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Research Article

Growth and production of upland rice (*Oryza sativa* L.) in ultisol using liquid organic fertilizer and NPK

Arman Effendi [1,*], Gusmawartati [1], and Rosnia [1]

[1] Department of Agrotechnology, Faculty of Agriculture, Universitas Riau,
Jl. Subrantas Kampus Bina Widya Km 12,5 Simpang Baru Pekanbaru, Riau, INDONESIA
* Corresponding author (✉ arman.effendi@lecturer.unri.ac.id)

ABSTRACT

One of the efforts to increase rice production in the dry land of ultisol such as in Riau is extensification. To alter low nutrient availability in ultisol, liquid organic fertilizer (LOF) from waste of banana corm and NPK fertilizers are evaluated. Research aimed to obtain the best dose of LOF and NPK fertilizers to improve the productivity of upland rice on ultisols. *This experiment was arranged in a completely randomized factorial design consisting of two factors. The first factor was LOF from banana corm (0 mL, 50 mL, 100 mL, and 150 mL per polybag). The second factor was NPK fertilizers (0%, 25%, 50%, and 100% recommendation dose); the recommendation base was: 300 kg Urea, 100 kg TSP, and 100 kg KCl ha^{-1}. The results indicated that the application of 150 mL LOF per polybag and NPK fertilizers at 100% recommendation significantly enhances plant height, number of tiller numbers, productive tiller, filled grain per panicle, and dry grain weight of Inpago 9 variety.*

Keywords: rice; organic matter; inorganic; sub-optimal soil

INTRODUCTION

The rice plant (*Oryza sativa* L.) is a food crop and an energy source that is consumed by Indonesian society in general. Rice needs in Indonesia are increasing from year to year; as a result of an increase in population, which is not followed by sufficient production. Riau is one of the areas that still potential under development rice commodity so that needs to be surmounted with improved rice production

According to the Riau Statistical Bureau (BPS) (2021), rice production in Riau Province in the year 2020 was as much as 217,458.87 tons with productivity of 4.1 tons ha^{-1}, and area harvest 53,062.35 ha. According to BPS Riau (2022), rice production in the year 2021 increased to 227,346.30 tons with productivity of 4.1 tons ha^{-1} and an area harvest of 54,317.04 ha. Therefore, increasing rice production through land extensification is important. Nevertheless, the average national productivity is still lower than the productivity of the Inpago 9 variety which is 7.4-8.4 ton ha, thus increasing productivity (intensification) is also important.

Land extensification is not easy because available land is mostly dry land dominated by ultisols. According to Sipayung et al. (2014), ultisols' soil has low nutrients, low pH, and low organic content. Utilization of ultisols' soil for increasing agricultural yields will face physical, chemical, and biological constrain, especially low nutrient availability. Such constrain can be overcome by giving liquid organic fertilizer (LOF) such as from banana corm in addition to NPK fertilizers. According to Suhastyo et al. (2013), liquid fertilizer from banana corm contains growth regulators such as gibberellins and cytokinins, as well as positive microbes such as Azospirillum, Azotobacter, Bacillus, Aeromonas, *Aspergillus niger*, phosphate solubilizing microbes and cellulolytic microbes. Microbes in banana corm play a role in the vegetative growth period of plants and disease tolerance. Research by Wahyudi et al. (2019) showed that applying LOF of banana corm at a concentration of

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15% (150 mL) gave the best results for the growth and production of peanut. This research aimed to obtain the best dose interaction treatment of LOF banana corm and NPK fertilizers on growth and productivity of upland rice in ultisols.

MATERIALS AND METHODS

This research was conducted at the upland field of UPT Experimental Station, Faculty of Agriculture, Riau University, the Bina Widya campus Km 12.5 Ward Simpang Baru, Subdistrict Tampan, Pekanbaru. The research was conducted from January to May 2022. The materials used in this study were Inpago 9 rice variety, banana corm 10 kg, EM-4 (effective microorganisms) as much 800 mL, eggs 10 unit, sugar 1 kg, fine bran ½ kg, Ajinomoto® 240 g (food taste enhancer), cow manure 10 ton ha^{-1}, Urea 300 kg ha^{-1}, TSP 100 kg ha^{-1}, KCl 100 kg ha^{-1}, polybag size 40x50 cm, and ultisols' soil.

The ingredients used in making banana corm LOF are 10 kg cut into pieces, 1 kg granulated sugar, 10 eggs, ½ kg fine bran, 240 g Ajinomoto, 800 mL EM-4, and 30 l groundwater. These ingredients are put into a plastic drum, stirred evenly, and closed tightly. Fermentation was carried out for 21 days. The fermentation process is characterized by the appearance of gas bubbling on the surface of the container, a smell like the aroma of tape, and the color of the solution being cloudy. Furthermore, the LOF solution can be applied as a treatment in this research.

The research experimental design was a completely randomized factorial design (CRFD) with two factors and three replications. The first factor was LOF banana corm of 4 levels: B0: 0 mL per polybag, B1: 50 mL per polybag, B2: 100 mL per polybag, and B3: 150 mL per polybag. The second factor was NPK fertilizer of 4 levels: P0: 0% recommendation dose, P1: 25% recommendation dose, P2: 50% recommendation dose, and P3: 100% recommendation dose. The 100% recommendation dose was 300 kg Urea ha^{-1}, 100 kg TSP ha^{-1}, and 100 KCL kg ha^{-1}. The recommended dose was 100 % per polybag, and the total amount of NPK applied was 2.25 g, 0.75 g, and 0.75 g for Urea, TSP, and KCl, respectively.

The 16 treatment combinations were replicated three times, resulting total of 48 experimental units. Each experimental unit consisted of one plant. The measurements were plant height (cm), maximum tiller numbers, number of productive tillers, flowering time (day), harvest age (day), number of filled grain, percentage of filled grain (%), weight of 1,000 grains (g), and weight of dry milled grain per hill (g). Experiment results were statistically analyzed using analysis of variance and the least significance difference (LSD) test at the 5% level using the SAS software.

RESULTS AND DISCUSSION

Plant height

The results of the analysis of variance showed that the interaction of LOF with NPK fertilizers had a significant effect as well as the main factor of LOF and NPK fertilizers had a significant effect on the plant height (Table 1). The liquid organic fertilizer banana corm affects plant height, the results showed that adding 150 mL per polybag was significantly different from 100 mL per polybag, 50 mL per polybag, and 0 mL per polybag. Applying liquid organic fertilizer of 150 mL per polybag likely increases the availability of nutrients needed by plants. Previous research by Wahyudi et al. (2019), stated that applying liquid organic fertilizer of banana corm with a concentration of 15% (150 mL) affected the height of the peanut plant.

The NPK fertilizers affected plant height; the 0% recommended dose was significantly different from the 25% recommended dose, 50% recommended dose, and 100% recommended dose (Table 1). This indicates that treatment of 0% of the recommended dose has not been able to meet the needs of the nutrients needed by plants to improve the height growth of upland rice plants. Lubis et al. (2017) stated that low or no inorganic fertilizer application will inhibit plant height growth.

Table 1. Plant height from liquid organic fertilizer and NPK dose applications.

LOF banana corm (mL per polybag)	NPK fertilizer dose (% of recommendation)				Average
	P0 : 0%	P1 : 25%	P2 : 50%	P3 : 100%	
	……. cm …….				
B0 : 0	84.00e	105.66abc	110.00ab	110.00ab	102.41c
B1 : 50	101.66cd	105.00abcd	107.00abc	110.00ab	105.91b
B2 : 100	98.00d	111.00a	107.66abc	103.66bcd	105.08b
B3 : 150	108.33abc	105.00abcd	109.33ab	112.00a	108.66a
Average	98.00b	106.66a	108.50a	108.91a	

Note: Numbers followed by the same letter in the same row and column are not significantly different according to the LSD test at the 5% level.

The interaction of LOF and NPK fertilizer on plant height was evident (Table 1). The plant height of LOF 150 mL per polybag with 100% NPK recommended dose was significantly different from other treatments. Suarsana et al. (2020) stated that liquid organic fertilizer contains macro and micronutrients so the combination of liquid organic fertilizer with inorganic fertilizers can provide better results for the growth of rice plants. Rachmadhani et al. (2014) stated that inorganic fertilizers containing higher nutrients and easily available for plants, and more quickly fulfilled, then plants can carry out better vegetative growth. It is probable that the effect of LOF is determined by the NPK level, where a higher NPK level facilitates a higher effect of LOF application.

Maximum tiller numbers

The results of the analysis of variance showed that the interaction of LOF with NPK fertilizers, as well as the main factor of LOF and NPK had a significant effect on the maximum tiller numbers of upland rice plants (Table 2). The application of LOF affects the maximum number of tillers. In addition, a dose of 150 mL per polybag was significantly different from 100 mL per polybag, 50 mL per polybag, and control. This shows that the application of LOF 150 mL per polybag provided the nutrients needed by plants for the growth of tillers. Since liquid organic fertilizer from banana corm contains organic matter, increasing its application to the soil, might improve the growth in the number of tillers. Rini (2014) stated that liquid organic fertilizer contains a lot of organic matter which is used to improve the physical, chemical, and biological properties to improve soil fertility.

Table 2. Maximum tiller numbers per hill from liquid organic fertilizer and NPK dose applications.

LOF banana corm (mL per polybag)	NPK fertilizer dose (% of recommendation)				Average
	P0 : 0%	P1 : 25%	P2 : 50%	P3 : 100%	
B0 : 0	6.66c	10.66bc	11.33bc	11.66bc	10.08b
B1 : 50	7.00c	9.00bc	8.66bc	13.66ab	9.58b
B2 : 100	7.33c	10.66bc	11.66bc	11.00bc	10.166b
B3 : 150	7.33c	10.00bc	13.66ab	18.33a	12.33a
Average	7.08c	10.08b	11.33b	13.66a	

Note: Numbers followed by the same letter in the same row and column are not significantly different according to the LSD test at the 5% level.

The application of NPK fertilizer affects the maximum number of tillers. NPK fertilizer at 100% recommended dose was significantly different from 50%, 25%, and 0% (Table 2). This shows that the application of NPK fertilizer at 100% recommended dose produces the highest maximum number of tillers. Yunita et al. (2016) stated that the higher the concentration of fertilizer applied, the faster it will increase the development of organs such as roots so that plants can absorb more nutrients and water. Marlina et al. (2015) added that the availability of NPK nutrients can stimulate the formation of productive tillers.

The interaction of LOF and NPK fertilizer affected the maximum number of tillers (Table 2). The interaction of banana liquid organic fertilizer 150 ml/polybag with the recommended dose of 100% NPK fertilizer is not significantly different from the

interaction of LOF 150 mL and 50% NPK, banana LOF 50 mL and 100% NPK, but significantly different from other interaction treatments. This shows that the interaction of LOF 150 mL per polybag with the recommended 100% dose of NPK fertilizer is able to provide sufficient nutrients so that seedling growth can be higher and the addition of liquid organic fertilizer provides the availability of nutrients for rice seed to grow. According to Ryan (2016), the provision of liquid organic fertilizer stimulates microorganisms in the soil to decompose more quickly and makes it easier for plants to absorb nutrients.

Number of productive tillers

The interaction of liquid organic fertilizer banana corm with NPK fertilizers, the main factor of LOF, and the main factor of NPK fertilizers had a significant effect on the number of productive tillers of upland rice plants (Table 3). The application of LOF affected the parameters of the number of productive tillers; and the dose of 150 mL per polybag was significantly different from the dose of 100 mL per polybag, 50 mL per polybag, and 0 mL per polybag. This shows that the application of liquid organic fertilizer banana corm at a dose of 150 mL per polybag has been able to meet the nutritional needs of plants, especially the phosphorus needed by plants for producing a higher number of productive tillers. According to the results analysis by Bahtiar et al. (2017) the banana corm contains 439 ppm of available P_2O_5.

Table 3. Number of productive tillers per hill from liquid organic fertilizer and NPK dose applications.

LOF banana corm (mL per polybag)	NPK fertilizer dose (% of recommendation)				Average
	P0 : 0%	P1 : 25%	P2 : 50%	P3 : 100%	
B0 : 0	5.00e	9.33bcde	10.00bcde	10.66bcd	8.75b
B1 : 50	6.33de	7.66bcde	6.66cde	11.66bc	8.08b
B2 : 100	5.33e	9.66bcde	10.66bcd	9.66bcde	8.83b
B3 : 150	5.66de	9.33bcde	12.66ab	17.00a	11.16a
Average	5.58c	9.00b	10.00ab	12.25a	

Note: Numbers followed by the same letter in the same row and column are not significantly different according to the LSD test at the 5% level.

The application of NPK fertilizers 100% recommended dose was not significantly different from the 50% recommended dose but significantly different from the 25% recommended dose and 0% recommended dose (Table 3). This shows that the application of NPK fertilizer at 50% and 100% recommended dose has been able to provide N, P, and K nutrients needed by plants, so that plants can carry out their physiological processes properly and stimulate and encourage the generative formation of plants, especially for seed formation. Azalika et al. (2018) stated that fulfilling the nutrient needs of rice plants in the generative phase plays an essential role in accelerating flowering and grain filling, so the plants can produce better quality and higher grain yield.

The interaction of LOF and NPK fertilizers affected the parameters of the number of productive tillers (Table 4). Application of LOF 150 ml/polybag with NPK fertilizers 100% recommended dose was not significantly different from the interaction of LOF 150 ml/polybag with NPK fertilizers 50% recommended dose recommendations but significantly different from other interactions. This shows that the interaction of LOF 150 ml/polybag with NPK fertilizers at 100% recommended dose resulted in many productive tillers because it already provided NPK nutrients for plant growth. During the vegetative phase, tillers will increase rapidly. A rapid increase in tillers characterizes active tillers until the maximum number of tillers is reached. After the maximum number of tillers is reached, some will form panicles, and some will die and not produce panicles (Ahyani and Iman, 2020).

Flowering time

The flowering age was counted at 50% of the tillers in a hill produced inflorescence. The interaction of LOF and NPK fertilizers as well as the main factors of LOF and NPK fertilizers had no significant effect on the flowering age of upland rice plants (Table 4). Wiji et al. (2017) mentioned that the flowering is influenced by genetic and environmental factors, including the temperature at the time of planting. The finding in the present research is contrary to Yunita et al. (2016) where liquid organic fertilizer accelerated flowering.

Table 4. Flowering time from liquid organic fertilizer and NPK dose applications.

LOF banana corm (mL per polybag)	NPK fertilizer dose (% of recommendation)				Average
	P0 : 0%	P1 : 25%	P2 : 50%	P3 : 100%	
	……. days …….				
B0 : 0	75.00	75.00	75.33	73.66	74.75
B1 : 50	74.33	73.66	75.33	7566	75.66
B2 : 100	74.00	73.33	75.00	73.66	74.00
B3 : 150	75.00	73.66	75.66	75.66	75.58
Average	74.58	73.91	75.33	76.16	

Harvest age

Neither the interaction of LOF with NPK fertilizers nor the main effects of LOF and NPK fertilizers affected the harvesting age of rice (Table 5). It is probable that genetic characteristics influence the harvesting age (Herawati, 2012). Moreover, the finding in the present research is in line with the finding of Siti et al. (2015) where applying N, P, and K fertilizers do not affect the harvesting age in rice.

Table 5. Harvest age from liquid organic fertilizer and NPK dose applications.

LOF banana corm (mL per polybag)	NPK fertilizer dose (% of recommendation)				Average
	P0 : 0%	P1 : 25%	P2 : 50%	P3 : 100%	
	……. days …….				
B0 : 0	107.00	107.00	106.66	106.33	106.75
B1 : 50	106.00	106.33	106.33	107.00	106.41
B2 : 100	106.33	106.00	106.00	106.66	106.25
B3 : 150	106.33	106.66	106.66	106.66	106.58
Average	106.41	106.50	106.41	106.66	

Number of filled grain

The interaction of LOF with NPK fertilizers, as well as the main factors of LOF and NPK fertilizers had a significant effect on the number of filled grains of upland rice plants (Table 6). The provision of LOF affects the number of rice grains of upland rice, giving a good dose of 150 mL per polybag, which is significantly different from other levels. Yunita et al. (2016) stated that the elements NPK contained in liquid organic fertilizer stimulate seed formation and carbohydrate content.

Table 6. Filled grains per panicle from liquid organic fertilizer and NPK dose applications.

LOF banana corm (mL per polybag)	NPK fertilizer dose (% of recommendation)				Average
	P0 : 0%	P1 : 25%	P2 : 50%	P3 : 100%	
B0 : 0	134.03c	155.50bc	157.07bc	160.17bc	151.69b
B1 : 50	142.23bc	155.63bc	158.90bc	152.30bc	152.26b
B2 : 100	136.93c	156.77bc	160.47bc	156.23bc	152.60b
B3 : 150	140.63bc	156.67bc	175.97b	230.83a	176.02a
Average	138.45c	156.14b	163.10ab	174.88a	

Note: Numbers followed by the same letter in the same row and column are not significantly different according to the LSD test at the 5% level.

Applying NPK fertilizers affected the number of filled grain of upland rice plants. The application of NPK fertilizers at 100% recommended dose was not significantly different from the 50% recommended dose but significantly different from the 25% and 0% recommended dose (Table 6). This shows that the application of NPK fertilizers at 100% recommended dose has been able to meet the nutrient needs of plants for producing a large filled grains. According to Rudy (2017), high photosynthate might be stored as reserves of energy to form flowers, fruits, and seeds. However, the photosynthetic rate was not evaluated in the present research.

The interaction of LOF and NPK fertilizers affected the number of rice grains (Table 6). The application of LOF 150 mL per polybag in combination with NPK fertilizers at 100% recommended dose was not significantly different from other treatments, although higher doses of both LOF and NPK tended to produce a higher number of rice grains. This indicates that the number of rice grains could be genetic x environment-controlled factors. Nasution et al. (2019) stated that grain filling requires sufficient phosphorus (P) and potassium (K) elements in the process of fertilization to seed ripening so that it goes well.

Percentage of filled grain

The interaction of LOF with NPK fertilizers as well as the main factors of LOF and the NPK fertilizers had no significant effect on the percentage of filled grain (Table 7). This is presumably because applying LOF to the soil has not had an optimal effect with this treatment. The percentage of filled grain may be correlated with the number of productive tillers and number of grain per panicle. Mahmud and Sulistyo (2014) stated that the high percentage of rice grain depends on the amount of grain formed, the availability of nutrients, and the balance among nutrients. The imbalance of nutrients might stimulate high empty grains per hill.

Table 7. Percentage of filled grain per panicle from liquid organic fertilizer and NPK dose applications.

LOF banana corm (mL per polybag)	NPK fertilizer dose (% of recommendation)				Average
	P0 : 0%	P1 : 25%	P2 : 50%	P3 : 100%	
B0 : 0	77.00	84.03	84.63	79.00	81.16
B1 : 50	84.88	83.66	83.53	84.06	84.03
B2 : 100	85.13	85.36	83.96	81.43	83.97
B3 : 150	82.70	84.86	81.26	84.03	83.21
Average	82.42	84.48	83.35	82.13	

Weight of 1,000 grains

The interaction of LOF with NPK fertilizers as well as the main factors of LOF and the NPK fertilizers had no significant effect on the weight of 1,000 rice grains (Table 8). According to Sution and Serom (2019) stated that genetics and environment influence seed size. Kaihatu and Pesireron (2011) added that other factors, such as competition between seeds in rice plants, can affect seed size. The more seeds produced, the higher the competition for assimilates, which will cause the size of the seeds to decrease.

Table 8. The weight of 1,000 grains from liquid organic fertilizer and NPK dose applications.

LOF banana corm (mL per polybag)	NPK fertilizer dose (% of recommendation)				Average
	P0 : 0%	P1 : 25%	P2 : 50%	P3 : 100%	
		..... g			
B0 : 0	26.23a	25.70a	26.46a	26.70a	26.27a
B1 : 50	26.46a	26.86a	26.83a	27.23a	26.85a
B2 : 100	26.73a	26.13a	26.50a	26.13a	26.37a
B3 : 150	26.50a	26.40a	27.20a	27.46a	26.89a
Average	26.48a	26.27a	26.75a	26.88a	

Note: Numbers followed by the same letter in the same row and column are not significantly different according to the LSD test at the 5% level.

Weight of dry milled grains

The interaction of LOF with NPK fertilizers, as well as the main factors of LOF and the NPK fertilizers had a significant effect on the weight of dry milled grains per hill (Table 9). Provision of LOF affects the weight of dry milled grain per hill; the provision of LOF 150 mL per polybag was significantly different from other treatments. It is probable that the nutrient provided by LOF 150 ml was higher; however, the nutrient content of LOF was not evaluated in the present study. Siwanto et al. (2015) stated that plant growth and yield are determined by the rate of photosynthesis which is controlled by the availability of sufficient nutrients and water.

Table 9. Weight of dry milled grains per hill of rice from liquid organic fertilizer and NPK dose applications.

LOF banana corm (mL per polybag)	NPK fertilizer dose (% of recommendation)				Average
	P0 : 0%	P1 : 25%	P2 : 50%	P3 : 100%	
	..... g				
B0 : 0	27.36c	34.36bc	45.56ab	41.13bc	37.10b
B1 : 50	31.30c	34.73bc	36.96bc	39.96bc	35.74b
B2 : 100	27.80c	38.13bc	40.80bc	39.80bc	36.63b
B3 : 150	28.90c	38.63bc	46.56ab	57.60a	42.92a
Average	28.84c	36.46b	42.47a	44.62a	

Note: Numbers followed by the same lowercase letter in the same row and column are not significantly different according to the LSD test at the 5% level.

The application of NPK fertilizers affected the weight of dry milled grains per hill (Table 9). The application of NPK fertilizers 100% recommended dose was not significantly different from the 50% recommended dose but significantly different from the 25% and 0% recommended dose. According to Abu et al. (2017), the availability of sufficient and balanced N element content will form amino acids and proteins, which can enhance the formation of plant seeds.

The interaction of LOF and NPK fertilizers affected the weight of dry milled grains (Table 9). Application of LOF 150 mL with NPK fertilizers 100% recommended dose was not significantly different from the interaction of LOF 0 mL per polybag with NPK fertilizers 50% recommended dose and interaction LOF 150 mL per polybag with NPK fertilizers 50% recommended dose but significantly different from other interactions. Since the amount of filled grain formation is highly dependent on the photosynthate availability, the differences in the number of dry milled grains could be due to different photosynthetic rates during the filling process. Grain weight is strongly influenced by the translocation of photosynthetic results into the formed grain so that it affects the weight of grain at a high photosynthetic rate, so the results of photosynthesis translocated into rice grains will be even greater and will further affect grain weight (Urairi *et al*., 2016).

CONCLUSIONS

This research revealed that the most effective treatment is the combination of 150 mL of liquid organic fertilizer per polybag and NPK fertilizers at 100% recommendation dose. In addition, the interaction of both treatments increased plant height, maximum tiller numbers, number of productive tillers, number of filled grain per panicle, and weight of dry milled grain per hill of Inpago 9 variety in ultisols' soil.

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