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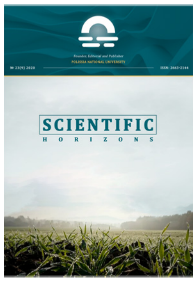

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Effects of different types of local potential manure on the availability and uptake of P and K of rice in Inceptisols

Suntoro Suntoro*
Doctor
Universitas Sebelas Maret
57126, 36A Ir. Sutami, Surakarta, Indonesia
https://orcid.org/0000-0003-0369-7539

Ganjar Herdiansyah
Master
Universitas Sebelas Maret
57126, 36A Ir. Sutami, Surakarta, Indonesia
https://orcid.org/0000-0001-5841-4642

Hery Widijanto
Doctor
Universitas Sebelas Maret
57126, 36A Ir. Sutami, Surakarta, Indonesia
https://orcid.org/0000-0002-1781-7004

Adelia Pebrina Liestyabudi
Undergraduate Student
Universitas Sebelas Maret
57126, 36A Ir. Sutami, Surakarta, Indonesia

Annisa Fitriyani Adien Istiqomah
Undergraduate Student
Universitas Sebelas Maret
57126, 36A Ir. Sutami, Surakarta, Indonesia

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Abstract. The availability of Inceptisols nutrients is not sufficient for organic farming activities in rice cultivation, therefore it can be optimized by adding organic fertilizers, one of which is manure. The study aims to determine the effect of various manure types on the availability and uptake of P and K nutrients of rice in Inceptisols. The study used a single-factor Randomized Complete Group Design with 10 treatments: T1 = control; T2 = NPK 200 kg/ha; T3 = cow manure 10 tons/ha; T4 = chicken manure 10 tons/ha; T5 = goat manure 10 tons/ha; T6 = quail manure 10 tons/ha; T7 = NPK 100 kg/ha + cow manure 5 tons/ha; T8 = NPK 100 kg/ha + chicken manure 5 tons/ha; T9 = NPK 100 kg/ha + goat manure 5 tons/ha; T10 = NPK 100 kg/ha + quail manure 5 tons/ha

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**Corresponding author*

repeated 3 times with experimental plots measuring 2.5 m×4 m. The results showed that quail manure applied singly or in combination with NPK fertilizer had a substantial effect on available P, exchangeable K, and plant P and K uptake. This is determined by high P and K nutrient contents in manure and has a lower C/N ratio than other manures. The results showed that quail manure was able to increase the availability and uptake of P and K nutrients of rice plants in Inceptisols. Thus, quail manure can be a recommended organic fertilizer for rice cultivation

Keywords: organic fertilizer; macro-nutrients; organic matter; soil fertility; rice field

INTRODUCTION

Rice is a crop and a source of staple food for most of Indonesia's population. The increasing population is always followed by the demand for rice. The demand for rice that must be met causes rice fields to be continuously planted. Moreover, inorganic fertilizers, that are not balanced with organic fertilizers, are used. This decreases land productivity. The decline in land/soil productivity is related to soil properties, namely soil physical, chemical and biological properties. One of the chemical properties that has a direct influence on crop production is nutrients.

The availability of nutrients in the soil is important for plant growth and development. This is because plants cannot survive if nutrients are not available in the soil. Following A. Adekiya *et al.* (2020), plants that do not get enough nutrients will have poor performance that affects growth and reduces crop yields. According to Sh. Jiban *et al.* (2020), rice plants need P nutrients in root development, ripening, and early flowering, while potassium elements optimize root development, increase plant vigour, stimulate cell division, help neutralize organic acids, and maintain plant metabolism. However, the presence of these nutrients cannot meet the needs of plants due to several factors, such as leaching or the formation of complex compounds with other elements. Low nutrient availability also occurs in Inceptisol soil.

Based on the results of research by I. Septyani and F. Harahap (2022), Inceptisol soils have low organic C content and nutrients N, P, K. Thus, Inceptisols have low nutrient availability. Thus, Inceptisols have low fertility. According to H. Husein *et al.* (2021), the presence of soil organic matter content and the availability of macronutrients in the soil are indicators of soil fertility. The low phosphorus and potassium nutrients in Inceptisol soils are determined by a lengthy process of the mineral rocks weathering and the process of releasing nutrients into plant-available forms. In addition, J. Sardans and J. Peñuelas (2021) stated that the element potassium has high mobility so it is easily leached from the soil profile. Therefore, efforts are needed to increase the content of nutrients as well as soil organic matter, namely with manure.

Manure improves the physical, chemical, and biological properties of soil. Manure can increase soil fertility, and water retention and control soil temperature to improve plant growth and productivity. According to S. Suntoro *et al.* (2023), long-term application of manure can provide a residual effect on the availability of nutrients and a looser soil structure. Compared to inorganic fertilizers, organic fertilizers can provide complete nutrients, although in small amounts. Therefore, it is needed in large quantities to meet the nutrient needs of plants. According to M. Islam *et al.* (2021), the mineralization process of manure requires microbes to release nutrients into the soil. N. Rayne and L. Aula (2020) state that manure applied alone or in combination with chemical fertilizers can increase the accumulation of macronutrients and micronutrients in the soil. Based on research by P. Gao *et al.* (2023), the combination of manure with NPK fertilizer can have a significant effect on available P and total soil P levels than inorganic fertilizer (NPK) alone. S. Dhaliwal *et al.* (2022) reported that the use of organic fertilizers and inorganic fertilizers can significantly increase the uptake of macronutrients and micronutrients and increase the yield of basmati grain and straw. Therefore, a study was conducted to analyse the effect of various types of manure on the availability and uptake of P and K nutrients of rice plants in Inceptisols.

MATERIALS AND METHODS

Study area. This research was conducted in Gempol Village, Karanganom District, Klaten Regency, Central Java. Soil and plant analysis were analysed at the Soil Chemistry and Fertility Laboratory, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta. The research was conducted from May 2023 to March 2024.

Procedures. *Study Methods.* This research uses an experimental method with a Randomized Completely Group Design (RCBD). The study used 10 treatments with 3 replications, resulting in 30 experimental plots. Plot sizes were 2.5 m × 4 m. Rice plants were planted at 25 × 25 cm spacing. The rice variety used was Rojolele. The treatments used are presented in Table 1.

***Table 1**. Treatment in the research*

Code	Treatment	Dose			
		Manure		NPK	
		(kg/ha)	(kg/plot)	(kg/ha)	(kg/plot)
T1	Control	0	0	0	0
T2	NPK	0	0	200	0,2

Table 1. Continued

Code	Treatment	Dose			
		Manure		NPK	
		(kg/ha)	(kg/plot)	(kg/ha)	(kg/plot)
T3	Cow manure	10.000	10	0	0
T4	Chicken manure	10.000	10	0	0
T5	Goat manure	10.000	10	0	0
T6	Quail manure	10.000	10	0	0
T7	NPK + cow manure	5.000	5	100	0,1
T8	NPK + chicken manure	5.000	5	100	0,1
T9	NPK + goat manure	5.000	5	100	0,1
T10	NPK + quail manure	5.000	5	100	0,1

Source: *compiled by the authors*

Implementation of research. Tillage was done by ploughing the soil until muddy and levelling it. The experimental plots used were 2.5 m × 4 m in size. Manure application was done after tillage, i.e. 6 days before planting. NPK fertilization was done twice, 7 and 21 days after planting (DAP). Maintenance included irrigation, weeding, and pest and disease control. Soil and plant sampling were conducted at the maximum vegetative phase (60 days). Soil samples were taken in each plot with a total of 30 samples and plant tissue samples were taken 3 samples per plot with a total of 90 samples.

Soil and plant analysis. Soil analysis included pH (electrometric method); organic C (Walkley and Black method); available P (Olsen method); exchangeable K, Cation Exchange Capacity (CEC), and Base Saturation (BS) (1 N ammonium acetate extraction method pH 7). Plant analysis included: plant tissue P and K (extraction with HNO_3 and $HClO_4$). The nutrient uptake of the upper crop (shoot) is obtained from the multiplication of the crop dry weight with the crop nutrient content. Manure analysis includes: pH (electrometric method), total N (Kjeldahl method), total P, and total K (HNO_3 and $HClO_4$ extraction) (Balai Pengujian Standar Instrumen Tanah dan Pupuk, 2023)

Data analysis. The results were analysed using ANOVA at the 95% and 99% confidence levels, followed by Duncan Multiple Range Test (DMRT) at the 95% confidence level to see whether there were differences between treatments, Pearson correlation test to determine the strength of the relationship between the observed variables, and regression test to see how much influence the independent variable has on the dependent variable.

RESULTS AND DISCUSSION

Soil characteristics. The soil at the study site belongs to the Inceptisols order. Inceptisol soils have an issue of low organic matter and nutrients N, P, K. (Yuniarti *et al.*, 2021). This soil has a pH of 6.71 (neutral), Organic C 1.36% (low), CEC 17.64 me/100g soil (moderate), Available P 9.93% (low), Exchangeable K 0.21 me/100 g (low), Base Saturation 32.26% (low) which are presented in Table 2.

Table 2*. Soil characteristics at the study site*

Analysis	Value	Unit	Classification
pH	6.71	-	Neutral
Organic C	1.39	%	Low
Total N	0.12	%	Low
Available P	9.92	ppm	Low
Exchangeable K	0.20	meq/100 g of soil	Low
Cation Exchange Capacity	17.81	meq/100 g of soil	Medium
Base Saturation	32.26	%	Low

Source: *classification based on Balai Pengujian Standar Instrumen Tanah dan Pupuk (Balai Pengujian Standar Instrumen Tanah dan Pupuk, 2023*

Based on these soil characteristics, the Inceptisol soil in Gempol Village has low soil fertility. The low soil fertility is determined by low available nutrients and soil organic matter content. According to H. Husein *et al.* (2021), soil fertility can increase along with the increase in soil organic matter content, and natural soil fertility can be maximized if the soil pH ranges from 5.5 to 7.0, good drainage, and the presence of various microorganisms that support plant growth.

Characteristics of manure. The manure, employed in this study, is sourced from animal manure in the local area. Potential local manures include cow, chicken, goat, and quail manure. The four manures have a C/N ratio of <20, so the mineralization process will occur faster. This is because the C/N ratio can be used to measure the quality of organic matter, which shows the decomposition process of organic matter (Istikorini *et al.,* 2022). The four manures also have Organic C content and nutrients N, P, and K that can potentially input organic matter into the soil (Table 3).

***Table 3**. Characteristics of manure*

Treatment	Analysis					
	pH	Total N (%)	Total P (%)	Total K (%)	Organic C (%)	C/N
Cow manure	9.06	2.03	0.62	15.57	30.09	14.8
Chicken manure	7.68	2.44	0.26	8.88	31.56	13.0
Goat manure	8.85	2.29	0.16	7.91	27.25	11.9
Quail manure	9.64	3.32	1.67	12.75	32.14	9.7

***Source:** compiled by the authors*

Effect of treatment on soil chemical properties. Variance analysis showed that applying different types of manure had a highly significant effect on soil pH, organic C, and CEC (sig.<0.01). Table 4 shows that treatment A (control) is not significantly different from other types of manure treatments (treatments T4, T5, T6, T7, T8, T9, T10). This treatment shows that the pH has decreased slightly but is still in a neutral condition. This can occur due to a buffer solution that can maintain soil pH. According to C. Yuan *et al.* (2021), the application of soil organic matter increases the soil ph buffering capacity. Treatment T2 (NPK 200 kg/ha) experienced the greatest decrease in soil pH of 6.36 (slightly acidic). This is because inorganic fertilizers such as NPK fertilizer can produce H^+ ions which can lower soil pH. The T3 treatment (10 tons/ha cow manure) also decreased the soil pH to 6.51 (slightly acidic). This decrease can occur since cow manure has the highest C/N ratio compared to other treatments, so the decomposition process is slow. This slow decomposition causes the manure to release still organic acids that can reduce soil pH.

***Table 4**. Effect of treatment on soil chemical properties*

Code	Treatment	pH	Organic C (%)	CEC (meq/100g soil)
T1	Control	6.85 c	1.30 a	20.00 a
T2	NPK	6.36 a	1.43 a	23.78 bc
T3	Cow manure	6.51 ab	2.38 bcd	22.11 ab
T4	Chicken manure	6.68 bc	2.17 bc	22.72 bc
T5	Goat manure	6.70 c	1.85 ab	24.68 cd
T6	Quail manure	6.80 c	2.69 cd	22.21 abc
T7	NPK + cow manure	6.78 c	2.43 bcd	20.03 a
T8	NPK + chicken manure	6.79 c	2.35 bcd	22.26 abc
T9	NPK + goat manure	6.67 bc	2.54 bcd	23.39 bc
T10	NPK + quail manure	6.83 c	2.97 d	26.90 d

***Note:** the numbers followed by different letters in a column show significant results in the DMRT test with a level of 5%*
***Source:** compiled by the authors*

Organic C which showed the highest result, was found in treatment T10 (NPK 100 kg/ha + quail manure 5 tons/ha) at 2.97% (moderate). This can occur as quail manure has greater organic C than other manures. Apart from that, adding NPK fertilizer can also increase the decomposition of organic matter. The T10 treatment (NPK 100 kg/ha + quail manure 5 tons/ha) also had the highest CEC compared to other treatments at 26.90 me/100 g soil (high). According to I. Purnamasari *et al.* (2021), soil CEC depends on pH, soil texture, clay type, and organic matter content.

Effect of Treatment on Soil Available P and Phosphorus Uptake. P nutrient is an essential element that is vital in the growth and development of rice plants, which spurs root growth and accelerates flowering and fruit ripening. The analysis of variance showed that the application of manure had a very significant effect on the availability and uptake of phosphorus (Sig.<0.01). Table 5 shows the results of Duncan's multiple range test at the 5% significance level on soil P-availability and P uptake of rice.

The treatment that gave the highest soil available P and was significantly to other treatments was T10 (NPK 100 kg/ha + quail manure 5 tons/ha) at 20.70 ppm (moderate). Quail manure is an easily weathered manure that mineralizes nutrients faster. In addition, quail manure has a higher P nutrient than other manures. According to A. Antonov *et al.* (2021), quail manure is a high-quality fertilizer as it contains nutrients needed by plants and has a more saturated composition. According to S. Suntoro *et al.* (2023), applying organic fertilizers together with inorganic fertilizers compared to organic fertilizers alone can positively affect microbial biomass and improve soil health. Based on Figure 1, if quail manure is not combined with NPK (treatment P6), it also has the highest yield among manure types, at 16.70 ppm, but is still in the low category.

***Table 5**. Effect of treatment on soil available p and phosphorus uptake*

Code	Perlakuan	Available P (ppm)	Shoot Dry Weight (g/plant)	P Plant Tissue (%)	P Uptake (g/plant)
T1	Control	10.43 a	8.33 a	0.098 a	0.82 a
T2	NPK	12.70 b	33.67 bc	0.133 b	4.46 bc
T3	Cow manure	13.40 bc	33.00 bc	0.144 bc	4.76 bc
T4	Chicken manure	15.44 cde	29.33 bc	0.162 cde	4.74 bc
T5	Goat manure	13.94 bcd	36.00 cd	0.151 bcd	5.45 bc
T6	Quail manure	16.70 e	36.33 cd	0.167 de	6.05 c
T7	NPK + cow manure	15.06 cde	34.33 bc	0.162 cde	5.56 bc
T8	NPK + chicken manure	14.98 cde	25.33 b	0.161 cde	4.08 b
T9	NPK + goat manure	16.18 cd	34.33 bc	0.163 cde	5.59 bc

***Note:** the numbers followed by different letters in a column show significant results in the DMRT test at a 95% confidence level. T1: control, T2: 200 kg/ha NPK fertilizer, T3: 10 tons/ha cow manure, T4: 10 tons/ha chicken manure, T5: 10 tons/ha goat manure, T6: 10 tons/ha quail manure, T7: 5 tons/ha cow manure + 100 kg/ha NPK, T8: 5 tons/ha chicken manure + 100 kg/ha NPK, T9: 5 tons/ha goat manure + 100 kg/ha NPK, T10: 5 tons/ha quail manure + 100 kg/ha NPK*
***Source:** compiled by the authors*

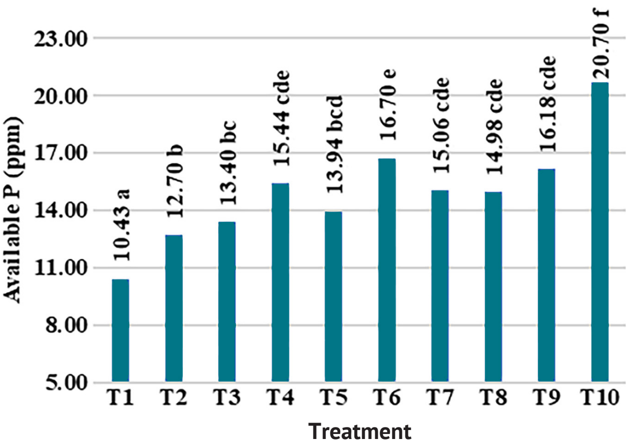

***Figure 1**. Effect of treatment on available P soil*

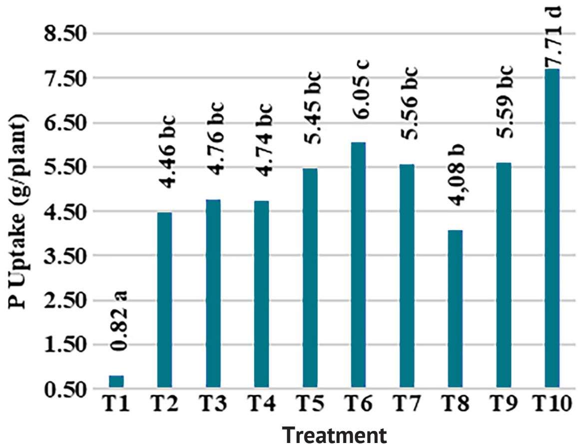

***Figure 2**. Effect of treatment on plant P uptake*

***Note:** T1: control, T2: 200 kg/ha NPK fertilizer, T3: 10 tons/ha cow manure, T4: 10 tons/ha chicken manure, T5: 10 tons/ha goat manure, T6: 10 tons/ha quail manure, T7: 5 tons/ha cow manure + 100 kg/ha NPK, T8: 5 tons/ha chicken manure + 100 kg/ha NPK, T9: 5 tons/ha goat manure + 100 kg/ha NPK, T10: 5 tons/ha quail manure + 100 kg/ha NPK*
***Source:** compiled by the authors*

Based on Figure 2, the treatment that showed the highest P uptake and was significant to other treatments was T2 (NPK 100 kg/ha + quail manure 5 tons/ha) at 7.71 g/plant. This is determined by the high availability of P nutrients in the soil, hence, rice plants can absorb P nutrients more. The research results by Z. Zaki *et al.* (2021) showed that quail manure increased wheat P uptake compared to peanut residue and animal manure. Based on the DMRT test, the application of NPK fertilizer was not significantly different from the application of 10 tons/ha manure (T3, T4, T5, T6) or the combination of 5 tons/ha manure with 200 kg/ha NPK fertilizer (T7, T8, T9). This can occur as the average availability of P in the NPK and manure treatments is moderate (Fig. 1).

Effect of Treatment on Soil Exchangeable K and Potassium Uptake. Potassium has a vital role in stem enlargement of rice plants, regulating enzyme activities, protein synthesis, and increasing the rate of photosynthesis. Analysis of variance showed that the application of manure had a significant effect on exchangeable K (Sig.<0.05) and had a very significant effect on K uptake in rice plants (Sig.<0.01). The results of Duncan's multiple range test at the 5% significance level on exchangeable K and K uptake of rice plants are presented in Table 6.

***Table 6**. Effect of treatment on soil exchangeable K and potassium uptake*

Code	Treatment	Exchangeable K (me/ 100 g of soil)	Shoot Dry Weight (g/plant)	K Plant Tissue (%)	K Uptake (g/plant)
T1	Control	0.17 a	8.33 a	1.93 a	16.06 a
T2	NPK	0.35 b	33.67 bc	3.90 bc	131.41 bc
T3	Cow manure	0.42 b	33.00 bc	3.71 bc	122.54 bc
T4	Chicken manure	0.30 ab	29.33 bc	3.89 bc	114.11 b
T5	Goat manure	0.44 b	36.00 cd	3.78 bc	136.20 bc
T6	Quail manure	0.44 b	36.33 cd	4.74 c	172.34 c
T7	NPK + cow manure	0.30 ab	34.33 bc	3.51 bc	120.62 bc
T8	NPK + chicken manure	0.36 b	25.33 b	4.10 bc	103.78 b
T9	NPK + goat manure	0.33 b	34.33 bc		106.78 b
T10	NPK + quail manure	0.46 b	44.33 d	3.35 b	148.52 bc

***Note:** the numbers followed by different letters in a column show significant results in the DMRT test at a 95% confidence level. T1: control, T2: 200 kg/ha NPK fertilizer, T3: 10 tons/ha cow manure, T4: 10 tons/ha chicken manure, T5: 10 tons/ha goat manure, T6: 10 tons/ha quail manure, T7: 5 tons/ha cow manure + 100 kg/ha NPK, T8: 5 tons/ha chicken manure + 100 kg/ha NPK, T9: 5 tons/ha goat manure + 100 kg/ha NPK, T10: 5 tons/ha quail manure + 100 kg/ha NPK*
***Source:** compiled by the authors*

Figure 3 shows that treatment T10 (NPK 100 kg/ha + quail manure 5 tons/ha) has the highest exchangeable K compared to other treatments at 0.46 meq/100 g soil in the moderate category. The exchangeable K results in the T4 (10 tons/ha chicken manure) and T7 (100 kg/ha NPK + 5 tons/ha cow manure) treatments were not significantly different from the control treatment. Based on the C/N ratio of manure in Table 3, both cow and chicken manure have a higher C/N ratio than other manures, so the decomposition process is slower. H. Shaji *et al.* (2021) state that cow manure is a mineral-rich fertilizer, but mineralization is slow. In addition, the K nutrient itself is mobile, so it is easily leached and lost from the soil solution. The T7 treatment has a low CEC of 20.03 meq/100 g soil (Table 4). Low CEC causes low soil exchangeable K because K is easily leached away. In this case, the high CEC can influence the soil solution to release K slowly and reduce the rate of K leaching in the soil (Wijaya & Budianta, 2023).

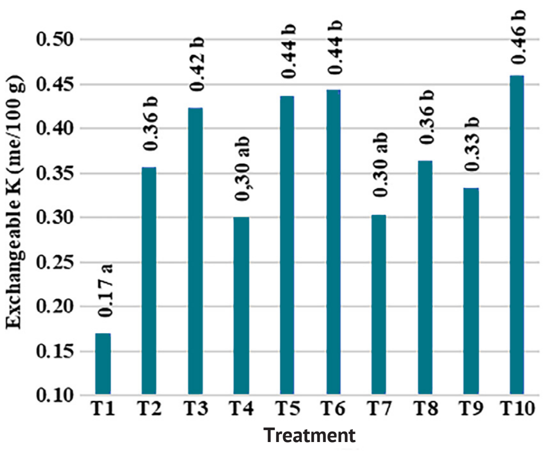

***Figure 3**. Effect of treatment on soil exchangeable K*

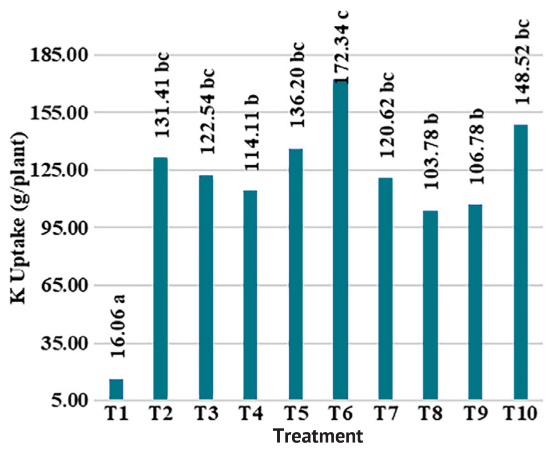

***Figure 4**. Effect of treatment on plant K uptake*

***Note:** T1: control, T2: 200 kg/ha NPK fertilizer, T3: 10 tons/ha cow manure, T4: 10 tons/ha chicken manure, T5: 10 tons/ha goat manure, T6: 10 tons/ha quail manure, T7: 5 tons/ha cow manure + 100 kg/ha NPK, T8: 5 tons/ha chicken manure + 100 kg/ha NPK, T9: 5 tons/ha goat manure + 100 kg/ha NPK, T10: 5 tons/ha quail manure + 100 kg/ha NPK*
***Source:** compiled by the authors*

Variance analysis showed that manure application had a substantial effect on the K uptake of rice plants. Figure 4 shows that the treatment that gives the highest K uptake of rice plants is P6 (10 tons/ha quail manure). The amount of K element absorbed by rice plants is determined by the concentration of K in the soil solution, if the concentration of K in the soil is high, then the uptake of K by plants is also high (Yuniarti *et al.*, 2023). Based on the DMRT test, treatment P6 was significantly different from treatment T1 (control), T4 (chicken manure 10 tons/ha), T8 (chicken manure 5 tons/ha + NPK 100 kg/ha), and P9 (goat manure 5 tons/ha + NPK 100 kg/ha). This is because there was no addition of nutrients in the control treatment, so K nutrients in the soil were not fulfilled. Meanwhile, chicken and goat manure have lower K nutrient levels than cow and quail manure (Table 3.), thus affecting the availability of K nutrients in the soil and impacting the K uptake of rice plants.

Correlation between Soil Variables and Plant Variables. Based on the correlation test results in Table 7, soil available P has a highly significant correlation with a very strong and positive to plant tissue P (r=0.736**) and plant P uptake (r=0.755**). This means that the higher the availability of P in the soil, the more P nutrients are absorbed by plants and enter the plant tissue. Figure 5 shows that the coefficient of determination (R^2) is 0.7503, meaning that plant tissue P levels are influenced by soil-available P levels of 75.03%. Figure 6 shows that the coefficient of determination (R^2) is 0.7745, meaning that plant P uptake levels are influenced by soil-available P levels of 77.45%.

***Table 7**. Correlation between soil variables and plant variables*

Variable	Correlation Coefficient (r)				
	P Plant Tissue	K Plant Tissue	P Uptake	K Uptake	Shoot Dry Weight
Available P	**0.736****	0.163	**0.755****	0.448*	**0.636****
Exchangeable K	0.458*	**0.468****	**0.559****	**0.596****	**0.567****
Organic C	**0.571****	0.276	**0.616****	**0.465****	**0.564****
CEC	0.428*	0.191	**0.549****	0.409*	**0.519****

***Note:** * = signifcance at P < 0.05 (significant correlation); ** = signifcance at P < 0.01(highly significant correlation*
***Source:** compiled by the authors*

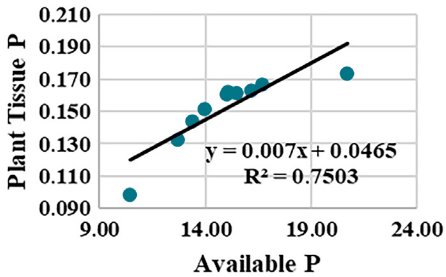

***Figure 5**. Relationship of soil available P to plant tissue P*
***Source:** compiled by the authors*

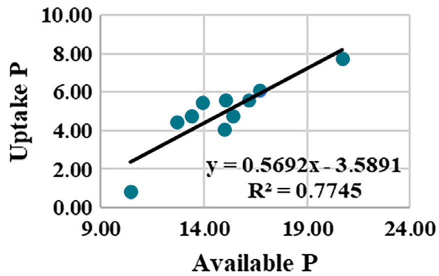

***Figure 6**. Relationship of soil available P to plant P uptake*
***Source:** compiled by the authors*

Exchangeable K had a substantial correlation with a moderate and positive relationship to tissue K (r = 0.468**) and plant K uptake (r = 0.596**). The relationship shows that the increasing concentration of soil exchangeable K will be followed by increased tissue K and K uptake of rice plants. Figure 7 shows that the coefficient of determination (R^2) value of 0.4898 means that plant tissue K content is influenced by soil exchangeable K concentration by 48.98%. Figure 8 shows that the coefficient of determination (R^2) of 0.7831 denotes that plant K uptake is influenced by soil exchangeable K concentration by 78.31%.

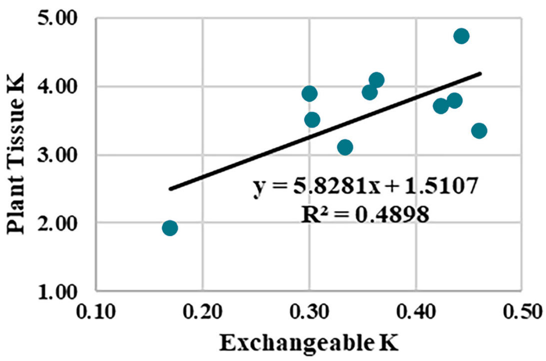

***Figure 7**. Relationship of soil exchangeable K to plant tissue K*
***Source:** compiled by the authors*

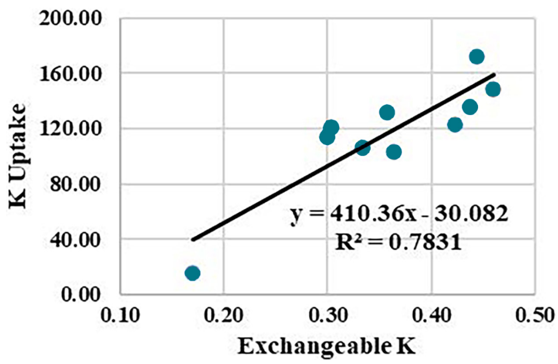

***Figure 8**. Relationship of soil exchangeable K to plant K uptake*
***Source:** compiled by the authors*

Organic C showed a substantial correlation with tissue P, plant P uptake, and plant K uptake. Based on the correlation coefficient value, organic C is moderately related to tissue P (r = 0.571**) and plant tissue K uptake (r = 0.465**). Meanwhile, organic C has a strong relationship with plant P uptake (r = 0.616**). The positive correlation results indicate that any increase in organic C value will be followed by an increase in tissue P content, P uptake, and plant K uptake. According to Soong *et al.* (2020), soil microorganisms need carbon to meet energy needs. In this case, organic C can spur soil microorganisms' activities to increase the soil's decomposition process. Figure 9 shows that the coefficient of determination (R^2) value of 0.7636 means that plant tissue P is influenced by soil organic C concentration of 76.36%. Figure 10 shows that the coefficient of determination (R^2) value of 0.635 means that plant P uptake is influenced by soil organic C concentration of 63.5%. Figure 11 shows that the coefficient of determination (R^2) value of 0.3726 denotes that plant K uptake is influenced by soil organic C concentration of 37.26%.

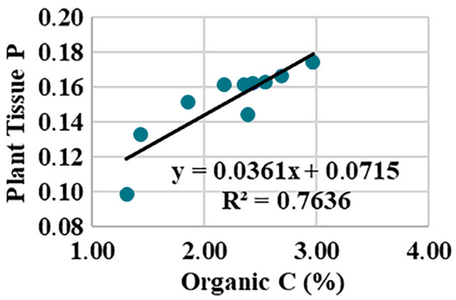

Figure 9. *Relationship of organic C to plant tissue P*
Source: *compiled by the authors*

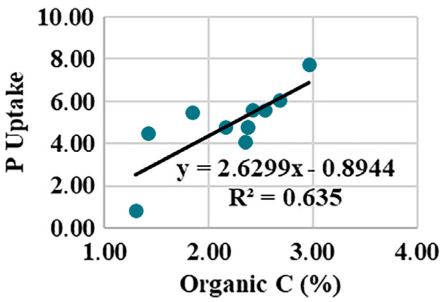

Figure 10. *Relationship of organic C to plant P uptake*
Source: *compiled by the authors*

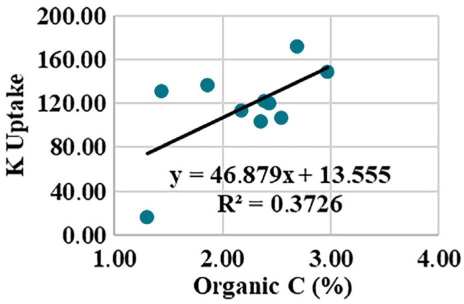

Figure 11. *Relationship of organic C to plant K uptake*
Source: *compiled by the authors*

The correlation analysis results show that CEC has a highly significant correlation with a moderate and positive relationship to plant P uptake (r = 0.549**). The decomposition process of organic matter can affect CEC as it can produce humic compounds that donate soil colloids so that soil CEC will increase. The increase in CEC is also determined by the increase in the negative charge of soil colloids derived from the dissociation of carboxyl or hydroxyl functional groups from organic compounds (Xu *et al.,* 2021). Organic matter as manure through its mineralization process can provide available phosphorus to the soil. In addition, organic matter also activates the decomposition process of the original soil organic matter to release phosphorus. The added organic matter can also form phospho-humate and phospho-vulvate complexes that plant more easily take up. In this case, applying soil organic matter can increase soil CEC, followed by an increase in P in the soil.

CONCLUSIONS

The application of manure had a significant effect on available P, exchangeable K, P uptake, and K uptake of rice. Application of quail manure 5 ton/ha and NPK fertilizer 100 kg/ha obtained the highest value on soil available P of 20.70 ppm (high) and soil exchangeable K of 0.46 me/100 g of soil (moderate). This is because quail manure contains the highest P and K nutrients and has the lowest C/N ratio than other types of manure so that it is more quickly mineralized. In addition, the application of NPK fertilizer to the soil can also increase P and K nutrients in the soil. The application of 5 ton/ha quail manure and 100 kg/ha NPK fertilizer also produced the highest plant P uptake of 5.59 g/plant because the presence of available P in the soil was high. P uptake was highly correlated with soil available P (r = 0.755**) and was influenced by available P by 77.45%. Meanwhile, K uptake of rice plants obtained the highest value at

10 ton/ha quail manure at 172.34 g/plant, but the fertilizer application was not significantly different from 5 ton/ha quail manure and 100 kg/ha NPK fertilizer. K uptake was highly correlated with exchangeable K (r = 0.596**) and influenced by exchangeable K 78.31%. Thus, 5 ton/ha quail manure and 100 kg/ha NPK fertilizer can be a dose recommendation and consideration in choosing the type of manure that can support the growth of rice in Inceptisols. Further research in this area needs to be conducted to determine the effect of quail manure and NPK fertilizer on different soil types and varieties of rice.

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CONFLICT OF INTEREST

None.

REFERENCES

[1] Adekiya, A.O., Ejue, W.S., Olayanju, A., Dunsin, O., Aboyeji, C.M., Aremu, C., Adegbite, K., & Akinpelu, O. (2020). Different organic manure sources and NPK fertilizer on soil chemical properties, growth, yield and quality of okra. *Scientific Reports,* 10, article number 16083. doi: 10.1038/s41598-020-73291-x.

[2] Antonov, A., Ivanov, G., & Pastukhova, N. (2021). Quail droppings utilization system. *IOP Conference Series: Earth and Environmental Science*, 666, article number 022073. doi: 10.1088/1755-1315/666/2/022073.

[3] Balai Pengujian Standar Instrumen Tanah dan Pupuk. (2023). Retrieved from https://tanahpupuk.bsip.pertanian.go.id/.

[4] Dhaliwal, S.S., Sharma, V., Kaur, J., Shukla, A.K., Hossain, A., Abdel-Hafez, S.H., Gaber, A., Sayed, S., & Singh, V.K. (2022). The pedospheric variation of dtpa-extractable Zn, Fe, Mn, Cu and other physicochemical characteristics in major soil orders in existing land use systems of Punjab, India. *Sustainability (Switzerland),* 14(1), article number 29. doi: 10.3390/su14010029.

[5] Gao, P., Zhang, T., Lei, X-y., Cui, X-w., Lu, Y-x., Fan, P-F., Long, Sh-P., Huang, J., Gao, J-Sh., Zhang, Zh-H., & Zhang, H. (2023). Improvement of soil fertility and rice yield after long-term application of cow manure combined with inorganic fertilizers. *Journal of Integrative Agriculture*, 22(7), 2221-2232. doi: 10.1016/j.jia.2023.02.037.

[6] Husein, H.H., Lucke, B., Bäumler, R., & Sahwan, W. (2021). A contribution to soil fertility assessment for arid and semi-arid lands. *Soil Systems*, 5(3), article number 42. doi: 10.3390/soilsystems5030042.

[7] Islam, M.R., Bilkis, S., Hoque, T.S., Uddin, S., Jahiruddin, M., Rahman, M.M., Siddique, A.B., Hossain, M.A., Marfo, Th.D., Danish, S., & Datta, R. (2021). Mineralization of farm manures and slurries under aerobic and anaerobic conditions for subsequent release of phosphorus and sulphur in soil. *Sustainability (Switzerland),* 13(15), article number 8605. doi: 10.3390/su13158605.

[8] Istikorini, Y., Nurhafifah, Hartoyo, A.P.P., Solikhin, A., & Octiaviani, E.A. (2022). Effect of plant growth-promoting rhizobacteria and bionanomaterial membrane applications on chemical properties of peat soils. *IOP Conference Series: Earth and Environmental Science*, 959, article number 01249. doi: 10.1088/1755-1315/959/1/012049.

[9] Jiban, Sh., Manoj, K., Subash, S., Kumari, Sh.K. (2020). Role of nutrients in rice (*Oryza sativa* L.): A review. *Agrica,* 9(1), 53-62. doi: 10.5958/2394-448x.2020.00008.5.

[10] Purnamasari, I., Rostaman, T., Widowati, R., & Anggria, L. (2021). Comparison of appropriate cation exchange capacity (CEC) extraction methods for soils from several regions of Indonesia. *IOP Conference Series: Earth and Environmental Science,* 648, article number 012209. doi: 10.1088/1755-1315/648/1/012209.

[11] Rayne, N., & Aula, L. (2020). Livestock manure and the impacts on soil health: A review. Soil Systems, 4(4), article number 64. doi: 10.3390/soilsystems4040064.

[12] Sardans, J., & Peñuelas, J. (2021). Potassium control of plant functions: Ecological and agricultural implications. *Plants*, 10(2), article number 419. doi: 10.3390/plants10020419.

[13] Septyani, I.A.P., & Harahap, F.S. (2022). Effect of co-compost biochar in improving nutrient availability and growth of rice (*Oryza sativa*) in intensive paddy field soil. *Journal of Soil and Climate,* 46(2), article number 133. doi: 10.21082/jti.v46n2.2022.133-144.

[14] Shaji, H., Chandran, V., & Mathew, L. (2021). Organic fertilizers as a route to controlled release of nutrients. In *Controlled release fertilizers for sustainable agriculture* (pp. 231-245). Cambridge: Academic Press. doi: 10.1016/B978-0-12-819555-0.00013-3.

[15] Soong, J.L., Fuchslueger, L., Marañon-Jimenez, S., Torn, M.S., Janssens, I.A., Penuelas, J., & Richter, A. (2020). Microbial carbon limitation: The need for integrating microorganisms into our understanding of ecosystem carbon cycling. *Global Change Biology*, 26(4), 1953-1961. doi: 10.1111/gcb.14962.

[16] Suntoro, S., Dewi, W.S., Syamsiyah, J., Mujiyo, M., Herdiansyah, G., Widijanto, H., & Herawati, A. (2023). Evaluation of land suitability as the basis for sustainable crop development. *IOP Conference Series: Earth and Environmental Science*, 1228, article number 012021. doi: 10.1088/1755-1315/1228/1/012021.

[17] Wijaya, R., & Budianta, D. (2023). Determination of in situ NPK fertilization for rice growth in intensive farming system. *Journal of Smart Agriculture and Environmental Technology,* 1(1), 1-6. doi: 10.10.60105/josaet.2023.1.1.1-6.

[18] Xu, Y., Yu, X., Xu, B., Peng, D., & Guo, X. (2021). Sorption of pharmaceuticals and personal care products on soil and soil components: Influencing factors and mechanisms. *Science of the Total Environment,* 753, article number 141891. doi: 10.1016/j.scitotenv.2020.141891.

[19] Yuan, C., Li, Q., Sun, Z., & Sun, H. (2021). Effects of natural organic matter on cadmium mobility in paddy soil: A review. *Journal of Environmental Sciences*, 104, 204-215. doi: 10.1016/j.jes.2020.11.016.

[20] Yuniarti, A., Ishak Sonjaya Sule, M., Sapta Sara, D., & Naufal Suryandani, H. (2021). The effect of N, P, K, and Si fertilizers on pH, P-available, P-uptake and black rice yield (*Oryza sativa* L. indica) on dryland Inceptisols. *Modern Chemistry,* 9(4), 83-87. doi: 10.11648/j.mc.20210904.13.

[21] Yuniarti, A., Solihin, E., Syifa, A., Wibowo, A., & Bawana, S. (2023). Effect of NPK, and Si fertilizers on exchangeable potassium, K Uptake and growth of black rice (*Oryza sativa* L. indica) on Ultisols. *E3S Web of Conferences,* 444, article number 04027. doi: 10.1051/e3sconf/202344404027.

[22] Zaki, Z., Habib, F., Galal, Y., & Abd El-Hameed, A.E.N. (2021). Effect of P rates combined With PDB on nutrients uptake by wheat grown under organic farming of sandy soil using 15N tracer technique. *Arab Journal of Nuclear Sciences and Applications,* 54(4), 67-82. doi: 10.21608/ajnsa.2021.53137.1421.

Вплив різних типів місцевого потенційного гною на доступність та поглинання P і K рисом в Inceptisols

Сунторо Сунторо
Доктор
Університет Себелас Марет
57126, вул. Ір. Сутамі, 36А, м. Суракарта, Індонезія
https://orcid.org/0000-0003-0369-7539

Ґанджар Гердіансях
Магістр
Університет Себелас Марет
57126, вул. Ір. Сутамі, 36А, м. Суракарта, Індонезія
https://orcid.org/0000-0001-5841-4642

Гері Відіянто
Доктор
Університет Себелас Марет
57126, вул. Ір. Сутамі, 36А, м. Суракарта, Індонезія
https://orcid.org/0000-0002-1781-7004

Аделія Пебріна Ліст'ябуді
Студент бакалавру
Університет Себелас Марет
57126, вул. Ір. Сутамі, 36А, м. Суракарта, Індонезія

Анніса Фітріяні Адієн Істікома
Студент бакалаву
Університет Себелас Марет
57126, вул. Ір. Сутамі, 36А, м. Суракарта, Індонезія

Анотація. Забезпеченість поживними речовинами Inceptisols є недостатньою для ведення органічного землеробства при вирощуванні рису, тому її можна оптимізувати шляхом внесення органічних добрив, одним з яких є гній. Метою дослідження було визначити вплив видів гною на доступність та засвоєння поживних речовин P і K рисом, що міститься в Inceptisols. У дослідженні використовувався однофакторний рандомізований дизайн повної групи з 10 варіантами обробки: T1 = контроль; T2 = NPK 200 кг/га; T3 = коров'ячий гній 10 т/га; T4 = курячий гній 10 т/га; T5 = козячий гній 10 т/га; T6 = перепелиний гній 10 т/га; T7 = коров'ячий гній 5 т/га + NPK 100 кг/га; T8 = курячий гній 5 т/га + NPK 100 кг/га; T9 = козячий гній 5 т/га + NPK 100 кг/га; T10 = перепелиний гній 5 т/га + NPK 100 кг/га повторили 3 рази з розміром дослідних ділянок 2.5 м × 4 м. Результати показали, що перепелиний послід, внесений окремо або в поєднанні з NPK добривом, мав дуже значний вплив на доступність P, обмінний K, а також поглинання P і K рослинами. Це пояснюється тим, що перепелиний послід містить високий вміст поживних речовин P і K і має низьке співвідношення C/N порівняно з іншими видами посліду. Результати показали, що перепелиний послід здатен підвищити доступність та поглинання поживних речовин P і K рослинами рису в Inceptisols. Таким чином, перепелиний послід може бути рекомендованим органічним добривом для вирощування рису

Ключові слова: органічне добриво; макроелементи; органічна речовина; родючість ґрунту; рисове поле