The Study of Superior Varieties and New Plant Types of Rice on Various Organic Cropping Systems in Tidal Land

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ABSTRACT
Increasing rice production with the use of high-yielding varieties and proper plant spacing must consider the environmental aspect. Organic agriculture is an effort to accelerate the cultivation techniques with environmental health, in addition, the research site is a tidal land that has been cultivating rice organically since 2009. The research aimed to study the growth and yield of superior varieties and new plant type of rice on various cropping systems in tidal land. The research was carried out at the Laboratory of Center for Protection of Food Crops and Horticulture, Sungai Tabuk District, Banjar Regency. The experimental design was a split-plot with three replications. The main plot were s1 = Tile System, s2 = Legowo System 2:1, s3 = Legowo System 8:1 cropping systems and subplots were v1= Ciherang, v2= Mekongga, v3= IPB Batola 6R, v4= IPB 3S varieties. The experimental unit was a plot with a size of 10 m². The results showed that there was no interaction between cropping systems and rice varieties. The main plot of cropping system Legowo 2:1 showed the best percentage of filled grain per panicle (87%). Sub-plot of rice varieties affected some plant growth and yield variables. Superior varieties Ciherang and Mekongga had more tillers and panicles per clump. The new plant type varieties showed a greater number of grains per panicle and tended to have a better percentage of filled grains per panicle and a weight of 1,000 grains.

Keywords: Legowo system, new plant type, superior variety, organic cultivation, tidal land.

INTRODUCTION
Rice (Oryza sativa L.) is a major food crop as the main source of carbohydrates for Indonesian people and part of the world’s population. Therefore, rice is a strategic commodity that might have a serious impact on the social and economic sectors. In line with this, national rice production must be considered to avoid the decline in production. South Kalimantan has tidal land with an area of about 250,000 ha, and about 45% of rice production is cultivated on this land, one of which is in Banjar Regency with an area of 18,881 ha (BPS, 2020). However, rice production in South Kalimantan has fluctuated over the last three years due to in-optimal cultivation techniques and the lack of the use of superior rice varieties. One of the cultivation techniques that are not optimal is the improper cropping system. Most farmers tend to assume that a cropping system with close spacing will give more yield because more population will be planted. Jajar legowo cropping system is technological engineering to increase crop population. In addition, the crops planted at the edge are expected to provide higher production and better grain quality, considering that legowo system has a large open space of 25 – 50%, thus the plants could receive optimal sunlight for the photosynthesis process (IAARD, 2016).

The survey conducted in Sungai Tabuk, Banjar Regency showed that the yield of superior rice variety, Ciherang, planted with tile system was 4.2 t ha⁻¹ (personal communication). According to Misran (2014), legowo row planting system can
increase the yield of dry grain harvest by around 19.90 to 22% compared to control (without legowo system). In addition to the cropping system, the use of superior superior varieties is one of the cultivation techniques that play an important role to increase the quantity and quality of rice production. The rice varieties used in this study were superior varieties, Ciherang and Mekongga, and new plant type (NPT) varieties namely IPB 3S and IPB Batola 6R.

Superior varieties have characters such as high response to inorganic fertilizer, early maturity, high productivity, resistance to certain pests and diseases (Badan Litbang Pertanian, 2012). Many superior modern varieties had been released since 1985, and Ciherang (released in 2000) has a dominant share of the rice area in Indonesia, because of its wide adaptation across the environment (Brennan and Malabaybas, 2011; Nurhati et al., 2008). While the important characteristics of NPT varieties were few productive tillers (8-10 stems), dense and large panicle (200-250 grains per panicle) and pithy, medium plant height or semi-dwarf (80-100 cm), erect and thick leaves with dark green color, growth duration 110-130 days, vigorous and deep root system, multiple diseases, and insect resistant, and higher harvest index (Khush, 1995; 2013).

Rice cultivation in this study was carried out organically, without chemical fertilizers and synthetic pesticides. The present study was aimed to analyze the growth and yield of superior varieties and new plant type of rice on various cropping systems in tidal land.

MATERIALS AND METHODS

The study was carried out from April to October 2019 in the rice fields of the Center for Protection of Food Crops and Horticulture (BPTPH) Sungai Tabuk District, Banjar Regency. The materials used were rice seeds of Ciherang and Mekongga (superior varieties), and of IPB Batola 6R and IPB 3S (NPT varieties), tricho-compost 1.57 t ha\(^{-1}\), biopesticide (made of Plant Growth-Promoting Rhizobacteria) for pest control, hand tractor, scale, sample bags, sacks, bucket, paper labels, stationery, and camera.

The experimental design was a split-plot design with three replications, consisting of the main plot of cropping systems (s1 = Tile System, s2 = Legowo System 2:1, s3 = Legowo System 8:1) and subplots of rice varieties (v1= Ciherang, v2= Mekongga, v3= IPB Batola 6R, v4= IPB 3S). The experimental unit was a plot with a size of 10 m\(^2\).

The research stages were land preparation, seed preparation, transplanting, plant maintenance, and observation. The data obtained were tested for homogeneity using the Bartlett test, then continued with the analysis of variance (anova). The result of anova was then tested with the Least Significant Difference (LSD) test at 5% of the significance level. Data analyses were performed using Minitab 18.

RESULTS

Tiller Number and Panicle number per Clump

The effect of varieties on tiller number at the age of 14, 28, and 42 days after transplanting (DAT) and panicle number per clump are presented in Table 1.

Table 1 above showed that Mekongga variety gave more tiller number compared to NPT varieties (IPB Batola 6R and IPB 3S), even it was not significantly different with Ciherang variety. In line with tiller number, the superior varieties also showed a more productive tiller number, i.e. panicle number per clump than the NPT varieties.
Table 1. The effect of varieties on tiller number and panicle number per clump

| Varieties          | Tiller number | Panicle number per clump |
|--------------------|---------------|--------------------------|
|                    | 14 DAT | 28 DAT | 42 DAT |                  |
| Ciherang (V1)      | 1.97   b  | 5.89  ab | 12.44 b | 10.78  bc       |
| Mekongga (V2)      | 2.32   b  | 7.56  b  | 14.78 b | 12.56  c        |
| IPB Batola 6R (V3) | 1.32   a  | 3.19  a  | 6.89  a | 7.22   a        |
| IPB 3S (V4)        | 1.92   b  | 4.00  a  | 7.11  a | 8.11   ab       |

Note: Different letters indicate significant difference at p<0.05 (LSD test)

Table 2. The effect of varieties on the number of grains per panicle and percentage of filled grains per panicle

| Varieties       | Number of grains per panicle | Percentage of filled grains per panicle (%) |
|-----------------|------------------------------|---------------------------------------------|
| Ciherang (V1)   | 125.11 a                     | 78.02 a                                     |
| Mekongga (V2)   | 117.45 a                     | 81.38 b                                     |
| IPB Batola 6R (V3) | 239.67 b                  | 79.32 a                                     |
| IPB 3S (V4)     | 220.67 b                     | 79.34 ab                                    |

Note: Different letters indicate significant difference at p<0.05 (LSD test)

**Number of Grains per Panicle and Percentage of Filled Grain per Panicle**

The effect of varieties on the number of grains per panicle and the percentage of filled grains per panicle are presented in Table 2, whereas the effect of the cropping system on the percentage of filled grains per panicle is presented in Table 3.

Table 2 above showed that NPT varieties (IPB Batola 6R and IPB 3S) gave a greater number of grains per panicle (239.67 and 220.67 respectively) compared to the superior varieties (Ciherang and Mekongga).

Nevertheless, the tendency was not observed on the percentage of filled grains per panicle. It showed that Mekongga as the superior variety has the highest percentage of filled grains per panicle (81.38%) and was not significantly different from IPB 3S, an NPT variety.

Table 3 showed that legowo system 2:1 gave the highest percentage of filled grains per panicle (87.95%) compared to other cropping systems.
Table 3. The effect of the cropping system on the percentage of filled grains per panicle

| Cropping system          | Percentage of filled grains per panicle (%) |
|--------------------------|--------------------------------------------|
| Tile system (S1)         | 74.34 a                                    |
| Legowo system 2:1 (S2)   | 87.95 b                                    |
| Legowo system 8:1 (S3)   | 70.39 a                                    |

Note: Different letters indicate significant difference at p<0.05 (LSD test)

Weight of 1000 grains

The effect of varieties on the weight of 1000 grains is presented in Table 4. It was shown that the NPT varieties, especially IPB 3S, tended to have a greater weight of 1000 grains compared to the superior varieties.

Table 4. The effect of varieties on the weight of 1000 grains

| Varieties            | Weight of 1000 grains (g) |
|----------------------|---------------------------|
| Ciherang (V1)        | 24.33 a                   |
| Mekongga (V2)        | 24.22 a                   |
| IPB Batola 6R (V3)   | 25.89 ab                  |
| IPB 3S (V4)          | 27.22 b                   |

Note: Different letters indicate significant difference at p<0.05 (LSD test).

Grain yield

Interaction between cropping system and varieties, as well as each independent treatment, did not affect rice yield. The graph of the average yield of rice is presented in Figure 1.

Figure 1 above showed that the average yield based on cropping system, regardless of the variety, was about 4.6 t ha\(^{-1}\) (for S1 = tile cropping system), about 4.9 t ha\(^{-1}\) (for S2 = legowo system 2:1), and about 5.4 t ha\(^{-1}\) (for S3 = legowo system 8:1). Meanwhile, the average yield based on variety, regardless of the cropping system, was about 5.0 t ha\(^{-1}\) (for V1 = Ciherang and V2 = Mekongga), 4.9 t ha\(^{-1}\) (for V3 = IPB Batola 6R), and 5.1 t ha\(^{-1}\) (V4 = for IPB 3S).

Figure 1. Average yields based on cropping system (A) and variety (B)

DISCUSSION

The superior variety (Ciherang and Mekongga) tended to produce more tillers compared to NPT varieties. In line with tiller number, these varieties also produced a greater panicle number per clump (10.76 and 12.56 stems) than of the NPT’s. The number of productive tillers (panicle number) is determined by the tiller number that grows prior to primordial phase. Some tillers that are formed after reaching the maximum
vegetative phase, will decline in growth. The tillers that are alive are expected to produce the maximum grain. The tillers that can produce panicles are called productive tillers (Yoshida, 1981). Tiller number is one of the main traits that are important in high-yielding varieties. The varieties with more tiller numbers are suitable for various spacing, they are able to compensate for dead tillers and reach maximum leaf area quickly (Yoshida, 1981).

Regarding yield component, in this case, the number of grains per panicle, the NPT varieties (IPB Batola 6R and IPB 3S) showed more grains per panicle compared to the superior varieties. These NPT varieties have the background parent Fatmawati variety, which is the first NPT variety released in 2003 (Abdullah et al., 2008). It was further explained that the characters of these NPT varieties, unlike the high-yielding indica cultivar, i.e IR64, have several agronomic traits inherited from tropical japonica-type varieties: low tiller number, low number of unproductive tillers, thick culm, lodging resistance, and large, dark green flag leaves, large panicle size, more grains per panicle (200 – 250 grains) and pithy grain (Khush 1995). The more grains per panicle was followed by the percentage of filled grains per panicle, even though this was only observed in IPB 3S variety from NPT. The interesting finding was Mekongga from superior variety was also showed a high percentage of filled grains per panicle. Empty grains could be caused by a large number of grains per panicle. Furthermore, the void or percentage of filled grains per panicle might be caused by genetic or non-genetic factors. Genetic factors can be improved through breeding, while non-genetic factors are mostly caused by the environment, for example, the high temperature that causes high respiration and limited nutrients due to poor soil fertility. According to Abdullah et al., (2008), it is necessary to create the NPT varieties which have more productive tillers and less grain per panicle to increase and stabilize the yield.

The weight of 1000 grains of NPT varieties was greater than the superior varieties. The weight of 1000 grains has a strong correlation with size and number of grains, and it is one of the observational variables that is closely related to the yield (Yoshida, 1981). In this study, the weight of 1000 grains of IPB 3S (27.22 g) was slightly lower than the description of the variety, which was 28.2 g, and the weight of 1000 grains of IPB Batola 6R (25.89 g) even exceeded the description, that is 25.1 g.

In terms of cropping system, legowo 2:1 system gave the highest percentage of filled grains per panicle compared to other cropping systems. Legowo cropping system is one of the technological innovations that have an impact on increasing rice productivity, as it will increase the number of grains per panicle of lowland rice compared to other cropping systems. In addition, each plant in legowo 2:1 system has sufficient free space so it will minimize the competition for light, air, and water to support grain filling (Arafah, 2008). This finding was also in line with Susilastuti et al., (2018), who confirmed that legowo 2:1 system provides the highest number of panicles per clump, number of grains per panicle, weight of 1000 grains, and yield per hectare of Ciherang variety in West Java Province. Furthermore, Darmawan (2016) also reported that legowo 2:1 system provides the highest grain production and weight of 1000 grains compared to the tile system, legowo 4:1, and SRI cropping system.

In general, the yield component such as the number of grains per panicle, percentage of filled grains per panicle, the weight of 1000 grains, in this study was in line with Ariyani et al., (2020) who confirmed that the NPT varieties (IPB Batola 6R and IPB 3S) have greater yield components compared to superior variety, Ciherang. The higher-yielding of NPT varieties compares to check variety (Ciherang) was also observed by Lestari et al., (2010) across marginal environments. In addition, it was confirmed that the grain yield had positively correlated with all agronomic characters i.e. number
of productive tillers, filled grain per panicle, total grain per panicle, percentage of filled grain, 1,000-grain weight (Lestari et al., 2011). Nevertheless, the interaction between the cropping system and varieties, nor the single treatment did not significantly affect the rice yield in this study.

Based on the cropping system, regardless of the variety, the tile cropping system provides a yield of about 4.5 t ha⁻¹, lower than the yield reported by Giamerti (2011) on various high-yielding varieties (5.09 t ha⁻¹). In legowo 2:1 cropping system, rice yield obtained in this study was about 4.9 t ha⁻¹, much lower compared to BPTP Jambi (2013), that is 8.6 t ha⁻¹ (irrigated paddy field), and of reported by Susilastuti et al., (2018) that is 9.9 t ha⁻¹, both on Ciherang variety. Sudaryono (2017) also mentioned that jarwo super 2:1 increases rice productivity between 12.26 – 32.03% compared to non jarwo super on Inpari 30, Inpari 32, Inpari 33, and Ciherang variety. Meanwhile, in legowo 8:1 cropping system, the yield obtained in this study was about 5.4 t ha⁻¹, still lower than reported by Misran (2014), that is 6.3 t ha⁻¹ on Batang Piaman variety in West Sumatera (Figure 1A). Regarding varieties, the yield of IPB 3S variety was slightly lower than the description (7.0 t ha⁻¹), and the yield of IPB Batola 6R was even above the description (5.1 t ha⁻¹). The yield of Ciherang variety was consistent with the description (5 – 7 t ha⁻¹), and the yield of Mekongga variety was slightly below the description (6 t ha⁻¹) (Figure 1B).

CONCLUSION

Legowo system 2:1 showed the highest percentage of filled grain per panicle (87%) compared to other cropping systems. Superior varieties Ciherang and Mekongga produced more tiller and panicles per clump than new plant types. The new plant type varieties tend to have a greater number of grains per panicle, percentage of filled grain, and weight of 1000 grains compared to superior varieties. We confirmed that legowo 2:1 cropping system might be applied to cultivate superior and new plant-type rice varieties in tidal land organically.

ACKNOWLEDGMENTS

The authors would like to thank Firmansyah, S.P., M.P, as the head of the Center for Protection of Food Crops and Horticulture of Banjar Regency and the staff who have facilitated the experiment station. The authors also thank Dr. Ir. Hajrial Aswidinnoor, M.Sc. as a breeder who has provided rice seeds of IPB 3S and IPB Batola 6R varieties.

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