 | 27.98 a  | 25.55 a   | 20.33 a  | 2.03                                   |
| R3        | 13.13 b–h               | 8.90 fgh | 9.45 e–h  | 10.49 b  | 1.05                                   |
| Average   | 10.01 ns                | 14.64 ns | 15.11 ns  |          |                                        |
|           | 20 days after cutting   |          |           |          |                                        |
| R1        | 15.53 ns                | 17.35 ns | 22.93 ns  | 18.60 b  | 0.93                                   |
| R2        | 15.25 ns                | 42.35ns  | 48.80 ns  | 35.47 a  | 1.77                                   |
| R3        | 27.90 ns                | 12.73 ns | 35.40 ns  | 25.34 ab | 1.27                                   |
| Average   | 19.56 b                 | 24.14 ab | 35.71 a   |          |                                        |
|           | 30 days after cutting   |          |           |          |                                        |
| R1        | 31.28 ns                | 39.95 ns | 36.88 ns  | 36.04 b  | 1.20                                   |
| R2        | 39.70 ns                | 58.33 ns | 63.63 ns  | 53.89 a  | 1.80                                   |
| R3        | 46.40 ns                | 38.13 ns | 49.93 ns  | 44.82 ab | 1.49                                   |
| Average   | 39.13 ns                | 45.47 ns | 50.15 ns  |          |                                        |
|           | 40 days after cutting   |          |           |          |                                        |
| R1        | 46.90 ns                | 52.98 ns | 50.73 ns  | 50.20 ns | 1.26                                   |
| R2        | 61.90 ns                | 63.93 ns | 75.23 ns  | 67.02 ns | 1.68                                   |
| R3        | 60.70 ns                | 54.28 ns | 55.83 ns  | 56.94 ns | 1.42                                   |
| Average   | 56.50 ns                | 57.06 ns | 60.60 ns  |          |                                        |
|           | 60 days after cutting   |          |           |          |                                        |
| R1        | 59.20 ns                | 65.80 ns | 58.18 ns  | 61.06 ns | 1.02                                   |
| R2        | 67.50 ns                | 70.38 ns | 77.53 ns  | 71.80 ns | 1.20                                   |
| R3        | 67.93 ns                | 66.28 ns | 64.63 ns  | 66.28 ns | 1.10                                   |
| Average   | 64.88 ns                | 67.49 ns | 66.78 ns  |          |                                        |

Note: Data followed by different letters in the same column and row are significantly different according to the DMRT at 5% significance. Size cutting of rice stems (R1 = 5 cm, R2 = 10 cm, and R3 = 15 cm). SLOF dosages (S1 = 5 mL L<sup>-1</sup>, S2 = 10 mL L<sup>-1</sup>, and S3 = 15 mL L<sup>-1</sup>). ns = not significant.

highest number of filled grains per panicle to 114.30 grains compared to the other combinations. The R2 treatment had the highest number of filled grains per panicle (97.58 grains) compared to the other cutting sizes. The S2 application had the highest number of filled grains per panicle (91.53 grains) compared to the other doses.

Based on the ANOVA results, the SLOF dosages significantly increased the yield per hill of ratoon rice. In contrast, the cutting of the rice stems and their interactions did not significantly increase the yield per hill of ratoon rice (Figure 2–Figure 4). The S2 application significantly had the highest yield per hill of ratoon rice of 54.32 g compared to the other doses. The R2 treatment had the highest yield per hill of ratoon rice of 46.56 g compared to the other cutting sizes. The R2S2 combination treatment had the highest yield per hill of ratoon rice of 60.63 g compared to the other combinations.

Based on the ANOVA results, the cutting of rice stems significantly increased the yield per hectare of ratoon rice. In contrast, the SLOF dosages and their interactions did not significantly increase the yield per hectare of ratoon rice (Figure 5). The R2 treatment had the highest yield per hectare of ratoon rice of 3.58 tons ha<sup>-1</sup> compared to the other cutting sizes. The S2 application had the highest yield per hectare of ratoon rice of 3.12 tons ha<sup>-1</sup> compared to the other dosages, whereas the R2S3 combination treatment had the highest yield per hectare of ratoon rice of 3.88 tons ha<sup>-1</sup> compared to the other combinations.

**Table 2** Number of tillers of ratoon rice after cutting the stems and Seprint liquid organic fertilizer (SLOF) dosages from 10 to 60 days after cutting (DAC).

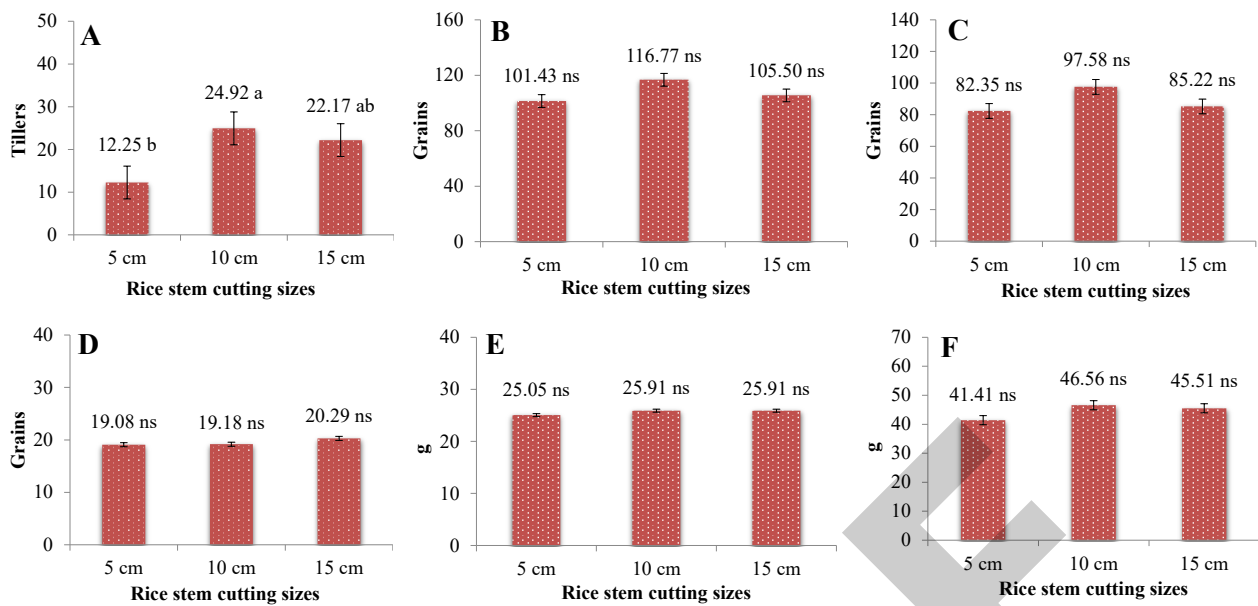
| Treatment             | Number of tillers of ratoon rice |          |          | Average  |
|-----------------------|----------------------------------|----------|----------|----------|
|                       | S1                               | S2       | S3       |          |
| 10 days after cutting |                                  |          |          |          |
| R1                    | 6.75 ns                          | 2.00 ns  | 3.75 ns  | 4.17 ns  |
| R2                    | 7.00 ns                          | 7.00 ns  | 6.00 ns  | 6.67 ns  |
| R3                    | 8.00 ns                          | 5.00 ns  | 4.50 ns  | 5.83 ns  |
| Average               | 7.25 ns                          | 4.67 ns  | 4.75 ns  |          |
| 20 days after cutting |                                  |          |          |          |
| R1                    | 8.75 ns                          | 4.25 ns  | 5.00 ns  | 6.00 ns  |
| R2                    | 8.25 ns                          | 14.50 ns | 15.25 ns | 12.67 ns |
| R3                    | 15.00 ns                         | 9.00 ns  | 8.75 ns  | 10.92 ns |
| Average               | 10.67 ns                         | 9.25 ns  | 9.67 ns  |          |
| 30 days after cutting |                                  |          |          |          |
| R1                    | 9.00 ns                          | 7.25 ns  | 8.00 ns  | 8.08 ns  |
| R2                    | 9.25 ns                          | 19.25 ns | 24.00 ns | 17.50 ns |
| R3                    | 20.00 ns                         | 12.75 ns | 15.00 ns | 15.92 ns |
| Average               | 12.75 ns                         | 13.08 ns | 15.67 ns |          |
| 40 days after cutting |                                  |          |          |          |
| R1                    | 10.75 ns                         | 12.00 ns | 10.50 ns | 11.08 b  |
| R2                    | 10.50 ns                         | 33.25 ns | 33.00 ns | 25.58 a  |
| R3                    | 22.75 ns                         | 23.00 ns | 19.50 ns | 21.75 ab |
| Average               | 14.67 ns                         | 22.75 ns | 21.00 ns |          |
| 60 days after cutting |                                  |          |          |          |
| R1                    | 13.00 ns                         | 13.25 ns | 13.25 ns | 13.17 b  |
| R2                    | 16.00 ns                         | 35.00 ns | 36.25 ns | 29.08 a  |
| R3                    | 24.00 ns                         | 27.75 ns | 23.50 ns | 25.08 a  |
| Average               | 17.67 ns                         | 25.33 ns | 24.33 ns |          |

Note: Data followed by different letters in the same column and row are significantly different according to the DMRT at 5%. Size cutting of rice stems (R1 = 5 cm, R2 = 10 cm, and R3 = 15 cm). SLOF dosages (S1 = 5 mL L<sup>-1</sup>, S2 = 10 mL L<sup>-1</sup>, and S3 = 15 mL L<sup>-1</sup>). ns = not significant.

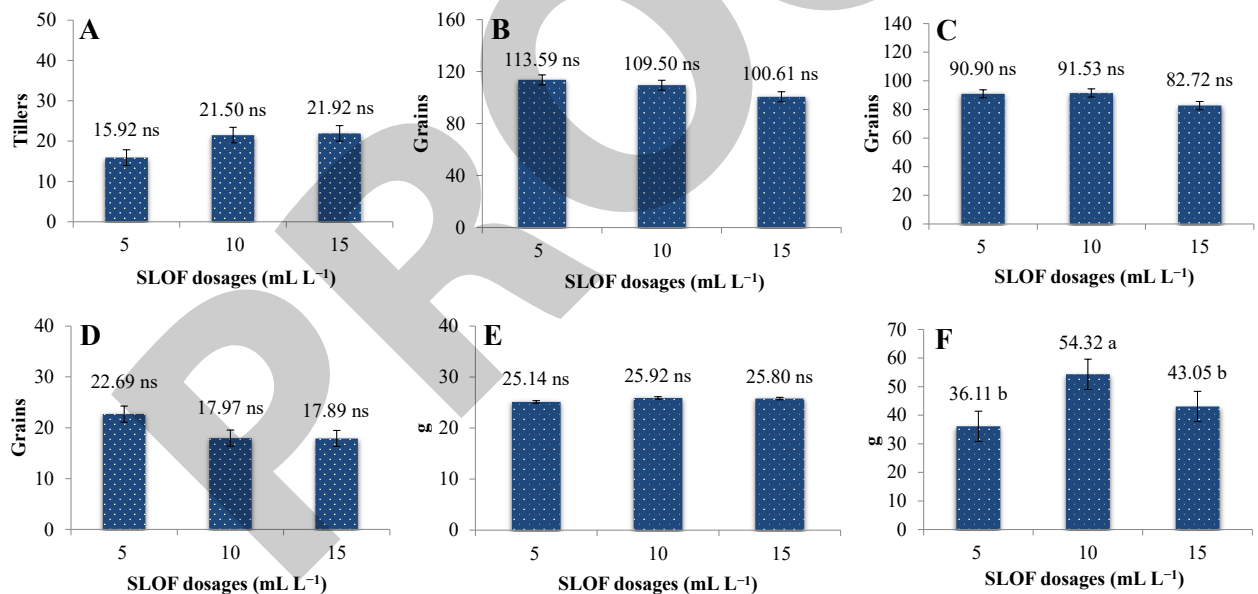
Based on the ANOVA results, the rice stem cutting sizes, SLOF dosages, and their interactions were insignificant on the yield components of ratoon rice (number of grains per panicle, number of empty grains per panicle, and 1,000-grains weight; Figure 2–Figure 4). The R2 treatment had the highest number of grains per panicle and 1,000-grains weight of 116.77 grains and 25.91 g, respectively, compared to the other cutting sizes. The R3 treatment had the highest number of empty grains per panicle (20.29 grains) compared to the other cutting sizes. The S1 application had the highest number of grains per panicle and number of empty grains per panicle of 113.59 and 22.69 grains, respectively, compared to the other doses. The S2 application had the highest 1,000-grains weight of 25.92 g compared to the other doses. The R2S1 combination treatment had the highest number of grains per panicle of 139.85 grains compared to the other combinations. The R3S1 and R3S2 combination treatments had the highest number of empty grains per panicle and 1,000-grains weight of 25.90 grains and 26.78 g, respectively, compared to the other combinations.

### 3.4. Correlations of Agronomic Traits of Ratoon Rice

The agronomic traits of ratoon rice include the plant height, number of tillers, number of productive tillers, number of grains per panicle, number of filled grains per panicle, 1,000-grains weight, and yield per hill significantly increase the yield per

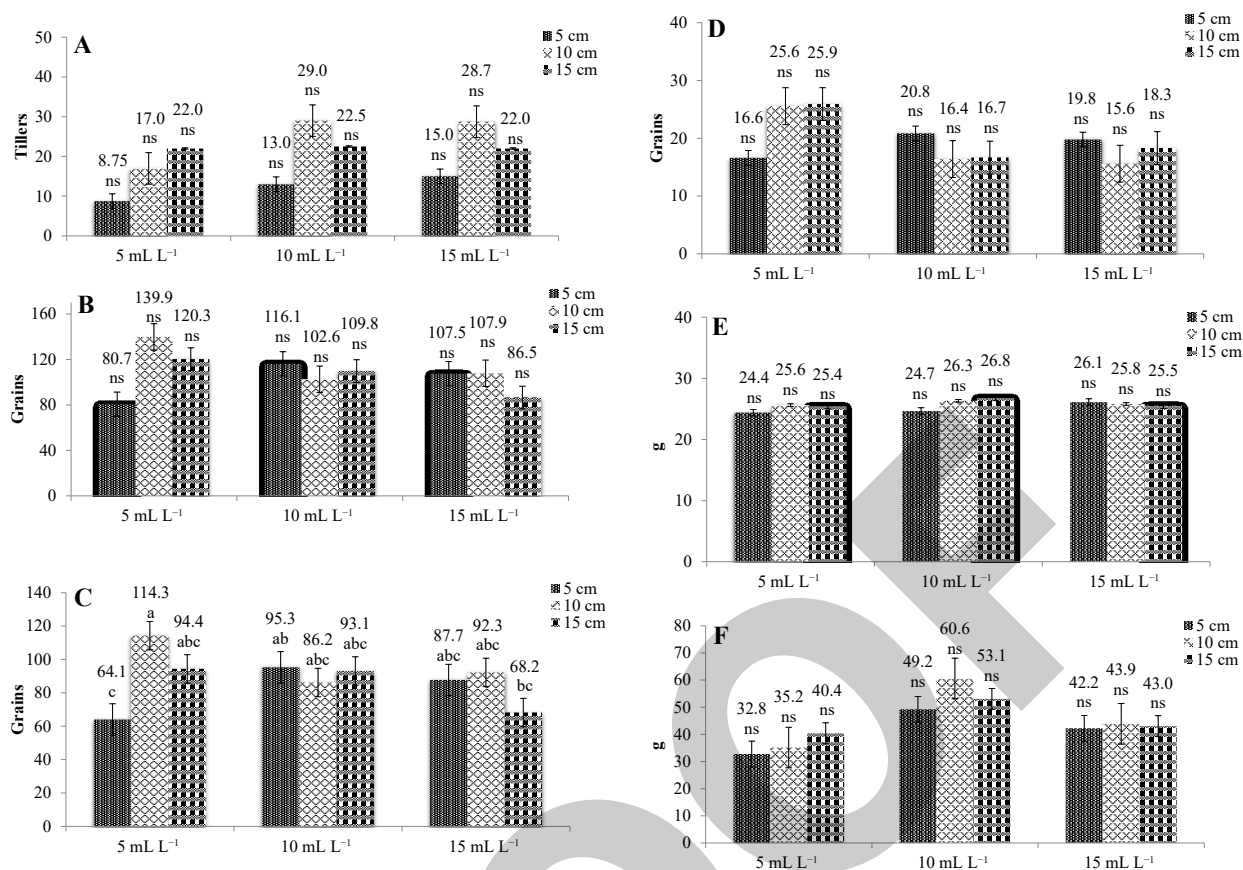


**Figure 2** Effect of rice stem cutting sizes on the yield component of ratoon rice: (A) number of productive tillers; (B) number of grains per panicle; (C) number of filled grains per panicle; (D) number of empty grains per panicle; (E) 1,000-grains weight; (F) yield per hill. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE).

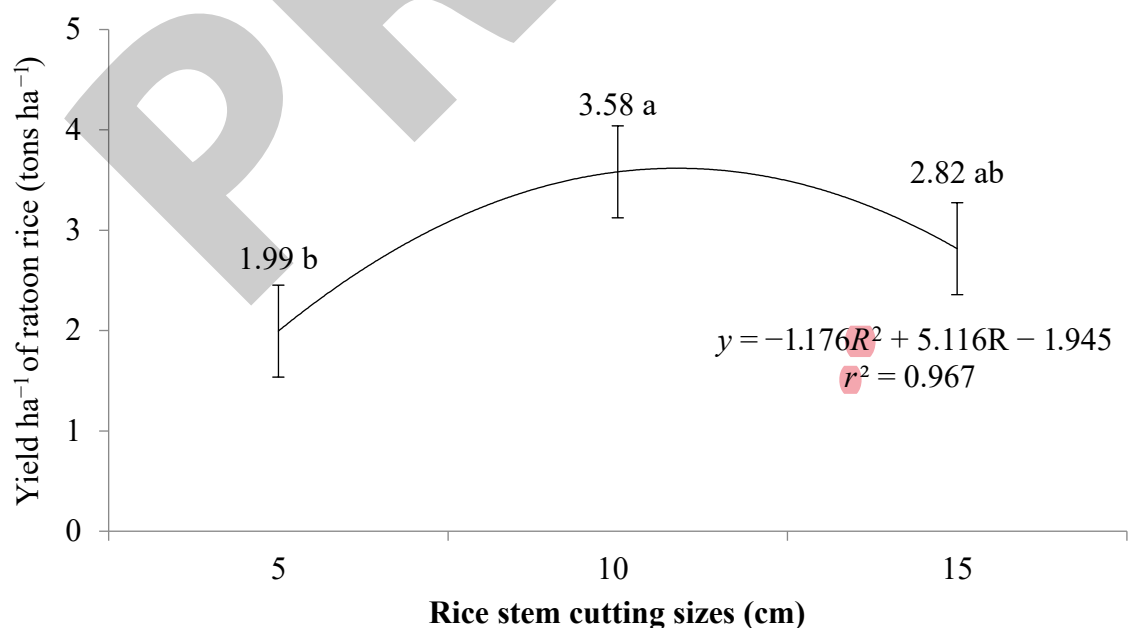


**Figure 3** Effect of Seprint liquid organic fertilizer (SLOF) dosages on the yield component of ratoon rice: (A) number of productive tillers; (B) number of grains per panicle; (C) number of filled grains per panicle; (D) number of empty grains per panicle; (E) 1,000-grains weight; (F) yield per hill. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE).

hectare of ratoon rice with the highest contribution was found in the number of productive tillers (correlation coefficient value of 0.885) (Table 3). The present study confirmed that an increase the yield per hectare of ratoon rice along with an increase in the number of productive tillers in the combination treatment of stem cutting with SLOF dosages.



**Figure 4** Combinations of stem cutting sizes and Seprint liquid organic fertilizer (SLOF) dosages on the yield component of ratoon rice: (A) number of productive tillers; (B) number of grains per panicle; (C) number of filled grains per panicle; (D) number of empty grains per panicle; (E) 1,000-grains weight; (F) yield per hill. Data followed by different letters on the same graph are significantly different according to DMRT at 5% ± standard error (SE).



**Figure 5** Effect of rice stem cutting sizes on the yield per hectare of ratoon rice. Data followed by different letters on the same line are significantly different according to DMRT at 5% ± standard error (SE).

**Table 3** Correlations of agronomic traits of ratoon rice in the treatment of stems cutting and Seprint liquid organic fertilizer (SLOF) dosages.

| Agronomic traits of ratoon rice | PH      | NT      | NPT     | NGP     | NFGP    | NEGP   | 1000-GW | YH     | Y |
|---------------------------------|---------|---------|---------|---------|---------|--------|---------|--------|---|
| PH                              | 1       |         |         |         |         |        |         |        |   |
| NT                              | 0.500** | 1       |         |         |         |        |         |        |   |
| NPT                             | 0.683** | 0.612** | 1       |         |         |        |         |        |   |
| NGP                             | -0.043  | -0.143  | 0.157   | 1       |         |        |         |        |   |
| NFGP                            | 0.104   | -0.051  | 0.217   | 0.927** | 1       |        |         |        |   |
| NEGP                            | -0.264  | -0.207  | 0.055   | 0.693** | 0.387*  | 1      |         |        |   |
| 1,000 GW                        | 0.167   | 0.243   | 0.271   | -0.085  | 0.090   | -0.311 | 1       |        |   |
| YH                              | 0.208   | 0.241   | 0.222   | 0.071   | 0.258   | -0.310 | 0.329*  | 1      |   |
| Y                               | 0.582** | 0.500** | 0.885** | 0.488** | 0.600** | 0.137  | 0.396*  | 0.360* | 1 |

Note: Correlation is significant at the \* 0.05 and \*\* 0.01 level (two-tailed). Agronomic traits: PH – plant height; NT – number of tillers; NPT – number of productive tillers; NGP – number of grains per panicle; NFGP – number of filled grains per panicle; NEGP – number of empty grains per panicle; 1,000 GW – 1,000-grains weight; YH – yield per hill; Y – yield per hectare.

#### 4. Discussion

Cutting 10 cm of the rice stem (R2 treatment) significantly increased the height of ratoon rice at 10 to 30 DAC and significantly increased the number of tillers of ratoon rice at 40 to 60 DAC and the number of productive tillers. The results were similar for the growth rate of ratoon rice, with the R2 treatment higher by 1.20 to 2.03 cm day<sup>-1</sup> compared to the R1 and R3 treatments that ranged from 0.89 to 1.26 cm day<sup>-1</sup> and 1.05 to 1.49 cm day<sup>-1</sup>, respectively. This was caused by an optimal carbohydrate supply from the emergence of the ratoon shoots that resulted in higher vegetative growth and was supported by the plant height, number of tillers, growth rate, and number of productive tillers on the R2 treatment being higher than the other cutting sizes (Table 1, Table 2 and Figure 2–Figure 4). The optimal cutting size of rice stems supports the growth and yield of ratoon rice. Santos et al. (2003) showed a decrease in yield ranging from 12% to 37% in <5 cm rice stem cuttings, whereas cuttings >20 cm of the rice stem produced tillers faster, and the number of grains was less than the optimal cutting size. Harrell et al. (2009) found that height cutting of the main plant stems affected the number of tillers and seed yield. Susilawati et al. (2012) stated that the height and number of productive tillers for ratoon rice in genotype IPB106-F-8-1 at a 10 cm cutting was higher than that at 20 cm and 30 cm cuttings. Mareza et al. (2016) stated that cutting 40 to 50 cm of the main rice stem was significant for the number of productive tillers, with the highest found at the 40 cm cutting (6.55 tillers) compared to the other cutting sizes.

The R2 treatment significantly increased the yield per hectare of ratoon rice to 3.58 tons ha<sup>-1</sup> compared to the other cutting sizes (Figure 5). The yield per hectare of ratoon rice in the study was smaller than that of the main plants (rice variety Inpari 30) where the initial planting was 5.08 tons ha<sup>-1</sup> and the yield decreased by 29.53% compared to the main plant. This resulted in a growth pattern (height and number of tillers) of ratoon rice that was higher in the R2 treatment compared to the other cutting sizes because photosynthesis caused the formation of assimilates and the production of filled grains. The number of productive tillers, number of filled grains per panicle, and 1,000-grains weight for the R2 treatment were also higher than the other cutting sizes (Figure 2–Figure 4). According to Harrell et al. (2009), the height of the cutting stems of the main plant affects the number of tillers and grains. Susilawati et al. (2012) showed that the yield per hectare of ratoon rice in genotype IPB106-F-8-1 for the 10 cm cutting was greater (2.1 tons ha<sup>-1</sup>) than that for the 20 and 30 cm cuttings (1.6 and 1.1 tons ha<sup>-1</sup>, respectively). Nuzul et al. (2018) found that the yield of ratoon rice decreased by 58.72% from that of the main plants.

The S3 treatment significantly increased the height of ratoon rice at 20 DAC (Table 1). SLOF has a main nutrient content of 11% N, which is higher than that of

K (2%). Therefore, a SLOF dose of 15 mL L<sup>-1</sup> could support the photosynthesis level and increase the vegetative phase of the ratoon rice. According to Surtinah (2009), liquid organic fertilizers are very efficient because plants easily absorb such fertilizers. Parman (2007) stated that liquid organic fertilizers improved soil physical, chemical, and biological properties, and increased the yield and quality of plants. Niis and Nik (2017) showed that the application of liquid organic fertilizer at a dose of 6 L ha<sup>-1</sup> significantly increased the highest number of seeds per panicle and the dry seed weight of rice by 107.38 seeds and 29.65 g, respectively, compared to doses of 2 and 4 L ha<sup>-1</sup>.

The S2 application significantly increased the yield per hill of ratoon rice by 54.32 g. SLOF contains 11% N and 2% K, which played an important role in improving the nutrient uptake and soil organic matter and increasing the availability of macro- and micronutrients for ratoon rice. Liquid organic fertilizers can play a role in cell division and increase assimilation, leading to increased biomass and yield of ratoon rice. According to Vidigal et al. (2002), the growth of onions increased progressively with an increased application of K fertilizer. El-Bassiony (2006) also stated that the application of K fertilizer increased the dry weight of onions. Martínez-Alcántara et al. (2016) stated that liquid organic fertilizers increased the uptake of macro- and micronutrients, and organic matter in soil compared to chemical fertilizers. Phibunwatthanawong and Riddech (2019) showed that liquid organic fertilizers contained micro- and supplementing nutrients, beneficial microorganisms such as plant growth-promoting rhizobacteria, and hormone indole acetic acid, which are not found in chemical fertilizers.

The R2S2 combination treatment significantly increased the ratoon rice height to 27.98 cm at 10 DAC. The R2S2 and R2S3 combination treatments had the highest ratoon rice height compared to the other combinations. This was caused by the main nutrients N and K in the S2 and S3 applications promoting the photosynthesis rate to form assimilates to stimulate ratoon rice growth, including the plant height, number of tillers, and number of productive tillers (Table 1, Table 2 and Figure 2–Figure 4). According to Nurhayati (2009), liquid organic fertilizer can promote metabolism in plants via the nutrient solubility process, and nutrient transport will occur from the roots to all parts of the plant. Hamzah (2014) stated that liquid organic fertilizer could increase plant height, and the number of branches and soybean pods.

The R2S1 combination treatment significantly increased the number of filled grains per panicle by 114.30 grains. This was because SLOF stimulated the metabolic process with the growth rate of ratoon rice, and photosynthesis formed assimilates and led to grain panicle production. According to Susilawati et al. (2012), the cutting of 10 cm of rice stem in genotype IPB106-F-8-1 significantly increased the number of grain per panicle, which was 108.0 grains higher than the 20 cm and 30 cm cuttings (78.5 and 71.1 grains, respectively). Mareza et al. (2016) stated that cutting 10 cm of the rice stems significantly improved the panicle length and the number of grains per panicle of ratoon rice by 14.93 cm and 47.05 grains, respectively, compared to the cuttings of 20 to 50 cm.

The correlations result confirmed that the number of productive tillers had a positive linear correlation (0.885) and was classified as very strong in increasing the yield per hectare of ratoon rice compared to another agronomic traits (Table 3). Similar results were reported by Sadeghi (2011); Ranawake et al. (2013) the number of productive tillers and the number of grains per panicle had a significant effect on grain yield per plant. Faruq et al. (2014) also reported that the number of productive tillers per hill has a correlated positively and significant increase the grain yield per plant of ratoon rice.

The application of ratoon rice technology combined with SLOF greatly encouraged rice yield to improve adequate food supply because a year of rice cultivation (main plants and ratoon technology) can produce an average yield of 8.66 tons ha<sup>-1</sup>. Thus, farmers will receive a double benefit by applying ratoon technology during a cycle of irrigated rice.

## 5. Conclusions

The R2 treatment significantly increased the ratoon rice height from 20.33 to 53.89 cm at 10 to 30 DAC, the number of tillers from 25.58 to 29.08 tillers at 40 to 60 DAC, the number of productive tillers to 24.92 tillers, and the yield per hectare of ratoon rice to 3.58 tons ha<sup>-1</sup>. The S3 application significantly increased the ratoon rice height to 35.71 cm at 20 DAC, and the S2 application significantly increased the yield per hill of ratoon rice to 54.32 g. The R2S2 combination treatment significantly increased the ratoon rice height to 27.98 cm at 10 DAC and the R2S1 combination treatment also significantly increased the number of filled grains per panicles of ratoon rice to 114.30 grains. The R2 treatment combined with various dosages of SLOF resulted in higher growth and yield of ratoon rice compared to the other cutting sizes.

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A: coordinating the research, designing ideas and methods, conceptualization; KT: conceptualization, analysis and interpretation of data, field coordinator, writing, reviewing, and editing of the manuscript; FNS: data collection and analysis, writing and reviewing of the manuscript; AAS and ZP: data collection

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#### ORIGINAL RESEARCH PAPER in PLANT STRUCTURE

# Agronomic Character of Ratoon Rice: Stem Cutting Sizes and Seprint Liquid Organic Fertilizer

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## Abstract

This study aimed to identify the optimum rice stem cutting size combined with the application of Seprint liquid organic fertilizer (SLOF) to promote the growth and yield of ratoon rice. This research was conducted in a greenhouse at the Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, North Sumatra Province, Indonesia, from January to August 2018. The experiment was set up as a completely randomized design factorial with four replications. The first factor consisted of the cutting sizes of the rice stem ( $R_1 = 5$  cm,  $R_2 = 10$  cm, and  $R_3 = 15$  cm) and the second factor involved the SLOF dosage ( $S_1 = 5$  mL L<sup>-1</sup>,  $S_2 = 10$  mL L<sup>-1</sup>, and  $S_3 = 15$  mL L<sup>-1</sup>). The parameters were analyzed using analysis of variance (ANOVA), and the means were determined by Duncan's multiple range test (DMRT). The results showed that the  $R_2$  treatment significantly increased the ratoon rice height at 10 to 30 days after cutting (DAC), the number of tillers at 40 to 60 DAC, the number of productive tillers, and the yield per hectare. The  $S_2$  and  $S_3$  applications significantly increased the yield per hill and ratoon rice height at 20 DAC. The  $R_2S_1$  and  $R_2S_2$  combination treatments significantly increased the number of filled grains per panicle and the ratoon rice height at 10 DAC. Cutting the stems at 10 cm combined with various dosages of SLOF resulted in greater growth and yield of ratoon rice for achieving an adequate food supply.

## Keywords

dosage; growth; yield; crop model; optimization technique; ratoon technology

## 1. Introduction

Food is a basic human need, and adequate, nutritious, and safe food can lead to high-quality human resources. Grain (rice) is a major source of energy. According to United States Department of Agriculture (USDA) data, countries with the highest level of rice consumption worldwide from 2015 to 2019 are located in Asia, specifically in China (29.66%), India (20.39%), Indonesia (7.88%), Bangladesh (7.32%), and Vietnam (4.54%) (Ministry of Agriculture of the Republic of Indonesia, 2019). In Indonesia, rice is the main food requirement for more than 90% of the population. The consumption of rice per capita has decreased, from 107.71 kg capita<sup>-1</sup> year<sup>-1</sup> in 2002 to 96.33 kg capita<sup>-1</sup> year<sup>-1</sup> in 2018 (Ministry of Agriculture of the Republic of Indonesia, 2019). However, domestic rice yield continues to increase, although it is trending toward a slower growth rate. Indonesia's population

growth increased linearly from 2005 to 2015 (226.71 to 258.16 million), and the projected population until 2035 is estimated to be up to 305.65 million (Statistics Indonesia, 2019). The total domestic consumption of Indonesian rice continues to increase, even though the per capita consumption shows a decrease.

The increased domestic consumption of rice in Indonesia must be followed by a program to increase rice yield via intensification. One of the intensification programs that can be followed is system cultivation of ratoon rice. Mengel and Wilson (1981) stated that ratoon is a technique of harvesting production from tillers from the main plant stumps to increase grain yield without increasing land area.

The ratoon technique has been used to shorten the age of the rice harvest. The maturing of hybrid rice varieties is required at 105–124 days after scattering or approximately 4 months (Indonesian Center for Rice Research, 2019). Therefore, in a year, there can only be two lots of rice planting until harvesting. The ratoon system can produce three to four lots of rice harvesting. The advantages of the ratoon system are the higher efficiency of resource use per unit area of land and unit per timing (Santos et al., 2003), reduction in land preparation, cost savings on planting seeds (Zandstra & Samson, 1979), and time saving of planting because of decreased growth time (Haque & Coleman, 1980). In addition, ratoon rice is preferred by farmers because of its high quality, including cooking and flavor, short growth period, reduced water and fertilizer costs, and decreased pest control (Yazdpour et al., 2012). Alizadeh and Habibi (2016) reported that the grain thickness and amylose content of ratoon rice were higher, ranging from 1.18% to 2.25% and 2.28% to 7.69%, respectively, compared to the main crop.

System cultivation of ratoon rice has been reported. Pratama et al. (2018) stated that the time of cutting the remaining stumps on day 10 of the rice harvest was significant for obtaining the largest root diameter of 0.89 mm with a stump cutting height of 4 cm above the soil surface and could increase grain productivity by 3.39 to 3.54 tons ha<sup>-1</sup>. Nuzul et al. (2018) stated that the highest yield components (e.g., the number and length of panicles, harvest age, grain number per panicle, filled grain, 1,000-grains weight, total dry weight, and harvest index), and rice yield (grain per hectare) were achieved in the cutting at harvest of a height 3 cm above the soil surface with a grain yield of 3.54 tons ha<sup>-1</sup>. Susilawati et al. (2012) stated that the cutting height of ratoon rice was related to the internode of the plant, and the nodes contained lateral shoots that produced ratoon shoots. Jichao and Xiaohui (1996) showed that the number of growing shoots was determined by the cutting height stems of the main plant; however, the condition was strongly influenced by residual assimilates as reserves in the stems that could be utilized for ratoon growth, and the vigor rate of the ratoon. The stem cutting height of the main plant can also affect the number of tillers and seed yield (Harrell et al., 2009) and trigger dormant shoot growth (Mahadevappa & Yogeesh, 1988).

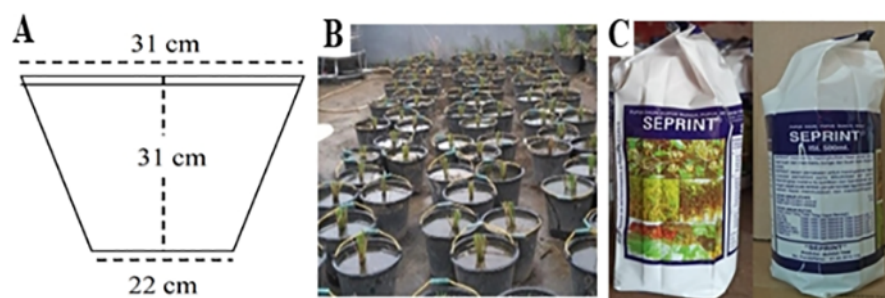
However, in these studies, the rice cultivation system was not separated from fertilizer use to achieve the optimal yield. Islam et al. (2008) reported that fertilizer application of N = 130 kg ha<sup>-1</sup>, P<sub>2</sub>O<sub>5</sub> = 75 kg ha<sup>-1</sup>, K<sub>2</sub>O = 80 kg ha<sup>-1</sup>, S = 13 kg ha<sup>-1</sup>, and Zn = 4 kg ha<sup>-1</sup> significantly increased the yield of Boro rice ratoon by 1.42 tons ha<sup>-1</sup>. The high price of fertilizer with limited availability has resulted in the use of liquid organic fertilizer as an alternative to increase the availability and efficiency of irrigation rice nutrient uptake. The effect of liquid organic fertilizer on the growth and yield of irrigated rice has been widely reported (Ginting, 2019; Mahmoodi et al., 2020; Niis & Nik, 2017; Oh & Kim, 2013; Solihin et al., 2019); however, studies regarding the use of liquid organic fertilizer on the growth and yield of ratoon rice are limited. Thus, a special assessment of the influence of specific liquid organic fertilizers is required to increase the growth and yield of ratoon rice.

The present study aimed to identify the optimum size of the rice stem cutting (ratoon) combined with the application of Seprint liquid organic fertilizer to promote growth and yield of ratoon in rice variety Inpari 30.

## 2. Material and Methods

### 2.1. Experiment I (Preliminary Research Stage)

The main plant included in the present study was the lowland rice variety Inpari 30. This variety was used because it has an average yield of up to  $7.2 \text{ tons ha}^{-1}$  (Indonesian Agency for Agricultural Research and Development, 2020), which is higher than that of the Ciherang, Situ Bagendit, and Pepe varieties (Pramono et al., 2011). In addition, the taste of this rice variety is preferred by farmers in the Cicantayan subdistrict compared to the Inpari 22, Inpari 24, and Inpari 25 varieties (Putra & Haryati, 2018) from the Assessment Institute for Agricultural Technology Pasar Miring, Pagar Merbau subdistrict, Deli Serdang District, North Sumatra Province, Indonesia. The main plant was placed in a 20-L water bucket with an upper diameter of 31 cm, a lower diameter of 22 cm, and a height of 31 cm (Figure 1A). This experiment was conducted in a greenhouse at the Faculty of Agriculture, University of Muhammadiyah Sumatera Utara, Indonesia, from January to August 2018. The bucket was filled with soil up to 5 cm from the surface. Two lowland rice seedlings were planted in the bucket and inundated with water until the vegetative phase of the main plant. The water in the bucket was then decreased to the bearing capacity for harvesting. The main plant was harvested 115 days after planting, followed by cutting the rice stem (Experiment II).



**Figure 1** Size of the bucket (A), design of the second experiment (B), and Seprint liquid organic fertilizer by Bunga Tani (C).

### 2.2. Experiment II (Main Research Stage)

After the main rice was harvested, it was cut from the rice stem base, as shown in Figure 1B. Seprint liquid organic fertilizer (SLOF) was applied 1 week after cutting the rice stems by dissolving in 1 L of water and pouring onto the soil surface. The nutrient content of SLOF was 11% N, 2%  $\text{K}_2\text{O}$ , 0.17%  $\text{P}_2\text{O}_5$ , 0.49% Bioret, 8.98% boron (B), 5.35% cobalt (Co), 5.83% manganese (Mn), <0.01 ppm molybdenum (Mo), 18.16 ppm zinc (Zn), and 9.94 copper (Cu) (Figure 1C) (source: Bunga Tani).

The bucket was inundated when cutting the rice stems until the end of the vegetative phase, and then the water was decreased to harvest the ratoon rice.

### 2.3. Research Design and Data Analysis

The present study was performed in a completely randomized design factorial with four replications. The first factor consisted of the cutting sizes of the rice stem ( $R_1 = 5 \text{ cm}$ ,  $R_2 = 10 \text{ cm}$ , and  $R_3 = 15 \text{ cm}$ ), and the second factor involved the SLOF dosage ( $S_1 = 5 \text{ mL L}^{-1}$ ,  $S_2 = 10 \text{ mL L}^{-1}$ , and  $S_3 = 15 \text{ mL L}^{-1}$ ). The distance between the treatments was  $50 \times 50 \text{ cm}$ . The parameters measured included the height and growth rate of the ratoon rice; the number of tillers at 10 to 60 days after cutting (DAC); the yield component of ratoon rice including the number of productive tillers, number of grains per panicle, number of filled grains per panicle, number of empty grains per panicle, 1,000-grains weight, yield per hill, and yield per hectare. The agronomic traits of ratoon rice are transformed in the form of natural logarithms ( $\ln$ ) due to the different units and then analyzed with the Pearson

correlation. The calculation of the growth rate and yield per hectare of the ratoon rice can be seen in Equation (1) and Equation (2):

$$\text{Growth rate (cm day}^{-1}\text{)} = \frac{\text{Average height of ratoon rice}}{\text{Days of cutting}} \quad (1)$$

$$\text{Yield (ha}^{-1}\text{)} = NP \times NPT \times NFGP \times 1,000 \text{ GW} \quad (2)$$

Notes:

- $NP$  – number population per hectare =  $\frac{\text{Land area (ha}^{-1}\text{)}}{\text{Plant spacing}} = \frac{10,000 \text{ m}^2}{0.5 \text{ m} \times 0.5 \text{ m}} = 40,000$  populations;
- $NPT$  – number of productive tillers;
- $NFGP$  – number of filled grains per panicle;
- 1,000 GW – 1,000-grains weight (g).

The parameters were analyzed using ANOVA, and the mean was determined by DMRT at 5% significance, and correlation analysis for agronomic traits of ratoon rice using IBM SPSS statistics v.20 software.

### 3. Results

#### 3.1. Height and Growth Rate of Ratoon Rice

Based on the ANOVA results, the cutting of the stems significantly increased the height of the ratoon rice at 10 to 30 DAC. In contrast, no significant increase was found at 40 and 60 DAC. SLOF application significantly increased the height of the ratoon rice at 20 DAC. In contrast, no significant increase was found at 10, 30, 40, and 60 DAC. The interaction of the cutting of the rice stems with SLOF application significantly increased the height of the ratoon rice at 10 DAC. However, no significant increase was found at 20 to 60 DAC (Table 1). The R2 treatment had the highest ratoon rice height at 10 to 60 DAC compared to the other cutting sizes, with significant increases from 10 to 30 DAC. The S3 application had the highest ratoon rice height at 10 to 40 DAC compared to the other doses, although it was significantly increased only at 20 DAC. The highest ratoon rice height was found in the S2 application at 60 DAC. The R2S2 and R2S3 combination treatments significantly increased the ratoon rice height to 27.98 cm and 25.55 cm, respectively, at 10 DAC. The highest ratoon rice heights were found in the R2S3 treatment at 20 to 60 DAC.

#### 3.2. Number of Tillers of Ratoon Rice

Based on the ANOVA results, the cutting of the rice stems significantly increased the number of tillers of ratoon rice at 40 and 60 DAC. In contrast, no significant increase was found at 10 to 30 DAC. The SLOF application and interaction with stem cutting did not significantly increase the number of tillers of ratoon rice (Table 2).

The average number of tillers of lowland rice before becoming a ratoon ranged from 9.25 to 11.75 tillers. The R2 treatment had the highest number of tillers of ratoon rice at 10 to 60 DAC compared to the other cutting sizes, with significant increases at 40 to 60 DAC. The S2 application had the highest number of tillers of ratoon rice (25.33 tillers) at 60 DAC compared to the other doses. The R2S3 combination treatment had the highest number of tillers of ratoon rice at 36.25 tillers at 60 DAC compared to the other combinations.

#### 3.3. Yield Component of Ratoon Rice

Based on the ANOVA results, the cutting of the rice stems significantly affected the number of productive tillers. In contrast, the SLOF dosages and interactions with stem cuttings did not significantly increase the number of productive tillers of ratoon rice (Figure 2–Figure 4). The R2 treatment had the highest number of productive tillers (24.92 tillers) compared to the other rice stem cuttings.

Based on the ANOVA results, the cutting of the rice stems and SLOF dosages did not significantly affect the number of filled grains per panicle. In contrast, their interactions significantly increased the number of filled grains per panicle of ratoon

**Table 1** Effect of rice stem cutting and Seprint liquid organic fertilizer (SLOF) dosages on the ratoon rice height from 10 to 60 days after cutting (DAC).

| Treatment             | Ratoon rice height (cm) |          |           | Average  | Growth rate<br>(cm day <sup>-1</sup> ) |
|-----------------------|-------------------------|----------|-----------|----------|----------------------------------------|
|                       | S1                      | S2       | S3        |          |                                        |
| 10 days after cutting |                         |          |           |          |                                        |
| R1                    | 9.46 d–h                | 7.05 h   | 10.33 c–h | 8.95 b   | 0.89                                   |
| R2                    | 7.45 gh                 | 27.98 a  | 25.55 a   | 20.33 a  | 2.03                                   |
| R3                    | 13.13 b–h               | 8.90 fgh | 9.45 e–h  | 10.49 b  | 1.05                                   |
| Average               | 10.01 ns                | 14.64 ns | 15.11 ns  |          |                                        |
| 20 days after cutting |                         |          |           |          |                                        |
| R1                    | 15.53 ns                | 17.35 ns | 22.93 ns  | 18.60 b  | 0.93                                   |
| R2                    | 15.25 ns                | 42.35ns  | 48.80 ns  | 35.47 a  | 1.77                                   |
| R3                    | 27.90 ns                | 12.73 ns | 35.40 ns  | 25.34 ab | 1.27                                   |
| Average               | 19.56 b                 | 24.14 ab | 35.71 a   |          |                                        |
| 30 days after cutting |                         |          |           |          |                                        |
| R1                    | 31.28 ns                | 39.95 ns | 36.88 ns  | 36.04 b  | 1.20                                   |
| R2                    | 39.70 ns                | 58.33 ns | 63.63 ns  | 53.89 a  | 1.80                                   |
| R3                    | 46.40 ns                | 38.13 ns | 49.93 ns  | 44.82 ab | 1.49                                   |
| Average               | 39.13 ns                | 45.47 ns | 50.15 ns  |          |                                        |
| 40 days after cutting |                         |          |           |          |                                        |
| R1                    | 46.90 ns                | 52.98 ns | 50.73 ns  | 50.20 ns | 1.26                                   |
| R2                    | 61.90 ns                | 63.93 ns | 75.23 ns  | 67.02 ns | 1.68                                   |
| R3                    | 60.70 ns                | 54.28 ns | 55.83 ns  | 56.94 ns | 1.42                                   |
| Average               | 56.50 ns                | 57.06 ns | 60.60 ns  |          |                                        |
| 60 days after cutting |                         |          |           |          |                                        |
| R1                    | 59.20 ns                | 65.80 ns | 58.18 ns  | 61.06 ns | 1.02                                   |
| R2                    | 67.50 ns                | 70.38 ns | 77.53 ns  | 71.80 ns | 1.20                                   |
| R3                    | 67.93 ns                | 66.28 ns | 64.63 ns  | 66.28 ns | 1.10                                   |
| Average               | 64.88 ns                | 67.49 ns | 66.78 ns  |          |                                        |

Note: Data followed by different letters in the same column and row are significantly different according to the DMRT at 5% significance. Size cutting of rice stems (R1 = 5 cm, R2 = 10 cm, and R3 = 15 cm). SLOF dosages (S1 = 5 mL L<sup>-1</sup>, S2 = 10 mL L<sup>-1</sup>, and S3 = 15 mL L<sup>-1</sup>). ns = not significant.

rice (Figure 2–Figure 4). The R2S1 combination treatment significantly increased the highest number of filled grains per panicle to 114.30 grains compared to the other combinations. The R2 treatment had the highest number of filled grains per panicle (97.58 grains) compared to the other cutting sizes. The S2 application had the highest number of filled grains per panicle (91.53 grains) compared to the other doses.

Based on the ANOVA results, the SLOF dosages significantly increased the yield per hill of ratoon rice. In contrast, the cutting of the rice stems and their interactions did not significantly increase the yield per hill of ratoon rice (Figure 2–Figure 4). The S2 application significantly had the highest yield per hill of ratoon rice of 54.32 g compared to the other doses. The R2 treatment had the highest yield per hill of ratoon rice of 46.56 g compared to the other cutting sizes. The R2S2 combination treatment had the highest yield per hill of ratoon rice of 60.63 g compared to the other combinations.

Based on the ANOVA results, the cutting of rice stems significantly increased the yield per hectare of ratoon rice. In contrast, the SLOF dosages and their interactions did not significantly increase the yield per hectare of ratoon rice (Figure 5). The R2 treatment had the highest yield per hectare of ratoon rice of 3.58 tons ha<sup>-1</sup> compared to the other cutting sizes. The S2 application had the highest yield per hectare of ratoon rice of 3.12 tons ha<sup>-1</sup> compared to the other dosages, whereas the R2S3 combination treatment had the highest yield per hectare of ratoon rice of 3.88 tons ha<sup>-1</sup> compared to the other combinations.

**Table 2** Number of tillers of ratoon rice after cutting the stems and Seprint liquid organic fertilizer (SLOF) dosages from 10 to 60 days after cutting (DAC).

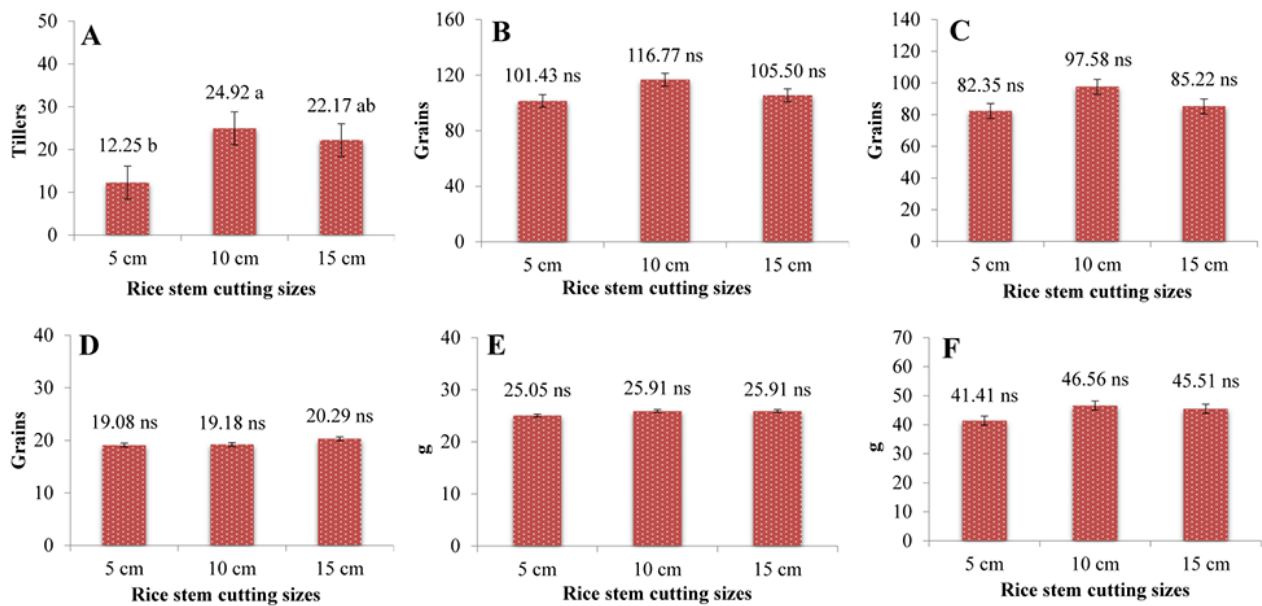
| Treatment             | Number of tillers of ratoon rice |          |          | Average  |
|-----------------------|----------------------------------|----------|----------|----------|
|                       | S1                               | S2       | S3       |          |
| 10 days after cutting |                                  |          |          |          |
| R1                    | 6.75 ns                          | 2.00 ns  | 3.75 ns  | 4.17 ns  |
| R2                    | 7.00 ns                          | 7.00 ns  | 6.00 ns  | 6.67 ns  |
| R3                    | 8.00 ns                          | 5.00 ns  | 4.50 ns  | 5.83 ns  |
| Average               | 7.25 ns                          | 4.67 ns  | 4.75 ns  |          |
| 20 days after cutting |                                  |          |          |          |
| R1                    | 8.75 ns                          | 4.25 ns  | 5.00 ns  | 6.00 ns  |
| R2                    | 8.25 ns                          | 14.50 ns | 15.25 ns | 12.67 ns |
| R3                    | 15.00 ns                         | 9.00 ns  | 8.75 ns  | 10.92 ns |
| Average               | 10.67 ns                         | 9.25 ns  | 9.67 ns  |          |
| 30 days after cutting |                                  |          |          |          |
| R1                    | 9.00 ns                          | 7.25 ns  | 8.00 ns  | 8.08 ns  |
| R2                    | 9.25 ns                          | 19.25 ns | 24.00 ns | 17.50 ns |
| R3                    | 20.00 ns                         | 12.75 ns | 15.00 ns | 15.92 ns |
| Average               | 12.75 ns                         | 13.08 ns | 15.67 ns |          |
| 40 days after cutting |                                  |          |          |          |
| R1                    | 10.75 ns                         | 12.00 ns | 10.50 ns | 11.08 b  |
| R2                    | 10.50 ns                         | 33.25 ns | 33.00 ns | 25.58 a  |
| R3                    | 22.75 ns                         | 23.00 ns | 19.50 ns | 21.75 ab |
| Average               | 14.67 ns                         | 22.75 ns | 21.00 ns |          |
| 60 days after cutting |                                  |          |          |          |
| R1                    | 13.00 ns                         | 13.25 ns | 13.25 ns | 13.17 b  |
| R2                    | 16.00 ns                         | 35.00 ns | 36.25 ns | 29.08 a  |
| R3                    | 24.00 ns                         | 27.75 ns | 23.50 ns | 25.08 a  |
| Average               | 17.67 ns                         | 25.33 ns | 24.33 ns |          |

Note: Data followed by different letters in the same column and row are significantly different according to the DMRT at 5%. Size cutting of rice stems (R1 = 5 cm, R2 = 10 cm, and R3 = 15 cm). SLOF dosages (S1 = 5 mL L<sup>-1</sup>, S2 = 10 mL L<sup>-1</sup>, and S3 = 15 mL L<sup>-1</sup>). ns = not significant.

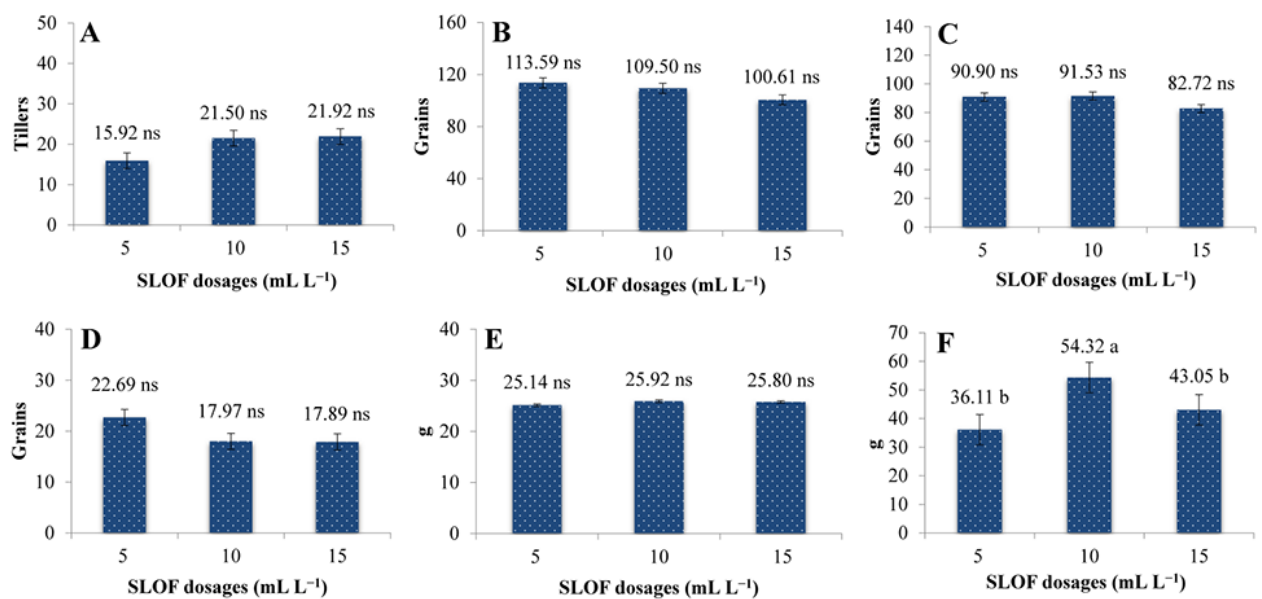
Based on the ANOVA results, the rice stem cutting sizes, SLOF dosages, and their interactions were insignificant on the yield components of ratoon rice (number of grains per panicle, number of empty grains per panicle, and 1,000-grains weight; Figure 2–Figure 4). The R2 treatment had the highest number of grains per panicle and 1,000-grains weight of 116.77 grains and 25.91 g, respectively, compared to the other cutting sizes. The R3 treatment had the highest number of empty grains per panicle (20.29 grains) compared to the other cutting sizes. The S1 application had the highest number of grains per panicle and number of empty grains per panicle of 113.59 and 22.69 grains, respectively, compared to the other doses. The S2 application had the highest 1,000-grains weight of 25.92 g compared to the other doses. The R2S1 combination treatment had the highest number of grains per panicle of 139.85 grains compared to the other combinations. The R3S1 and R3S2 combination treatments had the highest number of empty grains per panicle and 1,000-grains weight of 25.90 grains and 26.78 g, respectively, compared to the other combinations.

### 3.4. Correlations of Agronomic Traits of Ratoon Rice

The agronomic traits of ratoon rice include the plant height, number of tillers, number of productive tillers, number of grains per panicle, number of filled grains per panicle, 1,000-grains weight, and yield per hill significantly increase the yield per hectare of ratoon rice with the highest contribution was found in the number of

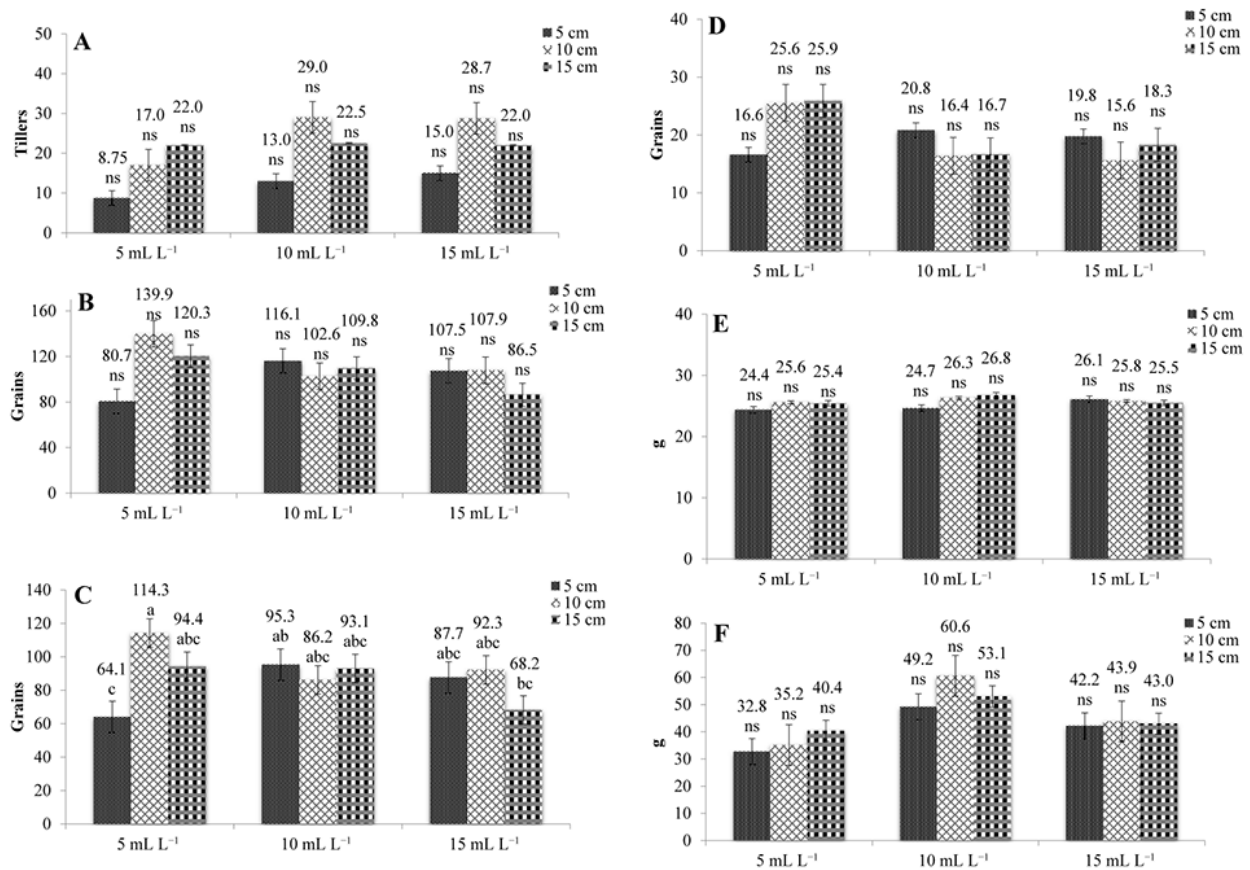


**Figure 2** Effect of rice stem cutting sizes on the yield component of ratoon rice: (A) number of productive tillers; (B) number of grains per panicle; (C) number of filled grains per panicle; (D) number of empty grains per panicle; (E) 1,000-grains weight; (F) yield per hill. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE).

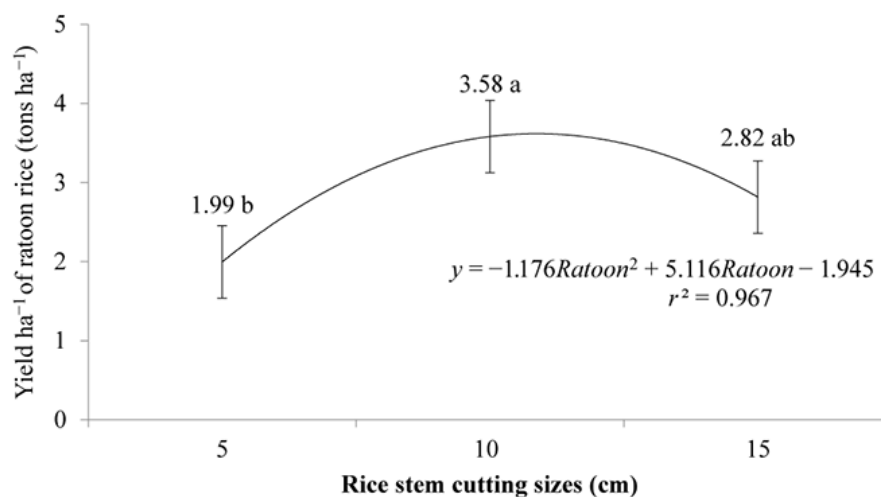


**Figure 3** Effect of Seprint liquid organic fertilizer (SLOF) dosages on the yield component of ratoon rice: (A) number of productive tillers; (B) number of grains per panicle; (C) number of filled grains per panicle; (D) number of empty grains per panicle; (E) 1,000-grains weight; (F) yield per hill. Data followed by different letters on the same graph are significantly different according to DMRT at 5%  $\pm$  standard error (SE).

productive tillers (correlation coefficient value of 0.885) (Table 3). The present study confirmed that an increase the yield per hectare of ratoon rice along with an increase in the number of productive tillers in the combination treatment of stem cutting with SLOF dosages.



**Figure 4** Combinations of stem cutting sizes and Seprint liquid organic fertilizer (SLOF) dosages on the yield component of ratoon rice: (A) number of productive tillers; (B) number of grains per panicle; (C) number of filled grains per panicle; (D) number of empty grains per panicle; (E) 1,000-grains weight; (F) yield per hill. Data followed by different letters on the same graph are significantly different according to DMRT at 5% ± standard error (SE).



**Figure 5** Effect of rice stem cutting sizes on the yield per hectare of ratoon rice. Data followed by different letters on the same line are significantly different according to DMRT at 5% ± standard error (SE).

**Table 3** Correlations of agronomic traits of ratoon rice in the treatment of stems cutting and Seprint liquid organic fertilizer (SLOF) dosages.

| Agronomic traits of ratoon rice | PH      | NT      | NPT     | NGP     | NFGP    | NEGP   | 1,000 GW | YH     | Y |
|---------------------------------|---------|---------|---------|---------|---------|--------|----------|--------|---|
| PH                              | 1       |         |         |         |         |        |          |        |   |
| NT                              | 0.500** | 1       |         |         |         |        |          |        |   |
| NPT                             | 0.683** | 0.612** | 1       |         |         |        |          |        |   |
| NGP                             | −0.043  | −0.143  | 0.157   | 1       |         |        |          |        |   |
| NFGP                            | 0.104   | −0.051  | 0.217   | 0.927** | 1       |        |          |        |   |
| NEGP                            | −0.264  | −0.207  | 0.055   | 0.693** | 0.387*  | 1      |          |        |   |
| 1,000 GW                        | 0.167   | 0.243   | 0.271   | −0.085  | 0.090   | −0.311 | 1        |        |   |
| YH                              | 0.208   | 0.241   | 0.222   | 0.071   | 0.258   | −0.310 | 0.329*   | 1      |   |
| Y                               | 0.582** | 0.500** | 0.885** | 0.488** | 0.600** | 0.137  | 0.396*   | 0.360* | 1 |

Note: Correlation is significant at the \* 0.05 and \*\* 0.01 level (two-tailed). Agronomic traits: PH – plant height; NT – number of tillers; NPT – number of productive tillers; NGP – number of grains per panicle; NFGP – number of filled grains per panicle; NEGP – number of empty grains per panicle; 1,000 GW – 1,000-grains weight; YH – yield per hill; Y – yield per hectare.

#### 4. Discussion

Cutting 10 cm of the rice stem (R2 treatment) significantly increased the height of ratoon rice at 10 to 30 DAC and significantly increased the number of tillers of ratoon rice at 40 to 60 DAC and the number of productive tillers. The results were similar for the growth rate of ratoon rice, with the R2 treatment higher by 1.20 to 2.03 cm day<sup>−1</sup> compared to the R1 and R3 treatments that ranged from 0.89 to 1.26 cm day<sup>−1</sup> and 1.05 to 1.49 cm day<sup>−1</sup>, respectively. This was caused by an optimal carbohydrate supply from the emergence of the ratoon shoots that resulted in higher vegetative growth and was supported by the plant height, number of tillers, growth rate, and number of productive tillers on the R2 treatment being higher than the other cutting sizes (Table 1, Table 2 and Figure 2–Figure 4). The optimal cutting size of rice stems supports the growth and yield of ratoon rice. Santos et al. (2003) showed a decrease in yield ranging from 12% to 37% in <5 cm rice stem cuttings, whereas cuttings >20 cm of the rice stem produced tillers faster, and the number of grains was less than the optimal cutting size. Harrell et al. (2009) found that height cutting of the main plant stems affected the number of tillers and seed yield. Susilawati et al. (2012) stated that the height and number of productive tillers for ratoon rice in genotype IPB106-F-8-1 at a 10 cm cutting was higher than that at 20 cm and 30 cm cuttings. Mareza et al. (2016) stated that cutting 40 to 50 cm of the main rice stem was significant for the number of productive tillers, with the highest found at the 40 cm cutting (6.55 tillers) compared to the other cutting sizes.

The R2 treatment significantly increased the yield per hectare of ratoon rice to 3.58 tons ha<sup>−1</sup> compared to the other cutting sizes (Figure 5). The yield per hectare of ratoon rice in the study was smaller than that of the main plants (rice variety Inpari 30) where the initial planting was 5.08 tons ha<sup>−1</sup> and the yield decreased by 29.53% compared to the main plant. This resulted in a growth pattern (height and number of tillers) of ratoon rice that was higher in the R2 treatment compared to the other cutting sizes because photosynthesis caused the formation of assimilates and the production of filled grains. The number of productive tillers, number of filled grains per panicle, and 1,000-grains weight for the R2 treatment were also higher than the other cutting sizes (Figure 2–Figure 4). According to Harrell et al. (2009), the height of the cutting stems of the main plant affects the number of tillers and grains. Susilawati et al. (2012) showed that the yield per hectare of ratoon rice in genotype IPB106-F-8-1 for the 10 cm cutting was greater (2.1 tons ha<sup>−1</sup>) than that for the 20 and 30 cm cuttings (1.6 and 1.1 tons ha<sup>−1</sup>, respectively). Nuzul et al. (2018) found that the yield of ratoon rice decreased by 58.72% from that of the main plants.

The S3 treatment significantly increased the height of ratoon rice at 20 DAC (Table 1). SLOF has a main nutrient content of 11% N, which is higher than that of

K (2%). Therefore, a SLOF dose of 15 mL L<sup>-1</sup> could support the photosynthesis level and increase the vegetative phase of the ratoon rice. According to Surtinah (2009), liquid organic fertilizers are very efficient because plants easily absorb such fertilizers. Parman (2007) stated that liquid organic fertilizers improved soil physical, chemical, and biological properties, and increased the yield and quality of plants. Niis and Nik (2017) showed that the application of liquid organic fertilizer at a dose of 6 L ha<sup>-1</sup> significantly increased the highest number of seeds per panicle and the dry seed weight of rice by 107.38 seeds and 29.65 g, respectively, compared to doses of 2 and 4 L ha<sup>-1</sup>.

The S2 application significantly increased the yield per hill of ratoon rice by 54.32 g. SLOF contains 11% N and 2% K, which played an important role in improving the nutrient uptake and soil organic matter and increasing the availability of macro- and micronutrients for ratoon rice. Liquid organic fertilizers can play a role in cell division and increase assimilation, leading to increased biomass and yield of ratoon rice. According to Vidigal et al. (2002), the growth of onions increased progressively with an increased application of K fertilizer. El-Bassiony (2006) also stated that the application of K fertilizer increased the dry weight of onions. Martínez-Alcántara et al. (2016) stated that liquid organic fertilizers increased the uptake of macro- and micronutrients, and organic matter in soil compared to chemical fertilizers. Phibunwatthanawong and Riddech (2019) showed that liquid organic fertilizers contained micro- and supplementing nutrients, beneficial microorganisms such as plant growth-promoting rhizobacteria, and hormone indole acetic acid, which are not found in chemical fertilizers.

The R2S2 combination treatment significantly increased the ratoon rice height to 27.98 cm at 10 DAC. The R2S2 and R2S3 combination treatments had the highest ratoon rice height compared to the other combinations. This was caused by the main nutrients N and K in the S2 and S3 applications promoting the photosynthesis rate to form assimilates to stimulate ratoon rice growth, including the plant height, number of tillers, and number of productive tillers (Table 1, Table 2 and Figure 2–Figure 4). According to Nurhayati (2009), liquid organic fertilizer can promote metabolism in plants via the nutrient solubility process, and nutrient transport will occur from the roots to all parts of the plant. Hamzah (2014) stated that liquid organic fertilizer could increase plant height, and the number of branches and soybean pods.

The R2S1 combination treatment significantly increased the number of filled grains per panicle by 114.30 grains. This was because SLOF stimulated the metabolic process with the growth rate of ratoon rice, and photosynthesis formed assimilates and led to grain panicle production. According to Susilawati et al. (2012), the cutting of 10 cm of rice stem in genotype IPB106-F-8-1 significantly increased the number of grain per panicle, which was 108.0 grains higher than the 20 cm and 30 cm cuttings (78.5 and 71.1 grains, respectively). Mareza et al. (2016) stated that cutting 10 cm of the rice stems significantly improved the panicle length and the number of grains per panicle of ratoon rice by 14.93 cm and 47.05 grains, respectively, compared to the cuttings of 20 to 50 cm.

The correlations result confirmed that the number of productive tillers had a positive linear correlation (0.885) and was classified as very strong in increasing the yield per hectare of ratoon rice compared to another agronomic traits (Table 3). Similar results were reported by Sadeghi (2011); Ranawake et al. (2013) the number of productive tillers and the number of grains per panicle had a significant effect on grain yield per plant. Faruq et al. (2014) also reported that the number of productive tillers per hill has a correlated positively and significant increase the grain yield per plant of ratoon rice.

The application of ratoon rice technology combined with SLOF greatly encouraged rice yield to improve adequate food supply because a year of rice cultivation (main plants and ratoon technology) can produce an average yield of 8.66 tons ha<sup>-1</sup>. Thus, farmers will receive a double benefit by applying ratoon technology during a cycle of irrigated rice.

## 5. Conclusions

The R2 treatment significantly increased the ratoon rice height from 20.33 to 53.89 cm at 10 to 30 DAC, the number of tillers from 25.58 to 29.08 tillers at 40 to 60 DAC, the number of productive tillers to 24.92 tillers, and the yield per hectare of ratoon rice to 3.58 tons ha<sup>-1</sup>. The S3 application significantly increased the ratoon rice height to 35.71 cm at 20 DAC, and the S2 application significantly increased the yield per hill of ratoon rice to 54.32 g. The R2S2 combination treatment significantly increased the ratoon rice height to 27.98 cm at 10 DAC and the R2S1 combination treatment also significantly increased the number of filled grains per panicles of ratoon rice to 114.30 grains. The R2 treatment combined with various dosages of SLOF resulted in higher growth and yield of ratoon rice compared to the other cutting sizes.

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