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Maximizing Yield of the Black Cute Rice Using Human Urine and NPK Fertilizer

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Abstract

Nutrients are one of the most important elements for plants. Lack of nutrients causes growth and yields will not be optimal. The use of organic liquid human urine and NPK fertilizer is a source of micro and macronutrients to increase the yield of black cute rice. This study aims to determine the best combination dose of organic liquid human urine and NPK fertilizer to maximize the yield of black cute rice. The research was arranged in a randomized complete block design (RCBD) with two factors and three replications. The first factor was human urine liquid organic fertilizer, which consisted of three levels, namely 0, 500, and 1000 L ha^{-1}. The second factor was the dose of NPK compound fertilizer, which consisted of three levels, namely 0, 150, and 300 kg ha^{-1}. The difference between the averages of the treatment was compared using Duncan's new multiple range test (DMRT) at a 5% significance level. The results showed that a combination of organic liquid human urine and NPK fertilizer could increase the number of productive tillers, canopy dry weight, and grain dry weight of black cute rice. The highest grain dry weight was found at the combination between human urine of 1000 L ha^{-1} and NPK compound of 300 kg ha^{-1} and yielded the maximum grain dry weight of 8.633 tons ha^{-1} in Litosol soil. The combination between human urine of 1,000 L ha^{-1} and NPK compound of 300 kg ha^{-1} can maximize the yield of black cute rice. For future research, we recommend that the combination between human urine of 1,000 L ha^{-1} and NPK compound of 300 kg ha^{-1} can use in other rice varieties.

Keywords: Black cute rice, human urine, NPK fertilizer, nutrient.

Introduction

Rice is the most important food crop in the world and the main source of food for more than half of the world's population. Rice accounts for 35-75% of the calories consumed by more than 3 billion Asians. Rice is grown on an area of 154 million hectares each year (11%) of agricultural land worldwide [1]. Rice is one of the food crops cultivated by most of the world's population [2].

Currently, several types of rice that are rich in anthocyanins are known, such as black rice, red rice, black glutinous rice (*Oryza sativa* L.), and others [3]. Black glutinous rice has different properties from black rice because of its higher amylopectin content. The productivity of black glutinous rice could not be separated from the application of fertilizer. Fertilizer is an organic or inorganic material that was applied to the soil to add one or more nutrients needed for plant growth. Human urine is a natural resource that can be used as natural fertilizer because it still contains nutrients.

In human feces, urine is mostly nitrogen (N), phosphorus (P), and potassium (K) [4]. Human urine contains large amounts of primary plant nutrients, namely nitrogen (N), phosphorus (P), potassium (K), and secondary nutrients, including sulfur (S), calcium (Ca), and Magnesium (Mg). Urine has an element of N, P, K value of 18:2:5 [5] and for urine mixed with flush water, a ratio of N, P, K, S was 15:1:3:1 [6]. The chemical composition of human urine depends on time, diet, climate, physical activity, and body size [7]. Beaune [8] stated that however human urine is composed of nitrogen (N), inorganic potassium (K), phosphorus (P), Calcium (Ca), Sulfur (S), and Magnesium (Mg) directly absorbable by plants, similarly to commercial fertilizers [5], [9], [10].

Too much human urine application can lead to the accumulation of sodium (Na) and nitrogen (N) in the soil and ultimately inhibit plant growth [11]. However, it contains some salts [10], and drugs [12], [13]. Regarding the problem of salt (Na), too much human urine volume applied to agricultural land as fertilizer can simultaneously lead to excess sodium in the soil and ultimately in plants. Sodium inhibits plant growth because it interferes with water uptake at the roots, spreading soil particles, limit root growth and/or interfere with the uptake of competitive nutrients [11]. Sheneni et al. [14] added that male and female urine increased the growth rate and phytochemical constituents of *Zea mays* by 50, 100, and 150 ml, respectively. High urine concentration (200 ml) inhibits the growth of *Zea mays*. This study shows that urine is a good source of fertilizer at very low concentrations.

The nutrient content in human urine is relatively low. For the need for sufficient rice plant nutrient elements, industrial fertilizers were needed, namely NPK compound fertilizers. Aksani et al. [15] in their research concluded that the fertilizer dose of the best response to vegetative and generative growth of rice plants was 250 kg ha^{-1} NPK fertilizer and 300 kg ha^{-1} urea. According to Nafiu et al. (2011) a dose of 200 kg ha^{-1} NPK was sufficient for optimal growth, dry matter production, and yield in field and greenhouse conditions. Also by Samira Samira et al. [17], the application of NPK significantly affected plant height, tiller number, panicle number clump^{-1}, number of total grain panicle^{-1}, percentage of unfilled grain, and filled grain panicle^{-1}, 1,000-grain weight, and potential yield ha^{-1}. Plant nutrient uptake N, P, K, Ca, and Mg increased in both experimental locations. Makinde et al. [18] stated that the combination of organic fertilizer and NPK with a ratio of 75:25 was the best. Paiman et al. [19], added that the use of NPK fertilizer can increase the tillers number clump^{-1}, root dry weight, straw dry weight, and grain dry weight of rice.

Based on the literature search, there has been no comprehensive research related to the combination of liquid organic human urine and NPK compound fertilizer to maximize the productivity of black cute rice in Litosol soil. No previous research has discussed the combination of liquid organic human urine and NPK fertilizers to increase the yield of black cute rice. A combination of liquid organic human urine and NPK compound fertilizer has contributed to increasing the productivity of black cute rice. This study aims to determine the best combination dose of organic liquid human urine and NPK fertilizer to maximize the yield of the black cute rice.

Materials and Methods

Study site

This research was conducted at Kedawung, Jumapolo, Karanganyar, Central Java, Indonesia, from March 19, 2017, to June 23, 2017, at an altitude of 600 m above sea level (ASL) in Litosol soil.

Materials preparation

In study was used anorganic fertilizer of NPK Mutiara. Compound fertilizer content of NPK Mutiara 16-16-16, namely total nitrogen of 6.5%, Nitrate of 6.5%, Ammonium of 9.5%, and total K_2O_5 of 16.0%. Organic liquid fertilizer of human urine content: C organic of 13.87%, total nitrogen of 0.36%, total P of 137.60 ppm, total K of 5,023.80 mg L^{-1} and pH of 4.1.

Experimental design

This study was a factorial and arranged in a randomized completely block design (RCBD) with and three replications. The first factor was liquid organic fertilizer of human urine, which consisted of three levels, namely, 0, 500, and 1000 L ha^{-1}. The second was NPK fertilizer dose, which consisted of three levels, namely, 0, 150, and 300 kg ha^{-1}. In this study was required 27 sample plots.

Research procedures

Soil chemical analysis was carried out before the study which included total N (Kjeldahl method), available P (Bray I method), available K (ammonium acetate extraction), cation exchange capacity (CEC), and pH H_2O. The soil analysis was carried out in the Soil Science laboratory of the Faculty of Agricultural, Sebelas Maret University, Surakarta, Center Java, Indonesia. The experimental plot was made with a size of 4 m (length) × 4 m (width). Then the soil was allowed to dry out until the soil conditions begin to split, and then water is given to the maximum. Irrigation with a flood system at 5 cm above the soil surface. Two weeks before planting, the soil was left damp. Planting was carried out with a plant spacing of 20 cm × 20 cm, and the total population was 400 seedlings rice $plot^{-1}$. Irrigation during rice plant growth was carried out as needed. Application of human urine and NPK fertilizer as a treatment was carried out on rice age of 14 DAP suitable for the treatment. Weeding was carried out on plants 14 days after planting (DAP) and 30 DAP. Pest and disease control used organic pesticides. Harvesting begins when the seed shells at the top of the panicle were clean and hard, and 80% of the seeds had a brown straw.

Parameters observed

The parameters observation included productive tillers number (stem $clump^{-1}$), crown dry weight (g $clump^{-1}$), and grain dry weight (tons ha^{-1}). Measurement of the crown and grain dry weight used the Ohaus PA214 Pioneer Analytical Balance.

Statistical analysis

Statistical was performed using analysis of variance (ANOVA) SAS 9.1 program. The difference between the average of the treatment was compared using DMRT at 5% significant level [20].

Results and Discussion

The chemical of soil analysis

Soil analysis of the contents included N, P, K, cation exchange capacity (CEC), and pH H_20. Soil analysis results are shown in Table 1.

Table 1: Pre-experiment of Litosol soil characteristics.

Parameter	Total N (%)	P_2O_5 total (%)	K_2O (mg L^{-1})	CEC (me 100 g^{-1})	pH H_2O
Value	0.36	0.014%	5,023.80	26.27	4.1
Criteria	Low	Very low	Very high	High	slightly acidic

Table 2: Criteria N, P, K, and CEC of soil

Parameter	Unit	Very low	Low	Medium	High	Very high
N Total	%	< 0.10	0.10-0.20	0.21-0.50	0.51-0.75	> 0.75
P2O5	%	< 0.021	0.021-0.039	0.040-0.060	0.061-0.1	> 0.1
K2O	Me/100 g	< 0.1	0.10-0.20	0.21-0.50	0.51-1.00	> 1.00
CEC	Me/100 g	< 5	5-16	17-24	25-40	40

Source: Soil Research Institute, Bogor, Indonesia (1983).

Table 3: Criteria pH of soil

Very acidic	Acidic	Slightly acidic	Neutral	Slightly alkaline	Alkaline
< 4.5	4.5-5.5	5.6-6.5	6.6-7.5	7.6-8.5	> 8.5

Source: Soil Research Institute, Bogor, Indonesia (1983).

The soil macronutrients were quite low among others total N 0.36% (low), available P 0.014% (very low), except K available 5023.80 me/100 g (very high). The cation exchange capacity was 26.27 me/100 g (high) while the soil pH was 4.1 (slightly acidic). Litosol soil was poor in N nutrients and was classified as less fertile and includes acid soils.

Growth and yield of rice

The ANOVA on productive tillers number, straw dry weight, and grain dry weight is presented in Table 4.

Table 4: Analysis of variance on productive tillers number, straw dry weight, and grain dry weight.

Treatment	Productive tillers number (stem clump^{-1})	Straw dry weight (g clump^{-1})	Grain dry weight (tons ha^{-1})
P	13.41**	15.66**	16.08 **
K	0.95 ns	1.03 ns	1.98 ns
P × K	3.12 *	4.52**	4.49 **
CV (%)	18.26	13.19	13.11

Remarks: P = dose of human urine fertilizer, K = dose of NPK fertilizer, P × K = interaction of P and K, CV = coefficient of variation, ns = non significance, * = at 5% significance level, and ** = at 1% significance level.

Table 4 shows that there was a significant interaction between the dose of liquid organic fertilizers of human urine and the dose of NPK Fertilizers on productive tillers number (stems), straw dry weight (g clump^{-1}), and grain dry weight (tons ha^{-1}).
The DMRT results on average productive tillers number, straw dry weight, and grain dry weight in various doses of human urine and NPK fertilizer can be seen in Table 5.

Table 5. Productive tillers number, straw dry weight, and grain dry weight in various doses of human urine and NPK fertilizer.

Human urine fertilizer (L ha^{-1})	NPK Fertilizer (kg ha^{-1})	Observations		
		Productive tillers number (stem clump^{-1})	Straw dry weight (g clump^{-1})	Grain dry weight (tons ha^{-1})
0	0	8.67 b	19.00 c	5.333 d
	150	9.07 b	20.53 bc	5.866 cd
	300	10.67 ab	21.00 bc	5.917 cd
500	0	11.33 ab	27.47 a	6.525 bcd
	150	12.07 ab	25.87 ab	7.350 abc
	300	12.33 ab	26.20 ab	7.217 abc
1000	0	13.67 a	27.27 a	7.350 abc
	150	14.87 a	26.27 ab	8.117 ab
	300	14.53 a	31.67 a	8.633 a

Remarks: The number in the same column was followed by the same characters are not significantly different based on DMRT at 5% significance level.

Table 5 explains that the highest number of productive tillers was the interaction of organic liquid human urine fertilizer with a dose of 1000 L with a compound fertilizer dose of 150 kg NPK ha^{-1} which was not different from the interaction between 1000 L of human urine and 300 kg NPK or without NPK fertilizer. Besides that, it is also no different from the dose of human urine of 500 l with a dose of NPK compound fertilizer at a dose of 0, 150, 300 kg ha^{-1} or without liquid organic fertilizer for human urine at a dose of 300 kg ha^{-1} NPK. While the number of productive tillers had the least interaction without human urine liquid organic fertilizer and without NPK compound fertilizer, which was no different from without human urine with a dose of NPK 150 or 300 kg ha^{-1}. Besides, it was also not different from the interaction of human urine dose of 500 L with 0.150 or 300 kg ha^{-1} NPK fertilizer.
The highest straw dry weight (Table 5) was achieved in the interaction of liquid organic fertilizer of human urine at a dose of 1000 L ha^{-1} with NPK compound fertilizer at a dose of 300 kg ha^{-1} but not different from human urine interactions doses of 1000 L ha^{-1} with NPK fertilizer at doses of 0 and 150 kg ha^{-1}. In addition, it was not different from the interaction of human urine with doses of 500 L with NPK doses of 0, 150, or 300 kg ha^{-1}. The lowest was without the application of liquid organic fertilizer of human urine and NPK fertilizer (control), but it was not different from without human urine with NPK doses of 150 or 300 kg ha^{-1}. At different doses of NPK fertilizers but at the same liquid organic fertilizer dose, there was no difference in straw dry weight, both the liquid organic fertilizer doses of 0, 500, 1000 L ha^{-1}. The role of liquid organic fertilizer was more dominant than NPK.
Table 5 shows that the highest grain dry weight was achieved at the interaction of the liquid organic fertilizer of human urine dose of 1000 L ha^{-1} with NPK fertilizer at a dose of 300 kg ha^{-1}, but not different from human urine interactions doses of 1000 L ha^{-1} with NPK doses of 0 and 150 kg ha^{-1}. Besides that, it was also not different from the interaction of human urine dose of 1000 L ha^{-1} with NPK dose of 150 and 300 kg ha^{-1}. The lowest was without liquid organic fertilizer of human urine and NPK fertilizer, but it was not different from human urine at a dose of 0 L ha^{-1} with NPK at a dose of 150 or 300 kg ha^{-1}. The effect of a combination dose of human urine and NPK fertilizer on grain dry weight can be seen in Figure1.

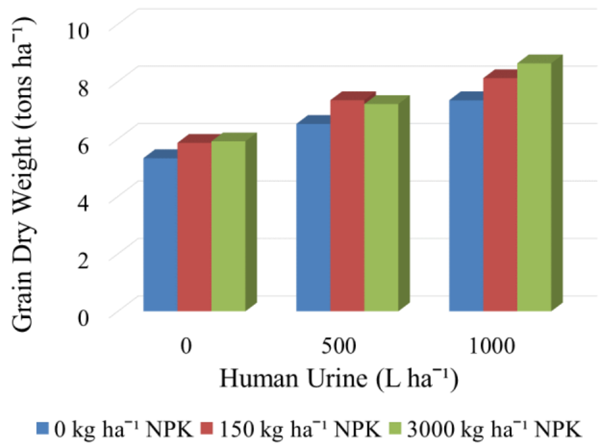

Figure 1: The effect of combination dose of human urine and NPK fertilizer on grain dry weight.

Figure 1 shows that the number of productive tiller was at least in the interaction without liquid organic fertilizer human urine with NPK 150 kg ha^{-1} or without NPK fertilizer and the most interactions with human urine at a dose of 1000 L ha^{-1}, with NPK doses of 0, 150, or 300 kg ha^{-1}. The combination of liquid organic fertilizer from human urine at a dose of 1000 L ha^{-1} with various doses of NPK compound fertilizer or without NPK compound fertilizer did not show a significant difference.

The liquid organic fertilizer of human urine played a greater role in the number of productive tillers. The most striking advantage of liquid organic fertilizers was the absorption of nutrients runs faster than fertilizers given through the roots [21]. It was because the leaves have stomata that could open and close mechanically so that rice plants could grow well. Liquid organic fertilizers were contained micronutrients. Generally, plants were often lack micronutrients if they only rely on root fertilizers, which mostly contain macronutrients [22], stated that microelements are elements that plants need in small amounts. Although only absorbed in small amounts, it was very important to support the success of the process in plants. Micronutrient elements play a role in helping smooth the photosynthesis process and increasing the chlorophyll content. According to Yunus and Dinana [22], an increase in chlorophyll content would increase the rate of plant photosynthesis and the resulting photosynthate content, ultimately increasing plant growth and the number of tillers.

In addition, the faster-absorbed process of nutrients than through the soil, liquid organic fertilizer of human urine had a more complete nutrient composition. Beaune et al. [8] human urine is freely available around the world and composed of nitrogen (N), inorganic potassium (K), phosphorus (P), and other nutrients directly absorbable by plants. Pradhan et al. [10]; Egigu et al. [5] stated that human urine is composed of nitrogen (N) (as urea (75-90%) and ammonium), inorganic potassium (K), phosphorus (P), Calcium (Ca), Sulfur (S), and Magnesium (Mg) directly absorbable by plants, similarly to commercial fertilizers. According to Elhani et al. [23], productive tillers depend on natural resources such as water, nutrients, and light. Grain yield up to 70% comes from the number of productive tillers [24].

The high straw dry weight in the application of human urine liquid organic fertilizer and NPK fertilizer was caused by the role of macro and micronutrient elements contained in human urine liquid organic fertilizer and elements N, P, and K contained in NPK fertilizer. Nitrogen is a macronutrient of the raw material for photosynthesis and chlorophyll. With enough nitrogen, the results of photosynthesis were also quite a lot. With the increase in photosynthetic yield, the growth would increase, so that the dry weight of biomass would increase too. The deficiency of N inhibited growth and decreased yield [21]. While the role of the phosphorus element is to form ATP which functions as energy in the photosynthesis process. The element of potassium as a catalyst for the translocation of photosynthesis results from the source organs (leaves) to the sink organs (panicles). With sufficient potassium, the translocation of photosynthesis results will be maximized so that it will increase the stover dry weight.

The dry weight of grain was related to the dry weight of biomass because the more photosynthetic organs, the more photosynthetic products were stored in the organ sink [22]. The dry weight of grain when harvested had the same pattern as the dry weight of biomass, namely, with a different dose of NPK fertilizer, but the dose of human urine liquid organic fertilizer was the same, there was no difference in dry weight of grain.

One of the causes of decreased productivity of irrigated rice fields was the low content of organic matter and an imbalance of soil nutrients due to improper fertilization [25]. Efficient fertilization was obtained from balanced fertilization, namely the application of fertilizer to the soil to achieve the status of all essential nutrients in a balanced and optimal manner in the soil. Balanced fertilization could increase production, improve the quality of agricultural products, fertilizer efficiency, soil fertility, and avoid environmental pollution. Fertilization combination greatly affected the growth of rice plants [24].

The dry weight of grain at harvest ha^{-1} related to the number of productive tillers and the dry weight of biomass. This is identical to the research of Maruyama et al. [26]. The grain yield had the same pattern as the number of productive tillers, panicle size, or the number of grain. Rice yield components, such as the number of panicles, seed rate, and grain weight increased significantly with P fertilization.

Conclusions

Based on the research results and the discussion above, the conclusion showed that a combination dose of organic liquid human urine and NPK fertilizer could increase the number of productive tillers, canopy dry weight, and grain dry weight of black cute rice. The highest grain dry weight was found at the combination between human urine of 1000 L ha^{-1} and NPK compound of 300 kg ha^{-1} and yielded in the maximum grain dry weight of 8.633 tons ha^{-1}. The combination between human urine of 1,000 L ha^{-1} and NPK compound of 300 kg ha^{-1} reach the maximum yield of black cute rice in Litosol soil. For future research, we recommend that the combination between human urine of 1,000 L ha^{-1} and NPK compound of 300 kg ha^{-1} can use in other rice varieties.

Data Availability

All data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest, financial or otherwise.

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