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RESEARCH ARTICLE

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

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Abstract:

Background:

The nutrient is one of the most important elements for plants. Lack of nutrients cause thegrowth and yield will not be optimal. The use of organic liquid human urine and NPK fertilizer are a source of micro and macronutrients to increase the yield of black cute rice.

Objective:

This study aims to determine the best treatment combination of human urine and NPK fertilizer dose to maximize the yield of black cute rice.

Methods:

The research was arranged in a randomized complete block design (RCBD) with two factors and three replications. The first factor was dose of human urine fertilizer, which consisted of three levels, namely, 0, 500, and 1000 L ha^{-1}. The second factor was the dose of NPK fertilizer, which consisted of three levels, namely, 0, 150, and 300 kg ha^{-1}.

Results:

The results showed that a combination of organic liquid human urine and NPK fertilizer could increase the productive tillers number, canopy dry weight, and grain dry weight of black cute rice. The highest grain dry weight was found at the combination between ferlilizer dose of human urine of 1,000 L ha^{-1} and NPK of 300 kg ha^{-1} and yielded the maximum grain dry weight of 8.633 t ha^{-1} in Litosol soil.

Conclusion:

The research fundings that the combination between human urine of 1,000 L ha^{-1} and NPK 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, Food crop, Plant.

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1. INTRODUCTION

Rice (*Oryza sativa* L.) 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 three 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].

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Currently, several types of rice are rich in anthocyanins, such as black rice, red rice, black glutinous rice, 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. According to Nabavi-Pelesaraei [4], the growing waste production is a result of the increased human population.

In human feces, urine was mostly nitrogen (N), phosphorus

(P), and potassium (K) [5]. Human urine contained 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 had an element of N, P, K value of 18:2:5 [6] and for urine mixed with flush water, a ratio of N, P, K, S was 15:1:3:1 [7]. The chemical composition of human urine depends on time, diet, climate, physical activity, and body size [8]. Beaune [9] 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 [6, 10, 11].

Too much human urine application can lead to the accumulation of sodium (Na) and nitrogen (N) in the soil and ultimately inhibit plant growth [12]. However, it contained some salts [11], and drugs [13, 14]. 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 inhibited plant growth because it interferes with water uptake at the roots, spreading soil particles, limiting root growth, and/or interfering with the uptake of competitive nutrients [12]. Sheneni *et al*. [15] added that male and female urine increased the growth rate and phytochemical constituents of *Zea mays* by 50, 100, and 150 ml clump^{-1}, respectively. High urine concentration (200 ml clump^{-1}) inhibited the growth of *Zea mays*. This study showed that human urine was a good source of fertilizer at very low concentrations.

The nutrient content in human urine was relatively low. The need for sufficient rice plant nutrient elements that industrial fertilizers were needed, namely NPK compound fertilizers. Aksani *et al*. [16] 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*. [17] 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*. [18], the application of NPK significantly affected plant height, tillers number, panicle number clump^{-1}, total grain number panicle^{-1}, percentage of unfilled grain, filled grain panicle^{-1}, 1,000-grain weight, and potential yield ha^{-1}. Makinde *et al*. [19] stated that the combination of organic fertilizer and NPK with a ratio of 75:25 was the best. Paiman *et al*. [20], 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 fertilizer combination of liquid organic human urine and NPK to increase the yield of black cute rice. A combination of liquid organic human urine and NPK has contributed to increasing the productivity of black cute rice. This study aims to determine the best treatment combination of human urine and NPK fertilizer dose to maximize the yield of the black cute rice.

2. MATERIALS AND METHODS

2.1. 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 levels in Litosol soil.

2.2. Materials Preparation

The study used inorganic fertilizer of NPK Mutiara. Compound 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%. Liquid organic fertilizer of human urine contained elements of 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.

2.3. Experimental Design

This study was arranged in a randomized completely block design (RCBD) with two factors and three replications. The first factor wasthe dose of human urine fertilizer, which consisted of three levels, namely, 0, 500, and 1,000 L ha^{-1}. The second was the dose of NPK fertilizer, which consisted of three levels, namely, 0, 150, and 300 kg ha^{-1}. 27 sample plots were required in this study.

2.4. 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 was given to the maximum. Irrigation was conducted with a flood system of 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 suitable needed. Application of human urine and NPK fertilizer as a treatment was carried out on rice at age of 14 DAP was suitable for the treatment. Weeding was carried out on plants at the ages of 14 days after planting (DAP) and 30 DAP. Pest and disease control used organic pesticides. Harvesting when the seed shells at the top of the panicle were clean and hard, and 80% of the seeds had a brown straw.

2.5. Parameters Observed

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

2.6. Statistical Analysis

Statistical was performed using the analysis of variance

(ANOVA) SAS 9.1 program. The difference between the average of the treatments was compared using DMRT at a 5% significant level [21].

3. RESULTS

3.1. The Chemical of Soil Analysis

The results of soil analysis contained N, P, K, cation exchange capacity (CEC), and pH H_2o. 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

Criteria of soil analysis indicate that the soil macronutrients in Litosol soil were quite low, namely, N total of 0.36% (low), P available of 0.014% (very low), except K available of 5,023.80 me 100 g^{-1} (very high). The cation exchange capacity was 26.27 me 100 g^{-1} (high) while the soil pH was 4.1 (slightly acidic). The Litosol soil was poor in N nutrients and was classified as less fertile and included acid soils.

3.2. Growth and Yield of Rice

The ANOVA on productive tillers number, straw dry weight, and grain dry weight of black cute rice is presented in Table **2**.

Table 2. 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 (t $ha^{-1)}$
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% significantlevel, and ** = at 1% significantlevel.

Table **2** shows that there was a significant interaction between the dose of human urine and NPK on productive tillers number (stems), straw dry weight (g $clump^{-1}$), and grain dry weight (t 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 **3**.

(Table **3**) explains that the highest number of productive tillers was the interaction of human urine dose of 1000 L $ha^{-1}$and NPK dose of 150 kg ha^{-1}, which was not different from the interaction between human urine of 1,000 L $ha^{-1}$and NPK of 300 kg ha^{-1}or without NPK fertilizer. Besides that, it is also not different from the dose of human urine of 500 L $ha^{-1}$with a dose of NPK fertilizer at a dose of 0, 150, and 300 kg ha^{-1} or without human urine and NPK dose of 300 kg ha^{-1}. While the productive tillers number had the least interaction without human urine and without NPK fertilizer, which was not different from without human urine and NPK dose of 150 or 300 kg ha^{-1}. Besides, it was also not different from the interaction of human urine dose of 500 L $ha^{-1}$and NPK dose of 150 or 300 kg ha^{-1}.

Table 3. 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 (t 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
1,000	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 followed by the same characters are not significantly different based on DMRT at a 5% significant level.

The highest straw dry weight (Table **3**) was achieved in the interaction of human urine dose of 1000 L $ha^{-1}$and NPK fertilizer dose of 300 kg ha^{-1} but not different with human urine interactions dose of 1000 L $ha^{-1}$and NPK fertilizer doses of 0 and 150 kg ha^{-1}. In addition, it was not different from the interaction of human urine dose of 500 L $ha^{-1}$and NPK doses of 0, 150, or 300 kg ha^{-1}. The lowest was without the application of human urine and NPK fertilizer (control), but it was not different from without human urine and NPK doses of 150 or 300 kg ha^{-1}. At different doses of NPK fertilizers, in the same human urine dose, there was no difference in straw dry weight, both the human urine doses of 0, 500, and 1,000 L ha^{-1}. The role of human urine was more dominant than NPK fertilizer.

Table **3** shows that the highest grain dry weight was achieved at the interaction of the human urine dose of 1000 L $ha^{-1}$and NPK fertilizer dose of 300 kg ha^{-1}, but not different from human urine interactions dose of 1000 L $ha^{-1}$and 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 $ha^{-1}$and NPK doses of 150 and 300 kg ha^{-1}. The lowest was without human urine and NPK fertilizer, but it was not different from without human urine and NPK 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 Fig. (**1**).

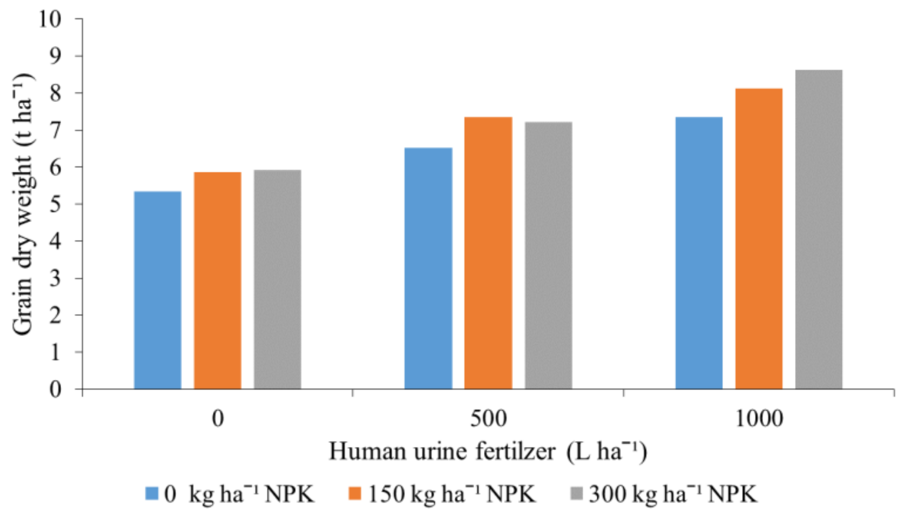

Fig. (1). The effect of a combination dose of human urine and NPK fertilizer on grain dry weight.

Fig. **1** shows that the productive tillers number was at least in the interaction without human urine and NPK 150 kg ha^{-1} or without NPK fertilizer and the most interactions with human urine dose of 1,000 L ha^{-1}, andNPK doses of 0, 150, or 300 kg ha^{-1}. The combination of human urine dose of 1,000 L ha^{-1} with various doses of NPK compound fertilizer or without NPK compound fertilizer did not show a significant difference.

4. DISCUSSION

Human urine played a greater role in the productive tillers number. The most striking advantage of liquid organic fertilizers was the absorption of nutrients runs faster than fertilizers given through the roots [22]. It was because the leaves have stomata that could open and close mechanically so that rice plants could grow well. Liquid organic fertilizer contained micronutrients. Generally, plants often lack micronutrients if they only rely on root fertilizers, which mostly contain macronutrients. Samanhudi *et al*. [23], 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 [23], an increase in chlorophyll content would increase the plant photosynthesis rate resulting in photosynthate content, ultimately increasing plant growth and tillers number.

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 was 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*. [11]; Egigu *et al*. [6] stated that human urine was 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*. [24], productive tillers number depends on natural resources such as water, nutrients, and light. Grain yield up to 70% came from the number of productive tillers [25].

The high straw dry weight in the application of human urine and NPK fertilizer were caused by the role of macro and micronutrient elements contained in human urine and elements of N, P, and K were 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 [22]. While the role of the phosphorus element was to form ATP which functions as energy in the photosynthesis process. The element of potassium as a catalyst for the translocation of photosynthesis has resulted from the source organs (leaves) to the sink organs (panicles). With sufficient potassium, the translocation of photosynthesis will be maximized so that it will increase the stover dry weight.

The grain dry weight is related to the dry weight of biomass because the more photosynthetic organs, the more photosynthetic products were stored in the organ sink [23]. The grain dry weight when harvesting 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 the grain dry weight. According to Nabavi-Pelesaraei [26], eco-efficiency of organic farming systems is positively related to yield and is systematically higher compared to conventional and limited input farming systems.

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 [27]. 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 crops [25].

The grain dry weight at harvest ha^{-1} is related to the productive tillers number and biomass dry weight. This was identical to the research of Maruyama *et al*. [28]. The grain yield had the same pattern as the productive tillers number, panicle size, or grain number. Rice yield components, such as the panicles number, seed rate, and grain weight increased significantly with P fertilization.

CONCLUSION

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

LIST OF ABBREVIATIONS

RCBD	=	Randomized Complete Block Design
CEC	=	Cation Exchange Capacity
DAP	=	Days After Planting

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No humans or animals were used in this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

None.

CONFLICTS OF INTEREST

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

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