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THE EFFECTS OF USING LIQUID ORGANIC NPK FERTILIZER FOR RICE PLANT GROWTH AND PRODUCTION (*Oriza sativa* L.)

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ABSTRACT
This research aims to determine the appropriate concentrations of nitrogen, phosphorus, and potassium (NPK) in liquid organic fertilizer (LOF) and to determine the appropriate dose of NPK and LOF concentrations for the growth and yield of rice plants. The research was conducted in Mertajati Village, Sausu Subdistrict, Parigi Moutong Regency, Indonesia, from August to December 2019. The study used a two-factor randomized block design (RBD). The first factor is the dose of NPK, which consists of three levels, i.e., NPK 200 kg/ha^{-1}, NPK 400 kg/ha^{-1}, and NPK 600 kg/ha^{-1}. The second factor is the concentration of LOF, which also consists of three concentration levels, i.e., without LOF, 2.5% LOF, and 5.0% LOF. The results revealed that the effects of LOF addition were the same for each dose of NPK and increasing the dose of NPK required an increase in the concentration of LOF. A dose of 400 kg ha^{-1} NPK fertilizer resulted in better growth and a higher yield, indicated by taller plants, higher panicles (19.53 panicles), and higher dry grain production (7.69 ton/ha^{-1}). The application of 2.5% liquid organic fertilizer resulted in better growth and a higher yield, indicated by taller plants, a higher number of tillers, faster flowering, more panicles per clump (19.72 panicles/clump^{-1}), a higher number of grains per panicle, a higher pithy grain weight (30.26 grams/1000 grains), and higher yields (7.79 tons/ha^{-1}).

Contribution/Originality: This study contributes new information regarding the application of 2.5% liquid organic fertilizer, which resulted in better growth and a higher yield, indicated by taller plants, a higher number of tillers, faster flowering, more panicles per clump, a higher pithy grain weight, and higher yields.

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1. INTRODUCTION

Rice is a source of energy and carbohydrates, and it is an important food crop and the main commodity in Indonesia. Efforts to increase rice production face a number of problems, including increasing environmental damage, increasing the conversion of agricultural land to non-agriculture, and global climate change. To overcome these problems, it is necessary to find solutions and develop technological innovations. Efforts to increase rice productivity need to be improved, especially in relation to the decline in production and technology saturation (Made, Kadekoh, & Samudin, 2016). One of the efforts to increase the productivity of rice plants is to provide the required nutrients. Fertilizer application aims to increase the nutrients needed by plants, because the nutrients contained in the soil are not always sufficient for optimal plant growth (Hamid & Tanweer, 2021; Ikhajiagbe, Igiebor, & Ogwu, 2021). The daily growth, development and production processes of plants require nutrients in the form of minerals and water. The nutrients normally needed by plants cannot be separated from the three main nutrients, i.e., nitrogen, phosphorus, and potassium (NPK). NPK compound fertilizer is an inorganic fertilizer. The advantages of using NPK compound fertilizers are: 1) The nutrient content is the same as a single fertilizer; 2) It can be used in place of a single fertilizer; 3) The use of compound fertilizer is simple; and 4) Transportation and storage of compound fertilizer saves time, space and cost (Susanto & Amirta, 2020). Liquid organic fertilizer (LOF) is a solution derived from the decomposition of organic materials, such as plant matter, animal manure, ash and water (Mangera & Ekowati, 2022; Raden, Fathillah, Fadli, & Suyadi, 2017). Sources of raw materials for organic fertilizer are available in abundance and are usually in the form of waste from households restaurant, markets, agricultural markets, livestock, and other organic waste (Devianti, Yusmanizar, Syakur, Munawar, & Yunus, 2021). Liquid organic fertilizers contain low macronutrients but contain sufficient micronutrients that are indispensable for plant growth and development.

Fertilization requires care to ensure that plants receive the required dose and concentration. The fertilizer used should not be lower than, or exceed, the required dose as it could hinder plant growth and development (Bindraban, Dimkpa, Nagarajan, Roy, & Rabbinge, 2015). The advantage of LOF is that it is a fast way to overcome nutrient deficiencies, doesn't cause nutrient leaching, and is able to provide nutrients quickly (Phibunwatthanawong & Riddech, 2019). Therefore, this research was conducted on the effects of NPK and LOF on the growth and production of rice plants with the aim of determining the appropriate concentration of NPK for optimal growth and yield of rice plants.

2. MATERIALS AND METHODS

2.1. Research Study and Time

This research was conducted in Mertajati Indah Village, Sausu Subdistrict, Parigi Mautong Regency, Central Sulawesi, Indonesia, from August to December 2019. The items used were a tractor, hoe, meter, scale, measuring cup, and blender. The materials used were Cigeulis rice seeds, Phonska NPK fertilizer (15:15:15), and liquid organic fertilizer (LOF).

2.2. Research Design

The study uses a two-factor randomized block design (RBD). The first factor was the dose of NPK, which consisted of three levels, i.e., NPK 200 kg ha^{-1}, which is equivalent to 120 g/plot^{-1} (P_1); NPK 400 kg ha^{-1}, which is equivalent to 240 g/plot $^{-1}$ (P_2); and NPK 600 kg ha^{-1}, which is equivalent to 360 g/plot^{-1} (P_3). The second factor was the concentration of LOF, which also consisted of three levels, i.e., without LOF (K_0), 2.5% LOF (K_1), and 5.0% LOF (K_2). Therefore, there were nine treatments in total, and each treatment combination was repeated three times as a group.

2.3. Research Implementation

Tillage was carried out twice and harrowing was carried out once, then plots of 300 cm x 200 cm were made. Preparation of liquid organic fertilizer was carried out by providing the formulation of ingredients (papaya leaves, moss, rice washing water, granulated sugar, brown sugar, Yakult, and water). Next, the papaya leaves and moss were blended, and the granulated sugar and brown sugar were heated until they became liquid. The solutions were mixed until evenly distributed, then slowly filtered. The LOF was incubated for a week, and then the liquid organic fertilizer was ready to be used. Planting was performed using a direct seeding system (called *Tabela*) using the *Jajar Legowo* 2:1 cropping pattern, with a spacing of 20 cm x 20 cm, and a population of 283,000 clumps per hectare.

The application of NPK fertilizer was carried out in two doses, with a treatment of 50% at 21 days after planting (DAP) and 50% at 42 DAP. The LOF was given at twice the concentration according to the treatment. The first application was 35 DAP with a dose of 200 L (equivalent to 120 mL/Plot^{-1}), and the second application was given at 49 DAP, with a dose of 300 L (equivalent to 180 mL/Plot^{-1}).

To determine the effects of the treatment, observations were recorded for plant height, number of tillers, age of flowering, number of panicles, and dry grain yield.

3. RESULTS AND DISCUSSION

3.1. Experimental Soil Characteristics

The results revealed the initial physical properties of the experimental soil; it had a sandy loam texture with a distribution of 53.04% sand, 31.71% silt and 15.25% clay, and a bulk density of 1.44 g/cm^{-1}. In terms of chemical properties, it had a slightly acidic pH level, a moderate organic carbon (c-organic) content (2.15%), a moderate nitrogen (N) content (0.24%), moderate C/N (11.94), moderate P_2O_5 (9.43 ppm), a moderate potassium (K) content (0.33 meq/100g), moderate cation exchange capacity (CEC) (23.03 meq/100g), and moderate base saturation (49.1%).

The C-organic content and CEC, which were classified as moderate, indicate that the experimental soil had moderate levels of organic matter. The pH value of the soil describes the level of soil acidity, which greatly affects the activity of micro-organisms in the soil and the uptake of plant nutrients.

3.2. Parameters of Rice

3.2.1. Plant Height

The analysis of variance (ANOVA) results show that the NPK and LOF administration had an effect on plant height, while the interaction between the two treatments had no effect. The median test results (see Table 1) show that fertilization using the 600 kg/ha^{-1} NPK resulted in higher plants, which was different from the 200 kg/ha^{-1} NPK, but not different from the 400 kg/ha^{-1} NPK. This is presumably because the administration of 600 kg NPK has fulfilled the plants' nutrient needs. Fertilizer application can increase plant growth because it increases the availability of N, P, and K. Table 1 also shows that the administration of the 5.0% LOF produced taller plants, which was different from that without LOF, but not different from that with a LOF concentration of 2.5%. This is apparently because the administration of 5.0% LOF has fulfilled the plants' nutrient needs. The increase in plant height is influenced by the provision of LOF concentrations, as well as by a dense population, which can cause competition for sunlight.

Table 1. Average plant height at various NPK doses and LOF concentrations.

Treatment	Plant Height (cm)	
NPK (kg/ha)	35 DAP	63 DAP
200	58.12 a	108.67 a
400	61.69 b	112.02 ab
600	61.96 b	114.73 b
Without LOF	58.64 a	107.99 a
2.5%	60.59 b	112.28 b
5.0%	62.54 c	115.05 b

Note: Values followed by the same letter in the same row are not significantly different in the HSD test (honestly significant difference) (α = 0.05). DAP = days after planting.

3.2.2. Number of Tillers

The ANOVA results revealed that the administration of LOF had an effect on the number of tillers, while the NPK dose and the interaction between the two treatments had no effect (see Table 2).

Table 2. Number of tillers per clump, and flowering age at various NPK doses and LOF concentrations.

Treatment	LOF concentration			Average	HSD 5%
Tillers					
NPK (kg/ha^{-1})	Without LOF	2.5 %	5.0%		
200	21.03	21.30	21.93	21.42	
400	20.83	21.56	22.03	21.47	
600	21.16	21.63	22.56	21.78	
Average	21.01 a	21.49 ab	22.17 b		1.01
Flowering Age					
200	77.66	75.33	73.66	75.55	
400	75.66	74.66	73.33	74.55	-
600	77.33	74.66	73.66	75.22	
Average	76.88 b	74.88 a	73.55 a		1.70

Note: Values followed by the same letter in the same row are not significantly different in the HSD test (α = 0.05).

The median test results shown in Table 2 indicate that the administration of LOF with a concentration of 5.0% produced more tillers, which was different from that without LOF, but not different from that with a LOF concentration of 2.5%. This is presumably because the administration of 5.0% LOF has fulfilled the plants' nutrient needs. The application of LOF tends to form the number of tillers based on the adequacy of light intensity. Meanwhile, the administration of the 2.5% LOF did not significantly increase the number of tillers because the number of nutrients was insufficient, so the growth will be stunted. The amount of nutrients required by the plant is closely related to the needs of the plant to grow optimally. If the amount of nutrients required is not available, then growth will be stunted. If the amount of available nutrients is higher than what is required by the plants, it can be defined as a condition of luxury consumption.

3.2.3. Flowering Age

The ANOVA results show that the LOF administration had an effect on the flowering age, while the NPK dose and the interaction between the two treatments had no effect. The flowering age results are presented in Table 2, and they show that the administration of LOF with a concentration of 5.0% resulted in faster flowering of plants, which was different from that without LOF, but not different from that with a LOF concentration of 2.5%. This is presumably because the application of LOF can accelerate the flowering age of rice plants. In addition, the direct seed planting system generated good results at the flowering age with a time difference of 3–10 days. The direct seed planting system can accelerate the flowering age by nine days compared to conventional planting patterns and harvesting age (Bahua & Gubali, 2020; Sahardi, Nappu, Idaryani, Nurlaila, & Syam, 2021). The direct seed planting system showed better prospects and can increase the production of harvested dry grain, eliminate the negative impact of nursery and grain quality, and shorten the life of the plant (Bahua & Gubali, 2020). Therefore, the direct seed planting system increases the opportunity to enhance cropping intensity, which improves productivity and farmers' income, both obtained through increased production per unit area, as well as production cost savings, such as labor and fertilizer costs, and opportunities for optimizing the use of land resources.

3.2.4. Panicles

The ANOVA results show that the NPK dose and LOF concentration had an effect on the number of panicles per clump, while the interaction between the two treatments had no effect. The average numbers of panicles per clump are presented in Table 3.

Table 3. Average numbers of panicles per clump at various NPK doses and LOF concentrations.

Treatment	LOF concentration			Average	HSD 5%
NPK (kg/ha-1)	Without LOF	2.5 %	5.0%		
Panicles					
200	17.33	18.53	19.13	18.33 a	
400	18.73	19.73	20.13	19.53 b	0.23
600	18.66	19.53	19.9	19.36 b	
Average	18.24 a	19.26 b	19.72 c		0.23
Panicle Length					
200	23.03	24.15	24.34	23.84	
400	23.43	24.27	24.58	24.09	-
600	23.95	24.35	24.90	24.40	
Average	23.47 a	24.25 b	24.60 b	-	0.74
Grains per panicle					
200	121.6	126.9	127.73	125.14 a	
400	128.13	147.1	134.66	136.63 b	6.27
600	131.83	142.03	142.5	138.78 b	
Average	127.18 a	138.67 b	134.96 b		6.27
Percentage of empty grain					
200	6.49	5.10	4.36	5.31	
400	5.70	5.27	4.81	5.26	-
600	5.54	4.68	4.40	4.87	
Average	6.91 b	5.02 a	4.52 a		0.78
Weight of 1000 grain seeds					
200	27.27	28.48	29.45	28.39	
400	25.66	28.54	31.92	28.70	-
600	26.36	30.45	29.42	28.74	
Average	26.43 a	29.15 b	30.26 b		0.86

Note: Values followed by the same letter in the same column or row are not significantly different in the HSD test ($\alpha = 0.05$).

The median test results Table 3 show that the administration of 400 kg/ha-1 of NPK produced a higher number of panicles per clump, which was different from 200 kg/ha-1 of NPK, but not different from that with 600 kg/ha of NPK. This is presumably because the administration of 400 kg/ha-1 of NPK has fulfilled the plants' nutrient needs, especially N and P, because these nutrients play an important role in the formation of tillers. Table 3 also shows that the administration of 5.0% LOF resulted in a higher number of panicles per clump in contrast to other treatments, in which the higher LOF concentration produced more panicles. This is presumably because the administration of 5.0% LOF has fulfilled the plants' nutrient needs. This is in agreement with Sutardi, Gunawan, Winarti, and Cahyaningrum (2021), who stated that the provision of LOF in each treatment has an effect on the number of panicles.

Panicle length. The ANOVA results show that the LOF concentration had an effect on the panicle length, while the NPK dose and the interaction between the two treatments had no effect. The average panicle lengths are presented in Table 3. The median test results show that the administration of LOF with a concentration of 5.0% resulted in longer panicles, which was different from that without LOF, but not different from that with a LOF concentration of 2.5%. In addition to the concentration of LOF, panicle length is more likely to be influenced by genetic and environmental factors. Spacing is one way to create environmental factors and nutrients that are evenly available for each individual plant. Available nutrients in sufficient quantities allow plants to grow and produce maximally. A low availability of nutrients in the production phase causes the inhibition of several plant metabolic processes, which decreases plant yield, inhibits flower formation, affects the panicle length, and decreases the number of seeds (Wei et al., 2017). The single factor of LOF treatment shows results with a significant effect.

Number of grains per panicle. The ANOVA results show that the NPK and LOF administration had an effect on the number of grains per panicle, while the interaction between the two treatments had no effect. The average number of grains per panicle is presented in Table 3. The median test results show that the administration of 600 kg/ha-1 of NPK resulted in more grains per panicle, which was different from that of 200 kg/ha-1 of NPK, but not different from that of 400 kg/ha-1 of NPK. This is presumably because the administration of 600 kg/ha-1 of NPK has fulfilled the plants' nutrient needs. Nitrogen plays an important role as a constituent of proteins that will be used by plants, including increasing the number of panicles (Ju, Liu, & Sun, 2021; Zhou et al., 2017). Panicle length is strongly influenced by the panicle initiation period, which is a critical period for the plant. Lack of nutrients and water during the initiation period can cause panicle formation to be poor, and this affects the ovules that will form. The number of grains per panicle is determined in the reproductive phase. Table 3 also shows that the administration of LOF with a concentration of 2.5% resulted in more grains per panicle, which was different from that without LOF, but not different from that with a LOF concentration of 5.0%. This is presumably because the administration of 2.5% LOF has met the plants' nutrient needs. Percentage of empty grain. The ANOVA results showed that LOF administration had an effect on the percentage of empty grain, while the NPK and the interaction between the two treatments had no effect. The average percentage of empty grain is presented in Table 3. The median test results show that the administration of LOF decreased the percentage of empty grain, and a higher concentration of LOF resulted in a decreased percentage of empty grain. The administration of LOF with a concentration of 5.0% resulted in a lower percentage of empty grain, which was different from that without LOF, but not different from that with a LOF concentration of 2.5%. This is presumably because the administration of 2.5% LOF has fulfilled the plants' nutrient needs. Empty grain was determined by the number of tillers that grew before reaching the primordial phase. K deficiency can cause a high amount of empty grain and incomplete grain filling, and the plant growth is closely related to the balance of required nutrients (Susanto & Sirappa, 2015). Weight of 1000 grain seeds. The ANOVA results showed that the administration of LOF had an effect on the weight of 1000 grain seeds, while the NPK and the interaction between the two treatments had no effect. The average weight of 1000 grain seeds is presented in Table 3. The median test results show that the administration of LOF with a concentration of 5.0% resulted in higher pithy grain, which was different from that without LOF, but not different from that of the LOF with the 2.5% concentration. The higher LOF concentration produced higher pithy grain. The pith of the grain is largely determined by the availability of nutrients and the plant's physiological processes.

3.3. Dry Grain Yield

The ANOVA results show that the administration of NPK and LOF had an effect on the dry grain yield, while the interaction between the two treatments had no effect. The average dry grain yield is presented in Table 4.

Table 4. Average dry grain yields at various NPK doses and LOF concentrations.

Treatment	Dry Grain Yield	
NPK (kg/ha)	**g/m**	**ton/ha**
200	639.44 a	6.394 a
400	769.22 b	7.692 b
600	775.55 b	7.755 b
HSD 5%	31.85	0.317
Without LOF	721.22 a	7.212 a
2.5%	737.55 a	7.375 a
5.0%	779.44 b	7.794 b
HSD 5%	31.85	0.317

Note: The value in each treatment followed by the same letter in the same column is not different in the HSD test ($\alpha = 0.05$).

The median test results (see Table 4) show that the administration of 600 kg/ha^{-1} of NPK resulted in heavier dry grain yields, which was different from that of 200 kg ha^{-1}, but not different from that of 400 kg/ha^{-1}. This is presumably because the administration of 400 kg/ha^{-1} of NPK has fulfilled the nutrient requirements of the plants. The application of NPK increased the dry grain weight because the NPK contents can meet the P and K nutrient needs of the plant, resulting in optimal grain production. Table 4 also shows that the administration of LOF with a concentration of 5.0% resulted in heavier dry grain yields, which was different from other treatments. This is presumably because the administration of LOF with a concentration of 5.0% had fulfilled the plants' nutrient needs. The application of LOF stimulated plant growth, roots, fruiting, and it reduced flower and fruit loss, so crop yield increased (Masniawati, Suhadiyah, Tambaru, & Sulastri, 2017). The growth and yield of plants are strongly influenced by many factors, i.e., genetic traits or inherited traits, such as plant age, plant morphology, yield, capacity to store food reserves, and resistance to disease, among others (Ata-Ul-Karim et al., 2022; Liu, Zhou, Li, & Xin, 2017; Oladosu et al., 2014). Meanwhile, external factors are environmental, such as climate, soil, and biotic factors (Peng et al., 2004; Song et al., 2022). Differences in growth and yield are affected by one or more of these factors. Differences in genetic makeup (genotype) is one of the factors causing diversity in plant appearance, and differences in genotype will always occur, even if the plant material used is derived from the same plant species.

4. CONCLUSION

The effects of LOF administration were the same for each dose of NPK, and increasing the NPK dose requires an increase in the LOF concentration. The application of 400 kg/ha^{-1} NPK fertilizer resulted in better growth and yield indicated by taller plants, higher panicles per clump (19.53 panicles/clump^{-1}), a higher number of grains per panicle (136.63 grains/panicle^{-1}), and higher dry grain production (7.69 ton/ha^{-1}). The application of 2.5% LOF achieved better growth and yield characterized by taller plants, a higher number of tillers, faster flowering, more panicles per clump (19.72 panicles/clump^{-1}), a higher number of grains per panicle, a lower percentage of empty grain, increased pithy grain weight (30.26 g/1000 grains), and higher yields (7.79 tons/ha^{-1}).

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