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The Effect of N, P, K and Si Fertilizers on Some Soil Chemical Properties, N, P uptake and Growth of Black Rice (Oryza sativa L. indica) in Ultisols

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ABSTRACT: This study aims to determine the effect of the combination of fertilizers N, P, K, and Si on the pH, N-total, Al-dd, N, P- uptake, and grown of black rice (*Oryza sativa* L. indica) in Ultisols from Jasinga. This research was conducted from October 2021 to January 2022 at the Experimental Land for Soil Chemistry and Plant Nutrition in Jatinangor, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang, West Java with an altitude of 752 meters above sea level. The experimental design was carried out using a Randomized Block Design (RAK) consisting of eight treatments and three replications, consisting of: control; 1 N, P, K without Silica; 1 N, P, K + ½ Silica; 1 N, P, K + 1 Silica; 1 N, P, K + 2 Silica; ¾ N, P, K + 1 Silica; ¾ N, P,K + 1½ Silica; ¾ N, P, K + 2 Silica; and without N, P, K + 2 Silica. The results showed that the combination of fertilizer doses of 1 N, P, K (Urea 300 kg/ha, SP-36 100 kg/ha, and KCl 100 kg/ha) with 1 Silica (2 mL/L) gave the best black rice yields in increasing plant height by 60.34 cm and number of tillers 34, plusthose dose is the best dose in increasing soil pH by 5.63, but the fertilizer dose was not able to increase soilP-Availability and N-Total.

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KEYWORDS: Black Rice, N, P, K Fertilizer, Si Fertilizer, Ultisols.

1. INTRODUCTION

Rice is the main food commodity that becomes the source of carbohydrates for the majority of Indonesian people. The need for rice has been increasing every year. This is in parallel with the increasingof the population in Indonesia, nevertheless rice production has been decreasing every year. According to The Statistics Indonesia (2021) there was a decrease in rice production by 0.43% due to a decrease harvested area of rice by 254.47 thousand ha, or around 2.3% compared to the harvested area in 2020 whichamounted to 10.66 million ha.

The use of Ultisol dry land can be a solution in increasing the rice harvest area which is generally dominated by lowland rice fields. Ultisols are one of the soil orders in Indonesia which have a wide distribution reaching 45,794, 000 ha or around 25% of Indonesia's total land area. The extent of land withthe soil order of Ultisols has the potential to be developed into productive agricultural land (Rakhmalia *et al*., 2015). Soil fertility status on dry land with soil order of Ultisols is low. Ultisols have several limiting factors that cause this soil order to be classified as suboptimal namely the low to moderate content of C- organic and N-total soil (Rachmalia *et al*., 2015). In Ultisols, leaching of bases and silicate ions occurs intensively, causing the soil to react sourly, base saturation and low Si content and high Al solubility so thatit becomes toxic to plants (Zulputra *et al*., 2018).

Fertilization can be done to increase soil fertility and plant productivity in Ultisols. Nitrogen, phosphorus, and potassium are important elements that must always be available to plants, because they function as metabolic and biochemical processes in plant cells (Firmansyah *et al*., 2017). Nitrogen (N), phosphorus (P) and potassium (K) fertilization play a role in providing primary macronutrients for rice plants. The N, P, and K elements have a very important role in plant growth and production, these three elements interact with each other in supporting plant growth. Balances fertilization can provide nutrients inthe soil, accelerate soil growth, reduce erosion hazards, and improve soil chemical properties (Karo *et al*., 2017).

Soil fertilization using Silica (Si) fertilizers on Indonesian agricultural land is still rarely or almost neverdone, while Indonesian agricultural land experiences a lot of leaching of nutrients such as Si (Putri *et al*., 2017). The need for Si has so far only relied on the availability of Si in the soil, which is not necessarily sufficient for plants (Nurmala *et al*., 2018). Concentration of Si in rice plants can increase the photosyntheticcanopy, as well as increase resistance to biotic and abiotic stresses. Si can play a role in keeping rice plantstems upright and increasing resistance to pests and plant diseases (Agency for Agricultural Research and Development, 2015).]

One type of rice plant that has the potential to be cultivated on Ultisol soil is black rice (*Oryza sativa* L.indica) which is a type of upland rice or dryland rice. Black rice can be an alternative functional food because it produces black rice which is rich in nutrients such as amino acids, potassium, magnesium, calcium, iron, and anthocyanin which are higher than ordinary rice (Suhartini *et al.*, 2010) and contains many nutrients such as fatty acids, amino, K, Mg, Ca, iron anthocyanin pigments and flavonoids so that they can increase the body's resistance (Putri *et al.*, 2017). Cultivation of black rice on Ultisol soil has the potential to increase rice production in Indonesia, but efforts need to be made to reduce the limiting factoron Ultisol soil due to low nutrient availability.

Black rice (*Oryza sativa* L. indica), which is a type of upland rice, is an alternative functional food. Black rice is a type of rice that is currently gaining popularity among the public and is consumed as a functional food that contains many nutrients such as amino acids, K, Mg, Ca, iron, anthocyanin pigment and flavonoids so that it can increase endurance (Putri *et al.*, 2017). Black rice is a rice variety that containsthe highest anthocyanin pigment compared to other types of rice (Suardi and Ridwan, 2009). The constraints experienced in the cultivation of black rice are the stems that fall easily because they have tall stems and the influence of high rainfall. The price of black rice is relatively expensive and tends to be limited in Indonesia because it is rarely cultivated.

Based on the description of the background, it is expected that the application of N, P, K, and Si fertilizers can increase soil N-total, N-uptake, P-availability P-uptake, soil pH, and black rice plant growth (*Oryza sativa* L. indica) in Ultisol Land.

2. MATERIALS AND METHODS

The experiments was carried out from October 2021 to January 2022 at the Experimental Field of the Soil Chemistry and Plant Nutrition Laboratory, Faculty of Agriculture, Universitas Padjadjaran , JatinangorDistrict, Sumedang Regency West Java with an altitude of ± 752 m above sea level (asl). Soil and plant analysis at the Soil Fertility and Plant Nutrition Laboratory, Department of Soil Science and Land Resources, Faculty of Agriculture, Universitas Padjadjaran , Jatinangor.

The materials used in this experiments were black rice seeds of the local variety, Jeliteng , zeolite as basic fertilizer, (inorganic fertilizer Urea (46% N), SP-36 (36% P_2O_5), KCl (50% K_2O), and liquid Si (19.90% SiO_2) with various doses according to the treatment and chemicals for soil and plant analysis testsin the laboratory. The soil used was taken from Neglasari Village, Jasinga District, Bogor Regency with theproperties as shown in Table 1. The design used in this experiment was a Randomized Block Design (RAK).There were 9 treatments arranged, consisting of:

A = Control (Without N, P, K and Si fertilizer)
B = 1 N, P, K without Silica
C = 1 N, P, K + ½ Silica
D = 1 N, P, K + 1 Silica
E = 1 N, P, K + 2 Silica
F = ¾ N, P, K + 1 Silica
G = ¾ N, P, K + 1 ½ Silica
H = ¾ N, P, K + 2 Silica
I = Without N, P, K + 2 Silica

Table 1. Soil Properties in Neglasari Village, Jasinga District, Bogor Regency

Parameter	Unit	Result	Criteria *
pH : H2O	-	5.00	tly acidic
pH : KCl 1N	-	3.98	–
C-organic	(%)	1.54	Low
N-total	(%)	0.27	Average
C/N	-	6	Low
P2O5 HCl 25%	(mg/100gr)	84.24	Very High
P2O5 (Bray)	(ppm P)	3.83	Very Low
K2O HCl 25%	(mg/100g)	6.39	Very Low
K-dd	($cmol.kg^{-1}$)	0.11	Low
Na-dd	($cmol.kg^{-1}$)	0.09	Very Low
Ca-dd	($cmol.kg^{-1}$)	1.08	Very Low
Mg-dd	($cmol.kg^{-1}$)	1.40	Average
KTK	($cmol.kg^{-1}$)	29.03	High
Base Saturation	(%)	9.25	Very Low

Al-dd	(cmol.kg^{-1})	10.68	-
H-dd	(cmol.kg^{-1})	1.57	-
Al Saturation	(%)	36.78	High
Texture:			
Sand	(%)	20	
Dust	(%)	27	Clay
Clay	(%)	53	
Total Si**	(%)	24.80	Low

Each treatment was repeated 3 times, so there were 27 experimental units. Black rice is planted on dry land using polybags with a size of 40 x 40 cm with a distance between polybags of 25 x 25 cm. The Jelitengblack rice seeds that were previously treated with hot water treatment, were then planted by digging theminto the ground in polybags. The variables observed included N-total, P-Availability, soil Aldd, N and P uptake and plant growth of black rice in the form of plant height and number of tillers. The data collected was then statistically analyzed using the SPSS program version 26 with the F test at the 5% level which was used to determine differences in the effect of the average treatment. If there is a significant differencein the results of the analysis of variance (Test F) at the 5% level , then a further test is carried out using Duncan's multiple range test at the 5% level.

3. RESULTS AND DISCUSSIONS

3.1 Soil Analysis

Table 2. The Effect of N, P, K, and Silica fertilizers on some soil chemical properties

		(%)	N-Total (ppm)	P-Available Treatment	Al-dd Soil pH (cmol.kg^{-1})
A	Control	0.25	0.49a	4.48a	11.94
B	1 N, P, K without Silica	0.32	1.10ab	5.19bcd	13.35
C	1 N, P, K + ½ Silica	0.28	2.50cde	4.84ab	14.92
D	1 N, P, K + 1 Silica	0.38	2.64cde	5.63d	12.61
E	1 N, P, K + 2 Silica	0.30	3.47e	5.42cd.	13.99
F	¾ N, P, K + 1 Silica	0.31	1.20ab	5.17bcd	12.87
G	¾ N, P, K + 1½ Silica	0.28	1.72bc	4.99bc	14.32
H	¾ N, P, K + 2 Silica	0.29	1.91bcd	5.37cd	13.71
I	Without N, P, K + 2 Silica	0.26	2.82de	5.33cd	15.37

3.1.1 N-Total

Based on Table 2, it is known that all treatments showed that the effects were not significantly different from one another. In the initial soil analysis the N-total soil was 0.27% while in the control treatment the value of N-total soil was 0.25% and the treatment without N, P, K + 2 Si the value of N-total soil was 0.26% indicating a decrease in N-total soil. The amount of N nutrients in the soil can decrease due to several mainfactors because it is absorbed by plants and other factors such as changes from available forms to unavailable, transfer of places and both. Loss of nutrients through leaching or displacement occurs is influenced by the nature of the soil, slope, rainfall.

The low N-total value in the soil is thought to occur due to the transformation of nitrogen forms or beingleached and used directly by black rice plants. According to Hardjowigeno (2010), changes in nitrogen in the soil can lead to the availability of nitrogen elements than can be utilized by plants and also the loss of nitrogen elements from the soil. The high rainfall at the time of the study greatly affected the considerableloss of N. This is in line with the research results of Nurmegawati *et al*. (2007), that some N is lost throughleaching. Nitrogen in the form of NO_3 is easily leached by rainwater. Rainwater can also leach some of theN and reduce the amount of N available to plants, causing low response of rice plants to N fertilizer and reducing fertilizer efficiency.

3.1.2 P-Availability

Based on the data in Table 2, it can be known that each treatment has an effect on P-availability in Ultisols. The P-Availability value in the 1 N, P, K + 2 Silica treatment was significantly different from thecontrol, 1 N, P, K treatment without Si and ¾ N, P, K + 1 Silica with a value of 3.47 ppm. When comparedwith P-Availability of the initial soil (3.83 ppm), the average value of P-Availability in all treatments decreased. The decreased availability of P in the soil is thought to be caused by Al toxicity in plants whichresults in the P element in the soil being bound by Al so that its form in the soil solution is not available toplants. The low amount of P-Availability in the soil is also in line with the high soil Al-dd value and low soil pH. The high concentration of exchangeable Al in the soil cause a greater amount of P to be bound byAl and form Al-P in soil colloids, so that the P element which available for plants will decrease (Tisdale *etal*., 2005).

The low soil P-Availability is mainly due to the decreased of P concentration in the soil as a result of being absorbed by plants, so that what remains in the soil is residual P. Along with the absorption of P by plants, P absorbed in the soil will also be released little by little into the soil solution (Tisdale *etal*., 2005).

This is supported by the results of research by Habiburrahman *et al*. (2018) which states that the amount of P that is lifted at harvest and the P that is absorbed by plants is quite small, while the amount of residual P in the soil is quite large.

Based on the initial analysis of the soil, Ultisol soil has very low base saturation (9.25%) which causes the mineral content in the soil to become unstable causing Al to be released. This causes high Al in the soilwhich then its presence in the soil will cause P fixation so that P is insoluble or unavailable (Utomo *et al*., 2016). The high clay content in the Ultisol also affects the amount of P retention, which causes the value ofsoil P-Availability to be low (Sandil *et al*., 2021).

3.1.3 Soil pH

Table 2 shows the average value of soil pH which is still in the low category, there are treatments that experience an increase or decrease in soil pH. The fertilization treatment gave a significant difference compared to the control treatment. The 1 N, P, K + 1 Si treatment showed the highest pH value with the pHvalue of 5.63 or a pH increase of 0.63 from the initial soil pH, but based on the analysis results, these valueswere not significantly different from the 1 N, P, K treatment without Si, 1 N, P, K + 1 Si, ¾ N, P, K + 1 Si,
¾ N, P, K + 2 Si, and without N, P, K + 2 Si.

The increase of soil pH is due to the applied urea fertilizer can release ammonia (NH_3) in the soil (Utomo*et al*., 2016) which results in an increase in the number of OH-ions. Soil acidity also increases due to the use of phosphate fertilizers and silicates. This is confirmed in the research of Zulputra *et al*. (2014) which states that the application of phosphate fertilizers and the provision of silicates can increase soil pH due tohydrolysis of water by the sodium silicate given to produce silicic acids and OH-ions.

The low soil pH after being treated was due to the high Al saturation in the soil and the increased soil Al-dd. Soil colloids dominates by Al will cause the soil to become more acidic, this is because when the Alreacts with water it will produce hydrogen so that the concentration of H^+ in the soil colloids will increase,which then causes the soil pH to react sour (Maryati *et al*., 2014). Aluminum in the soil solution will controlthe pH of the soil solution (Utomo *et al*., 2016), because Al^{3+} hydrolysis will produce H^+ and lower down soil pH (Nurhidayanti, 2017).

3.2 Plant Analysis

Table 3. The Effect of N, P, K and Silica Fertilizers on the N and P uptake of Black Rice Plants

	Treatment	N-Uptake (mg/plant)	P-Uptake (mg/plant)
A	Control	1.37 a	0.49a
B	1 N, P, K without Silica	3.09 bc	1.71bc
C	1 N, P, K + ½ Silica	3.23 c	1.31b
D	1 N, P, K + 1 Silica	3.34 c	2.24c
E	1 N, P, K + 2 Silica	2.96 bc	2.08bc
F	¾ N, P, K + 1 Silica	3.15 bc	1.61bc
G	¾ N, P, K + 1½ Silica	2.67 bc	1.36b
H	¾ N, P, K + 2 Silica	2.43 bc	1.63bc
I	Without N, P, K + 2 Silica	1.98 ab	0.43a

Note : Values followed by the same letter do not indicate significant difference based on Duncan's MultipleRange Test at 5% significance level.

3.2.1 N Uptake

Based on Duncan's Multiple Follow-Up Test with a level of 5% N uptake plant in the control treatmentwith an N uptake value of 1.37 mg/plant, significantly different from the 1 N, P, K without Si treatment with an N uptake value of 3.09 mg/plant, 1 N, P, K + ½ Si with an N uptake value of 3.23 mg/plant, 1 N, P,K + 1 Si with an N uptake value of N 3.34 mg/plant, 1 N, P, K + 2 Si with an uptake value N 2.96 mg/plant,
¾ N, P, K + 1 Si with an N uptake value of 3.15 mg/plant, ¾ N, P, K + 1½ Si with an N uptake value ofN 2.67 mg/plant, and ¾

N, P, K + 2 Si with an N uptake value of 2.43 mg/plant. The application of higherN fertilizer has a positive effect on N uptake. The increase of N uptake results occurs due to the combinationof N, P, K fertilizer doses, and Si can provide a balance of nutrients in the soil, so that the availability of soil nitrogen is in the optimum amount. Provision of sufficient N to plants causes the increase of the need for other nutrients such as P and K to balance the fast plant growth rate (Fairhurst *et al*., 2007).

The addition of N, P, K and Si fertilizers can increase N uptake in plants. This is in line with the resultsof Supramudho's research (2008), that the highest N uptake was achieved by adding inorganic fertilizer urea 300 kg/ha + ZA 100 kg/ha + SP-36 150 kg/ha + KCl 100 kg/ha, which is 5.893 g/plant. According toWinarso (2005), the increase of N uptake is expected to increase the efficiency of N uptake by plants. N uptake of plant in the control treatment, namely 1.37 mg/plant, was not significantly different from the treatment without N, P, K + 2 Si namely 1.98 mg/plant. This treatment had a low N uptake value because itwas not given additional nutrients while the other treatments showed quite good results of plant N uptake.Treatment 1 N, P, K without Si, 1 N, P, K + 2 Si, ¾ N, P, K + 1 Si, ¾ N, P, K + 1½ Si, and ¾ N, P, K + 2 Siwas not significantly different from the treatments of 1 N, P, K + ½ Si, and 1 N, P, K + 1 Si. This is presumably due to a lack of nutrient supply while the soil conditions are acidic and Al-dd is high. This condition causes the value of plant N uptake in black rice to be low.

3.1.2 P Uptake

Based on Table 3, the 1 N, P, K + Si treatment gave the highest average plant P uptake with an uptakevalue of 2.24 mg/plant, but was not significantly different from the 1 N, P, K + 2 Si, ¾ N, P, K + 1 Si, and ¾ N, P, K + 2 Si. The results of the analysis of variance showed that the 1 N, P, K + 1 Si treatment was significantly different from the control and treatment without N, P, K + 2 Si. The similarities in the two treatments were that the plants were not given the N, P, and K fertilizers. This shows that N, P, and K fertilization is very important for rice plants and greatly influences how plants absorb nutrients in the soil,especially P uptake.

Nuryani *et al*. (2010) in their research stated that inorganic fertilization can increase P uptake because its single and specific form of compounded fertilizer is able to slow down the release of nutrients in the soilthan non-compounded fertilizers (organic fertilizers). Toyip (2013) also stated that the given P fertilizationsignificantly affected the increase in the availability of P in the soil. Overall, the P uptake value of plants in all treatments was still very low. This low P uptake of plant is in line with the low amount of available P in the soil and soil pH. In acidic soils, P uptake in plants will be disrupted because P is not mobile, so that theabsorption of $H_2PO_4^-$ in the soil will decrease (Wulandari, 2020). The high Al-dd content of the soil in thisstudy also disrupted P uptake by plants, because Al precipitated P in plant roots, inhibiting P metabolism tothe upper part of plants (Prasetyo *et al*., 2008).

The results of the initial analysis of the soil which showed base saturation and low pH but had a high CEC, were also factors that inhibited nutrient uptake by rice plants (Stefanny *et al*., 2013). This is becausein soils with low base saturation, more sorption complexes are filled with acidic cations namely Al^{3+} and H^+ (Sembiring *et al*., 2015). The amount of acid cations that are too much will bind P elements in the soil so that the form cannot be absorbed by plants.

3.3 Plant Growth

The results of statistical analysis regarding the effect of N, P, K and Si fertilizers on plant height with various treatments of N, P, K, and Si fertilizer doses showed a significant effect on black rice plant height.Table 4. The Effect of N, P, K, and Si Fertilizers on the Height and Number of Black Rice Plants

	Treatment	Plant Height 9 MST (cm)	Number of Rice Tillers 9 MST
A	Control	40.50 a	13.66 ab
B	1 N, P, K without Silica	50.33 cd	24.33 bc
C	1 N, P, K + ½ Silica	47.33 bc	22.33 bc
D	1 N, P, K + 1 Silica	60.26 f	34.00 d
E	1 N, P, K + 2 Silica	54.03 de	30.33 c
F	¾ N, P, K + 1 Silica	54.76 de	26.66 c
G	¾ N, P, K + 1½ Silica	55.33 e	22.33 bc
H	¾ N, P, K + 2 Silica	52.50 de	25.66 c
I	Without N, P, K + 2 Silica	44.90 b	11.66 a

Note : Values followed by the same letter do not indicate a significant difference based on Duncan'sMultiple Range Test at 5% significance level.

3.3.1 Plant Height

Table 4 shows that the application of N, P, K, and Si fertilizers has an effect on the height of black riceplants. The height of black rice plants that were given N, P, K, and Si showed an average difference in height compared to plants that were not given N, P, K, and Si fertilizers. In the 1 N, P, K + 1 Si treatment,the highest plant height was 60.26 cm and significantly different from all other treatments. Plant height canbe affected by the availability of nutrients especially Nitrogen. This is an accordance with the statement ofHusny et al. (2014) that rice plants need nutrients to support their overall growth such as plant height, duringthe vegetative period rice plants need nutrients, both macro and micro nutrients to support the photosynthesis process.

Based on Duncan's Multiple Follow-Up Test with a significance level of 5%, treatment ¾ N, P, K + 1½Si with plant height of 55.33 cm was not significantly different from 1 N, P, K + 2 Si treatment, plant heightof 54.03 cm, treatment ¾ N, P, K + 1 Si with a plant height of 54.76cm, and ¾ N, P, K + 2 Si treatment witha plant height of 52.50cm. The treatment that produces the lowest plant height and was significantly different from the other treatments was the control treatment (without N, P, K, and Si) which was 40.50 plant height. The low plant height in the control treatment was due to lack of fertilization which caused a shortage of nutrients in the plants. Sutejo and Kartasapoetra (1990), stated that applying fertilizer to the soilwill increase the vegetative growth of plants because more nitrogen in the early phase is absorbed to increase vegetative growth such as plant height.

The application of N, P, K fertilizers has a significant effect on plant height, this is due to very low nutrients in the soil, so increasing the dose of N, P, K fertilizers can increase the availability of N nutrientswhich are needed by plants, especially for vegetative growth. The results of observations of plant height shows that the addition of N, P, K, and Si fertilizers could trigger plant height growth when compared to the treatment without fertilizer.

3.3.2 Number of Rice Tillers

Based on Duncan's Multiple Range Follow-Up Test with a significance level of 5% the number of rice tillersin the 1 N, P, K + 1 Si treatment with the result of 34 tillers was the highest number of tillers and significantly different from the other treatments. The control treatment with a rice tiller yield of 13.66 was not significantly different with the treatment without N, P, K + 2 Si with a rice tiller yield of 11.66 and gave a low rice tiller yield. The low number of rice tillers in this treatment was due to the absence of the addition of other nutrients throughfertilization so that the availability of nutrients in this treatment was lower compared to other treatments that were given fertilizer.

Treatment 1 N, P, K without Si with a yield of 24.33 tillers, treatment 1 N, P, K + ½ Si with a yield of 22.33 tillers was not significantly different from the 1 N, P, K + 2 Si treatment with 30.33 tillers, the ¾ N,P, K + 1 Si treatment with a yield of 26.66 tillers, and the ¾ N, P, K + 2 Si treatment with a yield of 25.66tillers. The growth of rice plant tillers is strongly affected by the application of urea which can contribute nutrients and fulfill plant nutrients which provide more optimal growth of rice plant tillers (Abu *et al*., 2017).

The application of 1 N, P, K + 1 Si fertilizer based on the recommendation produced plants with the highest number of tillers. This shows that the N, P, and K fertilization with the recommended dose combinedwith Si fertilizer produced relatively many tillers compared to the control and without N, P, K + 2 Si treatment. Warda (2011), states that the number of tillers is strongly influenced by environmental factors such as the application of fertilizers during tillage.

The number of tillers in black rice can be influenced by fertilization factors. The most required nutrientfor vegetative growth is N nutrient. N nutrient is needed by plants in the formation of protein is an integralpart of chlorophyll, which is the main absorber of light energy needed for photosynthesis (Gardner *et al*., 1991). This is the process that is thought to play an important role in increasing the number of tillers significantly due to N, P, and K fertilization in the soil.

4. CONCLUSION

Based on the results of the research that has been done, the following conclusions can be drawn :

1. The application of N, P, K, and Si fertilizers had no significant effect in increasing total-N, but hadsignificant effect on increasing N-uptake, available-P, soil pH, plant height, and tiller number of black rice in Ultisols from Jasinga.
2. The dose combination of 1 N, P, K (Urea 250 kg/ha, SP-36, 100 kg/ha, and KCl 100 kg/ha) + 1 Silica (1 L/ha) is the best dose in increasing soil pH, P uptake, plant height was 60.23 cm and the number of tillers was 34 tillers of black rice plants, however the dose of this fertilizer was not ableto increase P-Availability of Ultisol soil.

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