Effect and Effectivity of Granular Organic Fertilizer on Growth and Yield of Lowland Rice

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Abstract. The tendency to use inorganic fertilizers in very high doses has causesvarious negative impacts, namely damage to ecosystems, loss of soil fertility to health problems. Therefore, the use of organic fertilizers is encouraged to overcome these problems. The purpose of this study was to determine the effectiveness of Granules Organic Fertilizer (GOF) on the growth and yield of rice plants. The design used was a Randomized Block Design (RBD) with three replications and eight treatments. The GOF treatment was arranged in six levels: 1 000 kg ha^{-1} to 6 000 kg ha^{-1}, combined with Urea 300 kg ha^{-1} and Phonska 300 kg ha^{-1}, one standard fertilization treatment (Petroganic 2 000 kg ha^{-1} + Urea 300 kg ha^{-1} and Phonska 300 kg ha^{-1}) and one treatment without fertilization as a control. The results showed that GOF had a significant effect on the growth and yield of rice plants. The use of GOF 3 000 kg + 300 kg Urea + 300 kg Phonska gave the highest grain yield of 7.21 t ha^{-1} with RAE value of 116 % or an increase of 7.45 %, and with an R/C ratio of 1.4.

Key words: Balance fertilizer**,** fertilizer efficiency, food security, slow realese fertilizer, soil fertility

1 Introduction

Nowadays, rice farmers use production factors is not efficient [1] among others, rely on inorganic fertilizers with very high doses. That tendency causesvarious negative impact of using inorganic fertilizers, ranging from damage to the ecosystem, loss of soil fertility to health problems [2, 3]. Organic fertilizer refers to materials used as fertilizer that occur regularly in nature, usually as a by product or end product of a naturally occurring process. Organic fertilizers are sustained sources of nutrients due to slow release during decomposition [4]. Therefore, the use of organic fertilizer is encouraged to overcome these problems [5]

Organic fertilizer is fertilizer derived from dead plants, animal dung or animal parts, and other organic waste. It has been through an engineering process and can be enriched with

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minerals and microbes. Organic fertilizer is useful for increasing nutrient content and soil organic matter, and improving physical, chemical, and biological soil characteristics [2]. Organic fertilizers produced through the process of drying, cooking, composting [6], chopping, grinding and fermenting [7], or other method.

Nutrient composition in organic fertilizer is very dependent on the source of origin of the basic ingredients. The sources of organic fertilizer were from agricultural and non–agricultural activities. The source from agriculture activities can be in the form of crop residues and livestock manure, while from non–agriculture can come from municipal organic waste, industrial waste, and so on.

Organic fertilizer technology is growing rapidly. The use of Granules Organic Fertilizer (GOF) in rice plants is expected to improve land conditions, technically easy to apply, and improve the growth and yield of rice plants. Organic fertilizer senhance the natural soil processes, which have long–termeffects on soil fertility [4].

The purpose of this study was to determine the effectiveness of GOF on the growth and yield of rice plants.

2 Research methods

The study was conducted in the Mojosari research station, Mojokerto, East Java, Indonesia from February 2017 to August 2017. The materials used in this study included: Inpari 30 variety of rice seeds, GOF, comparative organic fertilizer (Petroganik), Urea fertilizer, and Phonska fertilizer. The equipment used were a tillage machine (hand tractor), hoe, and equipment for observation and harvest.

A previous study showed that soil at the Mojosari research station had a Neutral Acidity (pH). Organic matter content and macronutrients were low, but P and Ca were high.

The experimental design used was a Randomized Block Design (RBD). The treatment of organic fertilizer was arranged in six levels of organic fertilizer (1 000 kg ha^{-1}, 2 000 kg ha^{-1}, 3 000 kg ha^{-1}, 4 000 kg ha^{-1}, 5 000 kg ha^{-1}, and 6 000 kg ha^{-1}). Each of the level was combined with 300 kg of Urea and 300 kg of Phonska. As a comparison, it used one standard fertilizing treatment (Petroganik 2 000 kg ha^{-1} + Urea 300 kg ha^{-1} and Phonska 300 kg ha^{-1}) and one treatment without fertilization as a control. All treatments were repeated three times. Data were analyzed using ANOVA. Further tests were carried out using the Least Significant Difference Test (LSD) at the 5 % level.

RAE (Relative Agronomic Effectiveness) was used to compare the effectiveness of each organic fertilizer against standard fertilizer. RAE is the ratio between the increase in yield due to the use of a fertilizer with the increase in yield with the use of a standard fertilizer multiplied by 100 [2], with the Formula (1):

$$\text{RAE} = \frac{\text{Yield of tested fertilizer} - \text{results on control}}{\text{Standard fertilizer yields} - \text{results on control}} \times 100\ \% \quad (1)$$

To find out the feasibility level of rice farming, the simplest financial analysis approach using R/C was the ratio between revenue and cost. If R/C > 1, meansthe business is feasible to be continued, and if R/C < 1 then the business is not feasible/inefficient to be continued and R/C = 1 means the farming carried outreaches breakeven. Comparison between the amount of revenue and cost using the Formula (2) [8], as follows:

$$\text{R/C ratio} = \text{TR/TC} \quad (2)$$

TR = Total Revenue
TC = Total Cost

3 Results and discussions

Table 1 showed that at the age of 21 dap (day after plantation), the highest average plant height was shown in the treatment of 3 000 kg ha^{-1} GOF, but not significantly different with the treatment of 2 000 kg ha^{-1}, 4 000 kg ha^{-1} and 6 000 kg ha^{-1} GOF. At 70 dap, the highest average was shown in the treatment of 3 000 kg ha^{-1} GOF with average value of 89.4 but not significantly different from the standard treatment, 2 000 kg ha^{-1}, 4 000 kg ha^{-1}, 5 000 kg ha^{-1}, and 6 000 kg ha^{-1} GOF. At the age of 35 and 56 dap the highest average was shown in the treatment of 4 000 kg ha^{-1} GOF. At 56 dap, the addition of GOF organic fertilizer to 6 000 kg ha^{-1} did not show any significant difference. This indicated that the nutrients contained in the treated organic fertilizer did not affect the height of the rice plant because the GOF cannot be directly utilized by the plant and also the amount of nutrients contained in the GOF was low. According to [9], granules fertilizer or pellets can prevents the occurrence of segretion, prevents an overdose of plants against shedding sudden nutrition. The results of this study are different from [10] that plant height were significantly increased in all the treatments over control.

Table 1. Effect of GOF on plant height

Treatment (kg ha^{-1})	Plant height (cm)			
	21 dap	35 dap	56 dap	70 dap
Control (without fertilizer)	46.9 c	54.9 c	55.9 b	77.2 c
Standart (2 000 Petroganik + 300 Urea + 300 Phonska)	51.5 b	57.2 bc	69.7 a	85.3 ab
(1 000 GOF + 300 Urea + 300 Phonska)	52.2 b	56.9 bc	68.5 a	80.7 bc
(2 000 GOF + 300 Urea + 300 Phonska)	53.5 ab	58.5 bc	70.5 a	88.0 a
(3 000 GOF + 300 Urea + 300 Phonska)	57.7 a	61.3 ab	69.0 a	89.4 a
(4 000 GOF + 300 Urea + 300 Phonska)	54.7 ab	64.5 a	71.7 a	88.0 a
(5 000 GOF + 300 Urea + 300 Phonska)	52.9 b	59.9 ab	69.6 a	87.7 a
(6 000 GOF + 300 Urea + 300 Phonska)	55.1 ab	59.7 abc	70.5 a	88.0 a
Anova	*	*	*	*
CV (%)	4.62	4.78	5.22	3.15
LSD 5 %	4.29	4.95	6.23	4.72

Note: GOF = Granular Organic Fertilizer, dap = Day After Planting
The number followed by the same letter in one column was not significantly different based on the LSD test of 5 %
* = Significantly different at 5 %

Table 2 showed that the highest average number of tillers at the age of 21 dap was shown in the dose of 4 000 kg ha^{-1} GOF with an average value of 19.6. At the age of 35 dap, the highest average number of tillers was at the dose 5 000 kg ha^{-1} GOF, but not significantly different with the treatment of 3 000 kg ha^{-1} GOF. At the age of 56 and 70 dap, the highest number of tillers was obtained in the treatment of 5 000 kg ha^{-1} GOF. At the age of 70 dap, the number of tillers in the treatment was not significantly different with the treatment of 4 000 kg ha^{-1} GOF, 6 000 kg ha^{-1} GOF.

Table 2. Effect of GOF on number of tillers

Treatment (kg ha^{-1})	Number of tillers			
	21 dap	35 dap	56 dap	70 dap
Control (without fertilizer)	11.3 e	13.3 e	13.7 e	13.9 e
Standart (2 000 Petroganik + 300 Urea + 300 Phonska)	15 cd	15.0 d	17.8 d	17.9 d
(1 000 GOF + 300 Urea + 300 Phonska)	14.1 d	16.2 c	19.5 cd	19.5 cd
(2 000 GOF + 300 Urea + 300 Phonska)	17.3 b	19.6 b	21.0 bc	21.4 bc
(3 000 GOF + 300 Urea + 300 Phonska)	17.0 b	20.7 ab	21.0 bc	23.1 ab
(4 000 GOF + 300 Urea + 300 Phonska)	19.6 a	19.6 b	21.4 b	23.5 a
(5 000 GOF + 300 Urea + 300 Phonska)	16.3 bc	21.0 a	24.2 a	24.2 a
(6 000 GOF + 300 Urea + 300 Phonska)	15.5 bc	20.9 a	22.0 b	23.2 ab
Anova	**	**	**	**
CV (%)	7.12	3.68	5.12	5.84
LSD 5 %	1.96	3.11	1.80	2.13

Note: GOF = Granular Organic Fertilizer, dap = Day After Planting
The number followed by the same letter in one column was not significantly different based on the LSD test of 5 %
* = Significantly different at 5 %

The number of panicles per clump ranged from 7.9 to 14.6 panicles. The lowest number of panicles was found in the treatment without fertilization while the highest was achieved in the treatment of 3 000 kg ha^{-1} GOF, but not significantly different with the treatments of 2 000 kg ha^{-1} GOF, 4 000 kg ha^{-1} GOF, 5 000 kg ha^{-1} GOF, and 6 000 kg ha^{-1} GOF (Table 3).

The number of filled grains per panicle ranged from 86.6 to 172.0. Filled Grain panicle^{-1} is lowest in the treatment without fertilization, while the highest is in the treatment of 5 000 kg ha^{-1} GOF, which is not significantly different from the number of filled grain in the treatment of 3 000 kg ha^{-1} GOF, 4 000 kg ha^{-1} GOF and 6 000 kg ha^{-1} GOF (Table 3).

The number of empty grains panicle^{-1} ranges from 9.2 to 22.0. The highest number of empty grain is found in the highest fertilizer treatment (6 000 kg ha^{-1} GOF). While the lowest number of empty grains was found in the treatment of 2 000 kg ha^{-1} GOF, which was not significantly different from the treatment of 1 000 kg ha^{-1} GOF (Table 3).

Table 3. Effect of GOF on number of panicles per clump, number of filled and empty grain panicle^{-1}

Treatment (kg ha^{-1})	Number of panicles clump^{-1}	Number of grain per panicles	
		Filled	Empty
Control (without fertilizer)	7.9 d	86.6 c	11.7 d
Standart (2 000 Petroganik + 300 Urea + 300 Phonska)	12.5 bc	124.8 b	11.2 d
(1 000 GOF + 300 Urea + 300 Phonska)	11.2 c	121.7 bc	11.0 de
(2 000 GOF + 300 Urea + 300 Phonska)	13.3 ab	125.3 b	9.2 e
(3 000 GOF + 300 Urea + 300 Phonska)	14.6 a	152.9 ab	12.3 d
(4 000 GOF + 300 Urea + 300 Phonska)	14.4 a	148.8 ab	14.8 c
(5 000 GOF + 300 Urea + 300 Phonska)	14.5 a	172.0 a	18.1 b
(6 000 GOF + 300 Urea + 300 Phonska)	13.3 ab	154.8 ab	22.0 a
Anova	**	**	**
CV (%)	7.20	14.44	7.34
LSD 5 %	1.61	34.39	1.77

Note: GOF = Granular Organic Fertilizer
The number followed by the same letter in one column is not significantly different based on the LSD test of 5 %
** = Significantly different at 1 %

Table 4 showed that the weight of 1 000 seeds no significant difference among treatments. It showed that the GOF and petroganik did not affect the weight of seeds. For variable harvested driedgrain yield, the treatments showed very significant differences. Harvested dried grain yield ranged from 3.57 t ha^{-1} to 7.21 t ha^{-1}.

The lowest harvested dried grain yield was found in the treatment without fertilization, while the highest was achieved in the treatment of 3 000 GOF but no significant difference with the 4 000 GOF and 5 000 GOF (Table 4).

This research showed that the increase in the amount of GOF was not followed by the rate of increase in production. The reasons were, i) GOF utilization had the same effect as petroganik fertilizer, ii) In production parameters, GOF and petroganik gave the same advantages effect. Besides nutrients as a determinant of productivity, rice varieties also determined the yields.

Organic fertilizer is useful for improving the texture and structure of the soil, there by accelerating the process of absorption of nutrients by plants. Improved soil structure, a season–long supply of nutrients, and an increased water–holding capacity are some of the benefits of using organic fertilizers [11, 6]. The absorption of nutrients following the needs of plants havea positive impact on plant growth and yield. The generative phase begins with the emergence of rice panicles, followed by the process of fruit set and seed set. Environmental conditions and the availability of nutrients is very influential in the filling phase of rice grains. The different environmental conditions results in the difference in temperature and radiation which ultimately affected grain yield formation in rice [12, 13]. Therefore, providing the right type of nutrition and the right amount can increase rice yield and productivity.

Table 4. Effect of GOF on 1 000 seed weights and harvested dried grain yield

Treatment (kg ha^{-1})	1 000 seed weights (g)	Harvested dried grain yield (t ha^{-1})
Control (without fertilizer)	26.1 ab	3.57 e
Standart (2 000 Petroganik + 300 Urea + 300 Phonska)	25.9 ab	6.71 cd
(1 000 GOF + 300 Urea + 300 Phonska)	25.9 ab	6.65 d
(2 000 GOF + 300 Urea + 300 Phonska)	26.8 a	6.71 cd
(3 000 GOF + 300 Urea + 300 Phonska)	25.9 ab	7.21 a
(4 000 GOF + 300 Urea + 300 Phonska)	25.7 b	7.11 ab
(5 000 GOF + 300 Urea + 300 Phonska)	26.17 ab	7.15 a
(6 000 GOF + 300 Urea + 300 Phonska)	25.6 b	6.89 bc
Anova	ns	**
CV (%)	2.16	2.05
LSD 5%	0.98	0.23

Note: GOF = Granular Organic Fertilizer
The number followed by the same letter in one column is not significantly different based on the LSD test of 5 %
ns = Not significantly different
** = Significantly different at 1 %

The results of RAE analysis showed that the treatment GOF 1 000 kg had not been able to match the treatment Standart, because it had the RAE value of 98 %, which means that treatment GOF 1 000 kg was not feasible to apply. While the treatment GOF 3 000 kg was effective based on agronomic with the RAE value was 116 %. This means that the dose of the fertilizer can increase yield by 1.16 times (Table 5).

Table 5. RAE value of GOF treatments on rice plants

Treatments (kg ha^{-1})	RAE (%)
Control (without fertilizer)	–
Standart (2 000 Petroganik + 300 Urea + 300 Phonska)	–
(1 000 GOF + 300 Urea + 300 Phonska)	98
(2 000 GOF + 300 Urea + 300 Phonska)	100
(3 000 GOF + 300 Urea + 300 Phonska)	116
(4 000 GOF + 300 Urea + 300 Phonska)	113
(5 000 GOF + 300 Urea + 300 Phonska)	114
(6 000 GOF + 300 Urea + 300 Phonska)	106

Table 6 showed the results of the economic feasibility analysis of each treatment. The revenue rate is the result of multiplying the selling price of grain with grain yield. Based on the selling price of grain at the time of the study was IDR 3 500 kg^{-1}, then the average income of farmers ranged from ID R12 495 000 to IDR 25 235 000. The lowest income was shown in treatment without fertilizer while the highest was in treatment GOF 3 000 kg.

Table 6. Recapitulation of simple economicanalysis of GOF treatment on rice

Treatments (kg ha^{-1})	Income (x IDR 1 000)	Cost (x IDR 1 000)	Benefit (x IDR 1 000)	R/C
Control (without fertilizer)	12 495	13 480	(985)	0.93
Standart (2 000 Petroganik + 300 Urea + 300 Phonska)	23 485	15 740	7 745	1.49
(1 000 GOF + 300 Urea + 300 Phonska)	23 275	16 640	6 635	1.40
(2 000 GOF + 300 Urea + 300 Phonska)	23 485	18 540	4 945	1.27
(3 000 GOF + 300 Urea + 300 Phonska)	25 235	20 440	4 795	1.23
(4 000 GOF + 300 Urea + 300 Phonska)	24 885	22 340	2 545	1.11
(5 000 GOF + 300 Urea + 300 Phonska)	24 885	24 240	785	1.03
(6 000 GOF + 300 Urea + 300 Phonska)	24 115	26 140	(2 025)	0.92

Description of price per kg :
Grain yield = IDR 3 500, Urea = IDR 1 900, Phonska = IDR 2 300, Petroganik = IDR 500, GOF = IDR 1 900.

Farming costs consist of land rent, labor costs, seeds, organic fertilizer (Petroganik), GOF fertilizer, Phonska, Urea, fungicide, and insecticide in one planting season. The lowest total cost was shown in treatment without fertilizer of IDR 13 480 000 and the highest cost for treatment GOF 6 000 kg of IDR 26 140 000 (Table 6).

The benefit is the difference between revenue and costs incurred. Table 6 showed that the GOF treatment reached the highest profit was in treatment GOF 1 000 kg ha^{-1} of IDR 6 635 000 with an R/C ratio of 1.40 but still below the standard treatment (Table 6). Increased use of GOF 5 000 kg ha^{-1} resulted in reduced profits. On the use of GOF 6 000 kg ha^{-1} GOF suffered a loss of IDR 2 025 000 with an R/C ratio of 0.92. This showed that the increase in the use of GOF is not proportional to the rate of increase in production and results in reduced profits.

4 Conclusions

Granule Organic Fertilizer (GOF) significantly affected the growth and yield of rice plants. The use of GOF 3 000 kg + 300 kg Urea + 300 kg Phonska ha^{-1} had the highest grain yield

(7.21 t ha^{-1}) with an RAE value of 116 % or an increase of 0.5 t (7.45 %) compared to grain yield at the use of standard fertilizers (2 000 kg ha^{-1} Petroganic + 300 kg ha^{-1} Urea + 300 kg ha^{-1} Phonska). The highest profit rate for using GOF 1 000 kg ha^{-1} + 300 kg ha^{-1} Urea + 300 kg ha^{-1} Phonska was IDR 6 635 000 with an R/C ratio of 1.4.

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