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Direct Seed Planting System and Giving Liquid Organic Fertilizer as A New Method to Increase Rice Yield and Growth *(Oryza sativa* L.*)*

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ABSTRACT

The transplanting system is a common method in rice cultivation, whereas the direct seed planting system combined with the application of organic fertilizer is rarely applied. This study aimed to determine the impact both the direct seed planting system and the application of liquid organic fertilizer the growth and production of rice. The research used the factorial randomized block design, direct seed planting system tested by the transplanting system and application of liquid organic fertilizer doses 25, 35, and 45 l/ha. The observed variables were plant height, number of tillers, productive tillers, panicle length, weight of 1000 rice grains, and grain yield of plots. Data were analyzed by analysis of variance with 5% LSD test. The results revealed that direct seed planting system and application of liquid organic fertilizer impact the growth and yield of rice. The application of liquid organic fertilizer a dose of 45 l/ha gave the highest influence among all observed variables. There is a correlation between the treatment of the planting system and the application of liquid organic fertilizer on the growth of the number of tillers and productive tillers. The direct seed planting system increases the yield of rice more than the transplanting system.

INTRODUCTION

The direct seed planting system applied in paddy rice is a cultivation technique that does not require an initial nursery phase. This has proven to be more efficient compared with the transplanting system, which requires the involvement of seedbed 3 weeks before the transfer into the paddy field. The direct seed planting system tends to increase output, mainly through time management production and land use.

The direct seed planting system is most widely used by Indonesian farmers in the cultivation of lowland rice. Direct seed planting systems and the application of liquid organic fertilizers can significantly increase rice production, because liquid organic fertilizers do not damage the environment and can improve soil fertility, so they can supply nutrients that can be absorbed by plants for a vegetative and generative growth (Kartika et al., 2018).

The use of organic fertilizer in cultivation aids in maintaining fertility and physical, chemical, and biological soil properties. Liquid organic fertilizer is used in overcoming agricultural production constraints owing to their ability to provide the appropriate nutrients needed by plants (Moreno, Ondoño, Torres, & Bastida, 2017). Furthermore, the use of organic fertilizers serves to maintain the balance and sustainability of agricultural land ecosystems so that agricultural land can be sustainably used to produce food that is safe and healthy for public health (Martínez-Alcántara, Martínez-Cuenca, Bermejo, Legaz, & Quiñones, 2016).

The direct seed planting system is a good alternative to improve the production of lowland rice after the application of liquid organic fertilizer, as the nutrients that this fertilizer contains tend to be easily absorbed by plants. Moreover, there exist microorganisms that help reduce the incidence of nutrients getting washed away easily, subsequently providing a sufficient amount required for a quick

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growth (Jones et al., 2013). The application of liquid organic fertilizers can help accelerate the absorption of nutrients from solid organic fertilizers, which are slowly absorbed by the plants in the rice cultivation system, as it takes a period of about 12 weeks to completely mineralize (Fahrurrozi, Muktamar, Setyowati, Sudjatmiko, & Chozin, 2019).

The results of a research by Leogrande, Vitti, Stellacci, Cocozza, & Ventrella (2016) revealed that the application of liquid organic fertilizer in rice cultivation is an alternative in increasing rice growth and production. Liquid organic fertilizer is more easily absorbed by plants because its elements contain decomposing bacteria that can provide nutrients needed by plants. The advantage of liquid fertilizer is that it contains nutrients, such as nitrogen (N), phosphorus (P), and potassium (K), which increase plant growth in the vegetative and generative phases (Colla, Rouphael, Canaguier, Svecova, & Cardarelli, 2014). This research will provide information on rice growth and production through the implementation of direct seed planting system and transplanting systems and the treatment with liquid organic fertilizer.

MATERIALS AND METHODS

The research was conducted in West Limboto District, Gorontalo Regency, from August 2017 to January 2018. Rice cultivation was done using the Legowo 4:1 row planting system. This research uses a complete randomized block design with two factors. The first factor is the planting system, which is the direct seed planting system and the transplanting system. The second factor is the dose of the liquid organic fertilizer: 25, 35, and 45 l/ha. So, six treatment combinations are repeated three times. The tools used in this study were hand tractors, hoes, sickles, hand sprayers, plastic buckets, meters, and stationery. The materials used were Mekongga variety of rice seeds, liquid organic fertilizer, pesticides, and water. The observed variables included plant height, number of tillers and productive tillers, panicle length, weight of 1000 grains, and production per plot. The research data were analyzed statistically using analysis of variance, followed by the most significant difference test (LSD) at 5%. The six combinations of soil treatment and analysis at research sites are presented in Table 1 and Table 2.

RESULTS AND DISCUSSION

The direct seed planting system in rice cultivation has more advantages compared with the transplanting system, which include the following: the easy adaptation of seeds to the planting environment, faster harvest time of 10–15 days, less production and labor costs, and the use of seeds around 25–35 kg/ha.

Plant Growth

Direct seed planting system includes planting 2–3 rice seeds directly into the planting hole, without going through nurseries. To obtain optimal results, perfect tillage is needed to facilitate the growth of rice plants in the generative growth phase. Water management through drainage is carried out to prevent the seeds from being washed away during the plant growth process (Wang et al., 2016).

The most suitable location for the implementation of the direct seed planting system is the technical irrigated rice field agroecosystem. However, in dryland agroecosystems and rain-fed rice fields, the direct seed planting system can also be applied with water management requirements, and land preparation is carried out specifically by irrigating rice fields at the growth phase of rice using liquid organic fertilizers (Shah-Al-Emran, Krupnik, Kumar, Ali, & Pittelkow, 2019). The results revealed that the direct seed planting system, transplanting system, and treatment with liquid organic fertilizer had an impact on the height of rice plants, particularly the tall ones. The average height growth of rice plants is presented in Table 3.

Table 1. Combination treatment of planting systems and liquid organic fertilizers

No	Planting system	Dose of liquid organic fertilizer (l/ha)
1	Transplanting	25 l/ha ~ 3.48 kg N/ha ~ 4.33 kg P_2O_5/ha ~ 2.60 kg K_2O/ha
2	Direct Seed	25 l/ha ~ 3.48 kg N/ha ~ 4.33 kg P_2O_5/ha ~ 2.60 kg K_2O/ha
3	Transplanting	35 l/ha ~ 4.86 kg N/ha ~ 6.08 kg P_2O_5/ha ~ 3.64 kg K_2O/ha
4	Direct Seed	35 l/ha ~ 4.86 kg N/ha ~ 6.08 kg P_2O_5/ha ~ 3.64 kg K_2O/ha
5	Transplanting	45 l/ha ~ 6.25 kg N/ha ~ 7.81 kg P_2O_5/ha ~ 4.69 kg K_2O/ha
6	Direct Seed	45 l/ha ~ 6.25 kg N/ha ~ 7.81 kg P_2O_5/ha ~ 4.69 kg K_2O/ha

Table 2. Soil analysis at the research site

Type of analysis	Unit	Soil	
		Results*	Criteria**
pH H_2O	-	3.72	Very Sour
pH KCl	-	3.52	Sour
C-Organic	%	1.83	Low
N-Total	%	0.16	Low
P-Bray I	μg/g	5.38	Very Low
K-dd	cmol (+) / kg	0.52	Medium
Na	cmol (+) / kg	0.45	Medium
Ca	cmol (+) / kg	3.02	Low
Mg	cmol (+) / kg	0.52	Low
Cation exchange capacity	cmol (+) / kg	17.41	Medium
Al-dd	cmol (+) / kg	1.45	-
H-dd	cmol (+) / kg	0.42	-
Texture			Clay
Sand	%	21.35	
Dust	%	34.95	
Clay	%	46.67	

Remarks: *) The results of data analysis from the soil fertility laboratory, Faculty of Agriculture, Sam Ratulangi University, Manado. 2018; **) The criteria based on land research center 1983.

Table 3. Average plant height growth in the planting system and liquid organic fertilizer

Treatment	Plant height (cm)			
	3 wap	5 wap	7 wap	9 wap
Planting system				
Transplanting	35.23 b	55.46 b	83.57 b	99.58 b
Direct seed	30.45 a	61.67 a	93.56 a	107.57 a
LSD 5%	1.70	3.72	2.49	2.71
Liquid organic fertilizer (l/ha)				
25	31.03	53.63 a	83.34 a	96.48 a
35	35.89	60.21 b	95.54 b	109.09 b
45	43.46	63.36 b	103.31 c	115.49 c
LSD 5%	ns	4.56	3.05	3.32

Remarks: The numbers followed by different letters in the same column are significantly different from the 5% LSD test; wap = week after planting

The results of the research presented in Table 3 reveal that at the direct seed planting system, the average height of rice plants was higher compared with that of rice plants at the transplanting system. The average increase in the growth of rice plants occurs at 5, 7, and 9 wap. At 9 wap, the height of rice plants at the direct seed planting system reached 107.57 cm, whereas in the transplanting system, it only reached 99.58 cm, which means that at the direct seed planting system, the rice plant height increased by 7.99 cm. At the direct seed planting system, proper spacing can facilitate the entry of sunlight which is useful to accelerate the process of photosynthesis (Andres, Fogliatto, Ferrero, & Vidotto, 2015). The lengthening of a segment or increase in plant height can be caused by auxin activity or natural growth regulators in plants contained in liquid organic fertilizer. Auxin will carry out its function in cell elongation in the direction of the entry light, causing the plants to grow taller (Richards, 2008).

The results revealed that the direct seed planting system, transplantation system, and treatment with liquid organic fertilizer have an impact on the growth of the number of tillers at 3, 5, and 7 wap. The average growth of the number of tillers in the planting system treatment and the application of liquid organic fertilizer is presented in Table 4.

Table 4. Average number of tillers in the planting system treatment and the application of liquid organic fertilizer

Treatment	Number of tillers (stem)		
	3 wap	5 wap	7 wap
Planting system			
Transplanting	6.29 b	14.57 a	25.94 a
Direct seed	7.65 a	17.37 b	29.06 b
LSD 5%	0.59	0.73	0.98
Liquid organic fertilizer (l/ ha)			
25	6.46	14.26 a	25.32 a
35	7.51	16.67 b	27.72 b
45	6.93	16.99 b	29.44 c
LSD 5%	ns	0.89	1.20

Remarks: The numbers followed by different letters in the same column are significantly different from the 5% LSD test; wap = week after planting

Table 4 demonstrates that the direct seed planting system and the treatment with liquid organic fertilizer affect the growth of the number of tillers compared with the transplanting system. The growth in the number of tillers in the direct seed planting system at 7 wap reached 29.06 number of tillers, while in the transplanting system, it only reached to 25.94 number of tillers. This means that in the direct seed planting system, there is an increase of 3.12 in the number of tillers.

The results of the research by Javaid et al. (2012) revealed that in the direct seed planting system, seed growth is not tight because only 1–2 seeds are planted on each hole, so plants can easily absorb nutrients and get sunlight which help in the optimal metabolic process for growth in the number of tillers. However, in the transplanting system, the number of clumps of plants moved from the nursery will affect the density of plant growth; therefore. it will reduce the quality of plant clumps in increasing the growth of the number of tillers (Thakur & Uphoff, 2017). The correlation between the direct seed planting system and transplanting system with the liquid organic fertilizer on the growth of the number of tillers is explained in Fig. 1.

Fig. 1 explains that the direct seed planting system, transplanting system, and treatment with liquid organic fertilizer affect the growth of the number of tillers. The direct seed planting system will reach the generative stage faster, thus shortening the production period and increasing stem growth and rice plant population, whereas the transplanting system has a long production period, because plants need time to adapt to the planting environment after being removed from the nursery (Birhane, 2013).

The results revealed that the direct seed planting system and treatment with liquid organic fertilizer significantly affected the growth of the number of productive tillers, as a marked level of interaction is identified as explained in Fig. 2.

Fig. 2 explains that the interaction between the treatment of cropping systems and liquid organic fertilizer affects the growth of the number of productive tillers. The direct seed planting system and the application of liquid organic fertilizer at a dose of 45 l/ha had a higher influence on the growth of the number of productive tillers compared with that on the growth of the number of productive tillers in the transplanting system and application of liquid organic fertilizer at a dose of 45 l/ha. The application of liquid organic fertilizer can increase the growth of the number of productive tillers, especially in the 5 to 7 wap age phase of the rice, because in this phase the growth of leaves and stems of rice plants increases so that it can support the growth of a number of productive tillers, so liquid organic fertilizer is needed to provide organic material that can supply nutrients such as N, P, and K during the generative growth phase (Dimkpa & Bindraban, 2016).

The availability of nutrients in the soil is a factor that can increase crop production. If the land cannot provide sufficient nutrients for the plants, then the application of fertilizer is necessary to overcome nutrient deficiency (Qiao et al., 2011). Therefore, the application of liquid organic fertilizer is very helpful for plant growth, especially in the supply of nutrients such as N, P, and K, because liquid organic fertilizer contains essential nutrients and bacteria that can increase soil fertility (Zeng et al., 2019). The relationship between nutrient absorption of N, P, K, and plant growth is explained in Fig. 3.

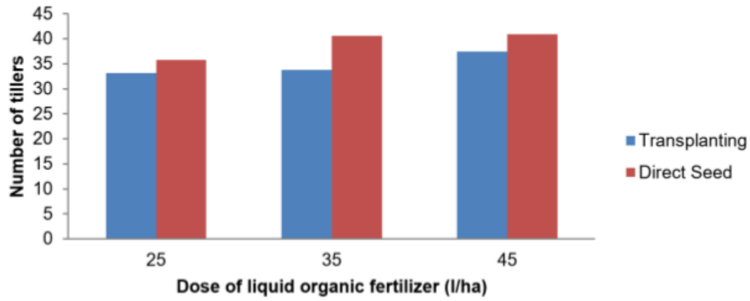

Fig. 1. The effect of the average growth of the number of tillers on the correlation between the direct seed planting system and the planting system as well as between the treatment of liquid organic fertilizer.

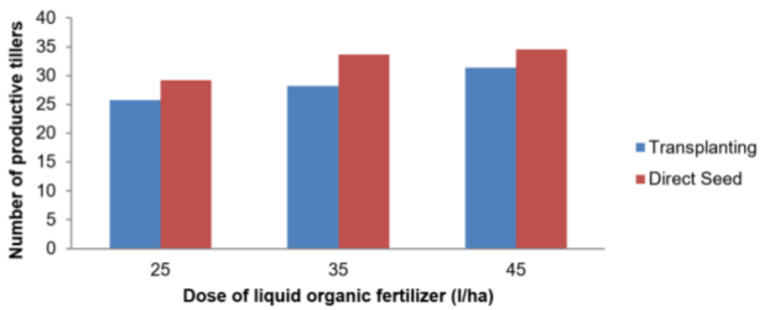

Fig. 2. The average number of productive tillers in the interaction of direct seed planting system and transplanting with the liquid organic fertilizer treatment.

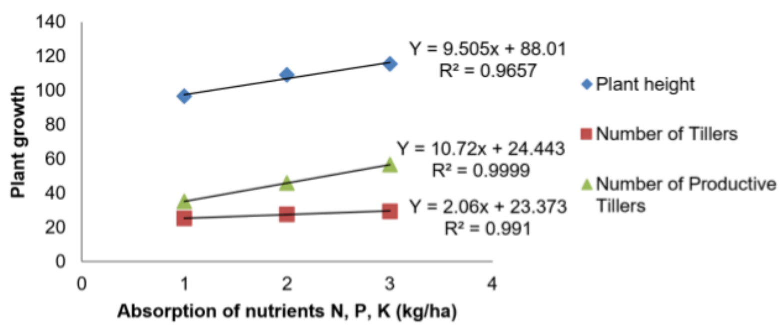

Fig. 3. Relationship between nutrient absorption and plant growth

Fig. 3 shows that the results of the regression analysis of the relationship between nutrient absorption of N, P, and K (kg/ha) and the growth of rice plants reveal a linear pattern, so that the increased absorption of nutrients N, P, and K contained in higher liquid organic fertilizer can increase higher plant growth. During the growth of rice plants, the absorption of nutrients N, P, and K of 9.505 kg/ha will increase plant height growth by 88.01 cm. The absorption of nutrients N, P, K of 10.72 kg/ha on rice growth will increase the growth of 24,443 number of tillers. Furthermore, the absorption of N, P, K nutrients of 2.06 kg/ha on rice growth will increase growth by 23,373 number of productive tillers.

The growth of height plants in a cumulative manner (R^2) absorbs 96.57% of nutrients N, P, and K, meaning that 3.43% of rice plant height growth is influenced by other factors. The growth of the number of tillers in a cumulative manner (R^2) absorbs 99.99% of nutrients N, P, and K, meaning that 0.01% of the growth of the number of tillers is influenced by other factors. The growth of the number of productive tillers in a cumulative manner (R^2) absorbs 99.1% of nutrients N, P, and K, meaning that 0.09% of the growth in the number of productive tillers is influenced by other factors.

Nitrogen nutrients are part of the chlorophyll molecule because the provision of nitrogen nutrients in sufficient quantities will increase the vegetative growth of rice plants, particularly increase in plant height and number of tillers. Nitrogen is also a functionally important constituent of enzymes that plays a vital role in plant metabolism, because the enzymes are composed of proteins (Gopal Ramdas et al., 2017). Nitrogen is a very mobile element in plants, which means that functional proteins that contain N can decompose in older plant parts. It will then be transported through the process of photosynthesis to young plant tissues that grow actively in the vegetative growth phase (Smith, Brye, Gbur, Chen, & Korth, 2014). Phosphorus plays a role in strengthening plant root systems in order to increase the number of tillers and strengthen plant stems, whereas K helps in forming proteins and carbohydrates that can accelerate the growth of the number of productive tillers (Xiao et al., 2019).

Plant Yield

Direct seed planting systems that use superior seeds, balanced fertilization, and good water management can achieve yields of around 5–6.2 t/ha of harvested unhusked rice when compared with the results on the transplanting system which only reaches 3–4.77 t/ha of the dried grain harvest. Rice yields can be seen from the following indicators: panicle length, 1000 grain weight, and yield per plot. The rice yields at the direct seed planting, transplanting system, and the liquid organic fertilizer treatment are presented in Fig. 4.

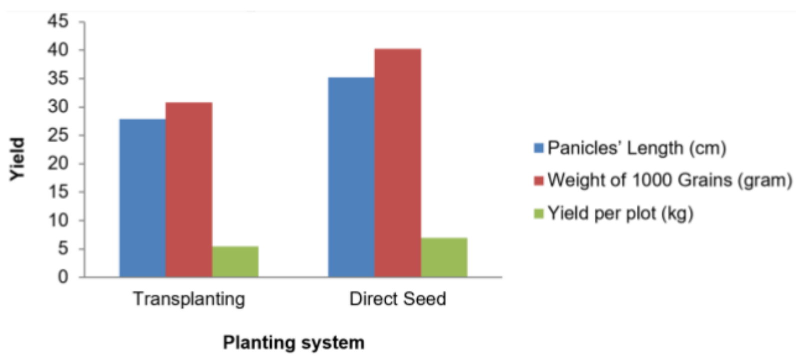

Fig. 4. Average crop yields at direct seed planting system and transplanting system

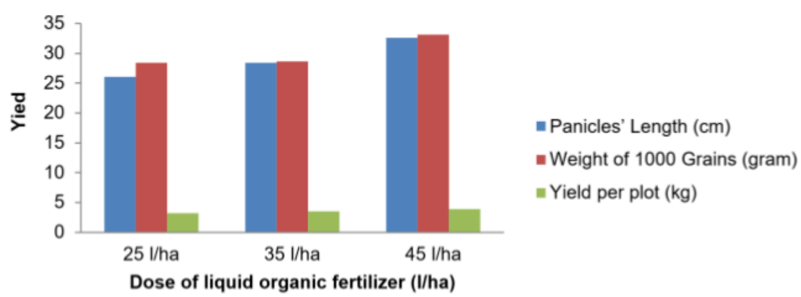

Fig. 5. The average yield of rice at the treatment with liquid organic fertilizer

Fig. 4 shows that panicle length at the direct seed planting system reached 35.18 cm, whereas in the planting system, it only reached 27.92 cm. The weight of 1000 grains at the direct seed planting system reached 40.25 g, whereas that at the transplanting system only reached 30.78 g. The yield per plot at the direct seed planting system reached 6.93 kg/ha, and at the transplanting system, the yield per plot only reached 5.49 kg/ha.

The increase in panicle length is usually caused by genetic and environmental factors, such as plant age, number of productive tillers, and water availability in the generative phase. The increase in panicle length will affect the number of results, because as each panicle length increases, the branches of grain stalk will grow to produce more grain (Sharma, Giri, & Tyagi, 2016). The increase in the weight of 1000 grains is influenced by genetic factors related to the shape and size of the grain. The average grain weight is a characteristic of each rice variegation that plays a role in rice production. Dry matter in the grains is determined based on filled rice grains produced by rice panicles whose growth increases by photosynthesis occurring in plant parts (Lal et al., 2020). The determining component of rice production is the percentage of the number of productive tillers, the weight of 1000 grains, and panicle length. The more the number of productive tillers and the grains of filled panicle during the generative growth phase, the higher the productivity of rice per hectare (Tun, Guo, Fang, & Tian, 2018).

The results in Fig. 4 reveal that rice production is higher in the direct seed planting system compared with that in the transplanting system. Rice production in the direct seed planting system reached 6.93 kg/ha, whereas that in the transplant system reached 5.49 kg/ha. Based on the distance of the 4:1 Legowo system with a spacing of 25 × 25 cm, with a planting area of 625 cm (6.25 m^2), the rice production in each planting system is converted to tons/ha, so that the production of rice in the direct seed planting system reached 11.1 t/ha, and that in the transplanting system reached 8.8 t/ha. Liquid organic fertilizer is a technology that can increase rice yield, because the amount of nutrients in the soil, especially N, P, and K, is very limited, so it requires additional nutrients from liquid organic fertilizer. The impact of liquid organic fertilizer on rice yield is explained in Fig. 5.

Fig. 5 explains that the treatment with liquid organic fertilizer with a dose of 45 l/ha has an effect on panicle length, weight of 1000 grains, and yield per plot. Applying liquid organic fertilizer to plants can increase crop production through the activation of microorganisms contained therein and those in the environment. The use of liquid organic fertilizer will provide better quality of rice yields, because it is more evenly distributed. Moreover, there is no accumulation of fertilizer concentration in one place, because organic fertilizer is not problematic with regard to nutrient leaching, and it is able to overcome deficiency in nutrients needed by plants for increased rice yields (Yoshinaga, Takai, Arai-Sanoh, Ishimaru, & Kondo, 2013). The relationship between nutrient absorption of N, P, and K and plant yield is explained in Fig. 6.

Fig. 6 shows that the results of the regression analysis of the relationship between nutrient absorption of N, P, and K (kg/ha) and plant yields revealed a linear pattern, so that the increased absorption of nutrients N, P, and K contained in higher liquid organic fertilizer can increase higher plant yields. Each rice plant yield absorbs 3.275 kg/ha of N, P, and K nutrients so that the panicle length will increase by 22.473 cm.

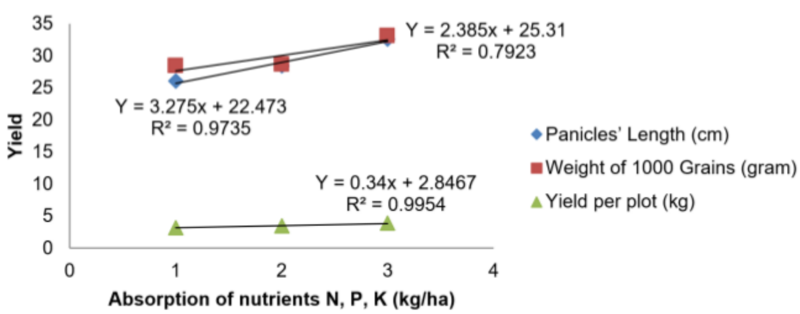

Fig. 6. Relationship between nutrient absorption and plant yield

Then every absorption of 2,385 kg/ha of nutrients N, P, and K will increase the weight of 1000 grains by 25.31 g, and each absorption of 0.34 kg/ha of nutrients N, P, and K will increase rice yield per plot by 2.8467 kg.

The growth of panicle length cumulatively (R^2) absorbs N, P, and K nutrients by 97.35%, meaning that 2.65% of panicle length growth is influenced by other factors. The absorption of the nutrients N, P, and K to cumulatively produce the weight of 1000 grains (R^2) is 79.23%, meaning that 20.77% of the resulting weight of 1000 grains of rice is influenced by other factors. The absorption of N, P, and K nutrients to produce rice production per plot cumulatively (R^2) is 99.54%, meaning 0.46% rice production yield per plot is influenced by other factors.

Increasing the doses of organic fertilizer will increase the availability of nutrients N, P, and K in the soil. Nutrients N, P, and K play a role in photosynthesis, which can affect the increase in rice yields, such as panicle length, grain number, and grain weight. Nutrient N increases the chlorophyl content of plant leaves so that plant photosynthesis increases. The application of liquid organic fertilizer in the rice planting process can increase the availability of N in the final stages of rice growth, which can affect leaf metabolism during seed filling (Santosa & Suryanto, 2015). The nutrient element P plays a role in the supply and transfer of energy throughout the biochemical process of rice, one of which is the acceleration of the cooking and development of grain so that the grain weight increases (Douglas & Dyson, 1985). Nutrient K plays a role in the formation of sugars, starches, and various enzymes to increase the amount of grain per panicle and grain weight percentage (Zandvakili, Barker, Hashemi, Etemadi, & Autio, 2019).

CONCLUSION

The treatment of direct seed planting system confers a direct effect on the growth and yield of paddy rice, in contrast with the transplanting system, and the best liquid organic fertilizer treatment was at a dose of 45 l/ha. Based on the growth of plants, there was also a better influence on the number of tillers and productive tillers, whereas the enhanced panicle length, production, and weight of 1000 grain are indicative of a superior yield. This suggests that the direct seed planting system combined with the application of liquid organic fertilizers by farmers as an improvement effort promotes plant yield, as well as vegetative and generative growth.

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