PENGARUH PUPUK BLOTONG DAN FOSFAT ALAM TERHADAP KEMAMPUAN PENYEMATAN P TANAH (KPPT) LATOSOL

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THE EFFECT OF FILTER CAKE FERTILIZER AND ROCK PHOSPHATE ON THE PHOSPHORUS FIXATION CAPACITY (PFC) OF LATOSOL SOIL

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ABSTRACT

Latosol soil is an acidic soil type that generally experiences phosphorus (P) deficiency due to the high phosphorus fixation capacity by sesquioxides and clay minerals such as kaolinite. Phosphorus is an essential macronutrient needed by plants, but its availability in the soil is often low. Filter cake is a solid waste by-product from the sugarcane juice filtration process in sugar mills and is utilized as an organic fertilizer. Filter cake fertilizer contains nutrients such as nitrogen, phosphorus, calcium, and other organic compounds that can improve the chemical properties of the soil. The application of rock phosphate combined with organic materials such as filter cake fertilizer on acidic soil has the potential to reduce the soil's capacity to fix phosphorus, thereby increasing phosphorus availability. This study aimed to determine the effect of applying filter cake fertilizer and rock phosphate on the phosphorus fixation capacity (PFC) of Latosol soil. The research used a factorial Completely Randomized Design (CRD) with two factors, namely filter cake fertilizer doses (0, 5, 10, and 15 tons/ha) and rock phosphate doses (0, 200, and 400 kg/ha). Data were analyzed using analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at the 5% significance level to observe differences among treatments. The results showed that both filter cake fertilizer and rock phosphate treatments had a significant effect on reducing the PFC value of Latosol soil. In addition, there was an interaction between the two treatments in reducing the PFC value. The best treatment was obtained from the combination of 15 tons/ha of filter cake fertilizer (B3) and 400 kg/ha of rock phosphate (F2), which was able to reduce the PFC value by 2.65%, from 265.02 ppm to 257.99 ppm.

Keywords: Filter Cake Fertilizer, Rock Phosphate, P-Fixation Capacity (KPPT), Latosol

INTRODUCTION

Latosol is a type of mineral soil that covers approximately 37.5% of the land area in Indonesia. Latosol soil has great potential to be developed as agricultural land; however, its fertility tends to be low because it is formed from volcanic parent material that has undergone intensive weathering and leaching (Aprilianda, 2012). This process leads to the loss of primary minerals, organic matter, and essential nutrients. In addition, the high content of sesquioxides such as aluminum oxide (Al_2O_3) and iron oxide (Fe_2O_3) makes this soil acidic, with low cation exchange capacity (CEC) and high phosphorus fixation capacity (P-retention), resulting in very limited phosphorus (P) availability for plants (Saptiningsih, 2015).

The soil phosphorus fixation capacity is the soil's ability to adsorb or bind phosphorus, making it unavailable to plants. The mechanisms of phosphorus fixation include precipitation-dissolution, sorption-desorption, and mineralization-immobilization reactions (Kaya, 2012). Phosphorus fixation and availability in the soil are strongly influenced by soil properties. Phosphorus becomes insoluble and unavailable to plants due to fixation processes, namely being bound by clay minerals and Al and Fe ions that form insoluble complex compounds (Sutarwi et al., 2013). According to Winarso (2005), factors that influence the level of phosphorus fixation and availability in soil include soil pH and clay type. Soil pH affects the form of phosphate ions present in the soil solution. At low pH, the dominant form of phosphorus is $H_2PO_4^-$. When the pH increases, this form changes to HPO_4^{2-} and under highly alkaline conditions to PO_4^{3-}. The type of clay influences the soil's capacity to adsorb phosphorus. Soils with 1:1 type clay (kaolinite) have a greater ability to adsorb phosphate compared to soils containing 2:1 type clay.

To reduce soil phosphorus fixation and increase phosphorus availability, it is necessary to apply organic materials and phosphorus sources, namely filter cake and rock phosphate. Filter cake is a solid waste by-product from the sugarcane juice filtering process in sugar factories, which is utilized as organic fertilizer because it contains nutrients and organic matter that can improve soil chemical properties (Supari et al., 2015). Filter cake and rock phosphate complement each other. Filter cake contains nutrients and organic compounds that can form complexes with Al and Fe, thereby reducing phosphorus fixation, and can increase the effectiveness of rock phosphate in supplying phosphorus to plants (Hasanudin and Gonggo, 2004). Rock phosphate is an alternative phosphorus source that is more environmentally friendly than synthetic phosphate fertilizers such as TSP or SP-36. However, its effectiveness in supplying phosphorus to plants is still limited, especially in soils with high phosphorus fixation capacity. Therefore, the use of rock phosphate needs to be combined with organic materials such as filter cake, which can enhance the solubility of rock phosphate and accelerate the release of phosphorus into the soil. Through the combination of filter cake and rock phosphate, it is expected that the chemical properties of Latosol soil can be improved and phosphorus availability increased. This combination works by binding phosphorus-fixing ions such as Al and Fe, thus making phosphorus from rock phosphate more available to plants (Santoso et al., 2003). This study was conducted to examine the extent to which this combination can reduce the soil phosphorus fixation capacity and improve phosphorus fertilization efficiency in Latosol soils.

MATERIALS AND METHODS

This research was conducted using an experimental method with a factorial completely randomized design (CRD), consisting of two treatment factors. The first factor was the dosage of filter cake (B), which consisted of four levels: 0, 5, 10, and 15 tons/ha. The second factor was the dosage of rock phosphate (F), which consisted of three levels: 0, 200, and 400 kg/ha. The combination of treatments totaled 12 and each was replicated three times, resulting in 36 experimental units. The research stages included preparation of tools and materials, sampling and preparation of soil samples, preparation of filter cake and rock phosphate treatments, treatment application, incubation, and laboratory analysis. Soil samples were taken as composite samples from the topsoil layer (0–20 cm) in Doga Hamlet, Nglanggeran, Patuk, Gunungkidul. The soil was air-dried, ground, and sieved using a 2 mm sieve. Subsequently, 2.06 kg of soil (equivalent to 2 kg oven-dried soil) was weighed and placed into labeled polybags.

Filter cake was obtained from Madukismo Sugar Factory, then air-dried, sieved using a 2 mm sieve, and weighed according to treatment dosages: 0 g, 5 g, 10 g, and 15 g per polybag. Rock phosphate was obtained from Javamas Agrophos, Nglipar, Gunungkidul, sieved using a 2 mm sieve, and weighed at 0 g, 0.2 g, and 0.4 g per polybag according to the treatment levels. The application of treatments was carried out by thoroughly mixing the soil, filter cake, and rock phosphate according to the treatment dosage, then returning the mixture to each polybag based on the label. Each polybag was watered with distilled water (aquadest) until field capacity was reached. Incubation was carried out for 30 days while maintaining soil moisture at field capacity. Additional aquadest was added based on the difference between the daily weighing of the polybag and its initial weight.

Analyses were performed on the soil before and after treatment, as well as on the filter cake and rock phosphate materials. Soil parameters analyzed before and after treatment included pH H_2O, organic carbon (C-organic), potential phosphorus (P-potential), and phosphorus fixation capacity (P-retention). The filter cake was analyzed for pH H_2O, organic carbon, total nitrogen (N-total), and total phosphorus (P-total). The rock phosphate was analyzed for pH H_2O and total phosphorus content. The data obtained were then analyzed using Analysis of Variance (ANOVA). If a significant effect was found among treatments, it was followed by Duncan’s Multiple Range Test (DMRT) at the 5% significance level.

RESULT AND DISCUSSION

A. Initial Soil Analysis Before Treatment

This analysis was conducted to determine the initial condition of the soil before treatment was applied.

Table 1. Results of Latosol Soil Analysis Before Treatment

Parameter	Value	Unit	Classification (*)
pH H_2O	5,33	-	Acidic
Organic carbon (C-organic)	0,37	%	Very Low
Potential Phosphorus (25% HCl extract)	5,70	mg/100g	Very Low
Phosphorus fixation capacity (PFC)	265,02	ppm	Very High

*: Balittanah, 2005

The Latosol soil in Doga Hamlet, Nglanggeran, Patuk, Gunungkidul exhibits low fertility constraints (Table 1). This condition is caused by pedogenetic processes occurring in regions with high temperature and rainfall, which result in intensive weathering and leaching of bases and silica. Consequently, there is an accumulation of sesquioxides and a deficiency of macronutrients, particularly phosphorus (P). The chemical characteristics of the soil indicate a pH (H_2O) of 5.33, categorized as acidic, which is attributed to base cation leaching and the dominance of H^+ ions (Hardjowigeno, 2015). The organic carbon (C-organic) content is 0.37%, classified as very low, reflecting the scarcity of organic matter due to latosolization processes (Sutrisno *et al.*, 2021). The potential phosphorus (P-potential) content is 5.70 mg/100g, also classified as very low, as phosphorus is fixed by Al and Fe in acidic soils to form insoluble compounds (Hardjowigeno, 2015). The phosphorus retention capacity (P-retention) value of 265.02 ppm is considered very high, indicating strong phosphorus adsorption by Al and Fe. This condition inhibits the availability of phosphorus to plants. Therefore, increasing P availability is necessary through the application of organic materials such as filter cake and natural phosphorus sources such as rock phosphate, which have the potential to reduce P-retention and improve soil fertility.

B. Chemical Composition of Filter Cake Fertilizer

This analysis was conducted to determine the chemical composition of the filter cake fertilizer.

Table 2. Chemical composition of filter cake

Parameter	Unit	Value	Classification (*)
pH H_2O	-	7,8	Meets requirement
Organic carbon (C-organic)	%	5,84	-
N-Total	%	0,15	-
P-Total	%	11,27	Meets requirement
C/N ratio	-	38,93	-

*: Ministry of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019

The chemical analysis of filter cake (Table 2) shows that it has a pH (H_2O) of 7.8 (neutral) and a total phosphorus content of 11.27%, which meets the minimum technical standards for solid organic fertilizers as stated in Regulation No. 261/KPTS/SR.310/M/4/2019 by the Ministry of Agriculture. This indicates that filter cake has the potential to increase soil pH and supply phosphorus, albeit in limited quantities. However, the organic carbon content (5.84%), total nitrogen (0.15%), and C/N ratio (38.93) do not meet the quality standards for organic fertilizers. The high C/N ratio suggests that the filter cake is not fully decomposed, which may result in slow mineralization (Faridah *et al.*, 2014; Fangohoi *et al.*, 2017). Nevertheless, the application of filter cake can still contribute to improving soil chemical properties and nutrient availability, particularly when combined with rock phosphate.

C. Chemical Composition of Rock Phosphate

This analysis was conducted to determine the chemical composition of the rock phosphate.

Table 3. Chemical composition of rock phosphate

Parameter	Value	Unit	Classification
pH H_2O	7,51	-	Meets requirement
P-Total	9,28	%	-

According to the Indonesian National Standard (SNI) 02-3776-2005, phosphate fertilizers intended for agricultural use must contain a minimum of 10% total phosphorus. The analysis of the rock phosphate used in this study (Table 3) shows a pH (H_2O) of 7.51 (neutral) and a total phosphorus content of 9.28%, which does not meet the minimum standard. The product packaging indicated a P-total content of 14%, suggesting a discrepancy between the labeled and actual product quality. This difference may result from product inconsistency or segregation of material during storage or distribution. Nevertheless, the P-total content, which is close to the threshold value, indicates that this rock phosphate still has potential as a phosphorus source—particularly when combined with organic matter to enhance its efficiency in acidic soils such as Latosols.

D. Effect of Filter Cake Fertilizer and Rock Phosphate on Soil pH H_2O

This analysis was conducted to determine the effect of combined treatments of filter cake fertilizer and rock phosphate on soil pH H_2O.

Table 4. Effect of filter cake fertilizer and rock phosphate on soil pH H_2O

Filter Cake Fertilizer	Rock Phosphate			Average (*)
	F0	F1	F2	
B0	5,67	5,68	5,71	5,68 w
B1	5,93	6,08	6,18	6,07 x
B2	6,36	6,47	6,56	6,46 y
B3	6,48	6,60	6,69	6,59 z
Average (**)	6,11 q	6,21 p	6,29 p	(-)

Explanation:
Means followed by the same letter in columns (*) or rows (**) are not significantly different based on Duncan's Multiple Range Test (DMRT) at the 5% significance level. (–) indicates no significant interaction between treatments.
B0 = 0 ton/ha filter cake fertilizer
B1 = 5 ton/ha filter cake fertilizer
B2 = 10 ton/ha filter cake fertilizer
B3 = 15 ton/ha filter cake fertilizer
F0 = 0 kg/ha rock phosphate
F1 = 200 kg/ha rock phosphate
F2 = 400 kg/ha rock phosphate

Soil reaction, expressed as pH value, indicates the level of acidity or alkalinity in soil. pH reflects the concentration of hydrogen ions (H^+) present. The higher the H^+ concentration, the more acidic the soil becomes. In acidic soils, H^+ ions dominate over OH^- ions (Hardjowigeno, 2007).

Based on the results (Table 4), both filter cake fertilizer and rock phosphate had a significant effect on increasing the soil pH (H_2O) of Latosol, although no interaction between the two treatments was observed. The increase in filter cake and rock phosphate doses was linearly correlated with higher soil pH values. The 15 ton/ha filter cake treatment (B3) resulted in the highest pH value, from 5.67 to 6.69. The increase in soil pH due to filter cake application is attributed to the organic matter's ability to bind H^+ ions, thereby reducing soil acidity. Organic anions from carboxyl (-COOH) and phenol (-OH) functional groups in filter cake release OH^- ions, which neutralize H^+ in the soil solution and colloids. A reduction in H^+ concentration also reduces Al and Fe ions in the soil solution, further contributing to the increase in soil pH (Fikdalillah *et al*., 2016).

The application of 200 kg/ha (F1) and 400 kg/ha (F2) rock phosphate also significantly increased pH compared to the control (F0), although no significant difference was found between F1 and F2. The highest rock phosphate dose (F2) raised soil pH from 5.67 to 6.29. The increase in soil pH due to rock phosphate is attributed to the release of OH^- ions into the soil solution. This occurs when phosphate anions ($H_2PO_4^-$) replace OH^- ions bound to $Al(OH)_3$, releasing OH^- ions, which react with Ca^{2+} to form $Ca(OH)_2$, thus contributing to the increase in soil pH (La Habi *et al*., 2012).

E. Effect of Filter Cake Fertilizer and Rock Phosphate on C-Organic

This analysis is used to find out the effect of the combination of filter cake fertilizer and rock phosphate treatments on the soil organic carbon parameter.

Table 5. Treatment of filter cake fertilizer and rock phosphate on C-organic (%)

Filter Cake Fertilizer	Rock Phosphate			Average (*)
	F0	F1	F2	
B0	0,257	0,258	0,255	0,256 x
B1	0,321	0,340	0,340	0,334 w
B2	0,359	0,339	0,361	0,353 w
B3	0,382	0,363	0,365	0,370 w
Average (**)	0,329 p	0,325 p	0,330 p	(-)

Explanation:
Means followed by the same letter in columns (*) or rows (**) are not significantly different based on Duncan’s Multiple Range Test (DMRT) at the 5% significance level. (–) indicates no significant interaction between treatments.

B0 = 0 ton/ha filter cake fertilizer
B1 = 5 ton/ha filter cake fertilizer
B2 = 10 ton/ha filter cake fertilizer
B3 = 15 ton/ha filter cake fertilizer
F0 = 0 kg/ha rock phosphate
F1 = 200 kg/ha rock phosphate
F2 = 400 kg/ha rock phosphate

Organic carbon (C-organic) is the carbon content (C) contained in soil organic matter, so C-organic indicates the amount of organic matter in the soil (Nopsagiarti et al., 2020). Soil organic matter content is closely related to soil C-organic because organic matter determination is based on the C-organic value, so the high or low content of organic matter depends on its C-organic content. Soil fertility highly depends on soil C-organic content because soil C-organic is also the main source of N in soil and plays a significant role in improving the physical, chemical, and biological properties of soil.

Based on the analysis results, the application of filter cake fertilizer significantly affects the increase of C-organic content in Latosol soil, while rock phosphate does not have a significant effect. The combination of both treatments also shows no significant interaction (Table 5). The application of filter cake fertilizer doses of 5, 10, and 15 tons/ha significantly differ from without filter cake fertilizer (0 ton/ha), but the three doses do not show significant differences among each other. Increasing the filter cake fertilizer dose is followed by an increase in soil C-organic content, with the highest value at 15 tons/ha (B3). This is caused by the role of filter cake fertilizer as a source of organic matter that increases soil C-organic content, although the increase is still considered low due to the relatively small C-organic content in the filter cake. Meanwhile, the application of rock phosphate does not increase soil C-organic content, because rock phosphate is an inorganic material that does not contain organic carbon. Therefore, its application does not contribute to the addition of organic matter or organic carbon in the soil, so this is different from organic materials such as filter cake fertilizer, which directly supplies carbon and supports the increase of soil C-organic content.

F. The Effect of Filter Cake Fertilizer and Natural Phosphate on Potential Phosphorus

This analysis aims to determine the effect of the combined treatment of filter cake fertilizer and rock phosphate on the parameter of potential P extracted by 25% HCl.

Table 6. The effect of filter cake fertilizer and rock phosphate treatments on potential phosphorus

Filter Cake Fertilizer	Rock Phosphate			Average (*)
	F0	F1	F2	
B0	3,22	4,86	4,38	4,16 w
B1	5,09	5,25	5,60	5,31 x
B2	5,73	7,15	8,59	7,16 y
B3	8,21	8,39	9,51	8,70 z
Average (**)	5,56 q	6,41 p	7,02 p	(-)

Explanation:
Means followed by the same letter in columns (*) or rows (**) are not significantly different based on Duncan's Multiple Range Test (DMRT) at the 5% significance level. (–) indicates no significant interaction between treatments.
B0 = 0 ton/ha filter cake fertilizer
B1 = 5 ton/ha filter cake fertilizer
B2 = 10 ton/ha filter cake fertilizer
B3 = 15 ton/ha filter cake fertilizer
F0 = 0 kg/ha rock phosphate
F1 = 200 kg/ha rock phosphate
F2 = 400 kg/ha rock phosphate

Phosphorus (P) in soil is very stable (immobile), so losses due to leaching are relatively insignificant. However, P nutrient often becomes a limiting factor because it is very reactive and easily binds with Fe and Al, forming complex compounds that are difficult to dissolve, limiting available P. This is a main problem of phosphorus in soil.

Based on the analysis results, treatments of filter cake fertilizer and rock phosphate significantly affected the increase of potential P content in Latosol soil. However, there was no interaction between the two treatments in increasing potential P (Table 6). The filter cake fertilizer treatment showed significant differences between treatment levels. The highest potential P value was obtained at the filter cake fertilizer dose of 15 tons/ha (B3), indicating an increase along with increasing filter cake fertilizer doses. This increase is caused by two main mechanisms, namely metal ion chelation and soil pH increase. Organic acids resulting from the decomposition of organic matter in filter cake fertilizer, such as humic and fulvic acids, are able to form complex compounds (chelates) with Al^{3+} and Fe^{3+} ions, thus reducing phosphate fixation by these ions and increasing phosphorus availability. Moreover, the application of filter cake fertilizer also increases soil pH, especially in acidic soils such as Latosol, which affects the decrease in solubility and reactivity of Al and Fe. This also reduces the formation of insoluble phosphate compounds, making phosphorus more available to plants. Djuniwati *et al* (2003) support these findings by stating that the increase in soil potential P is related to the rise in pH due to the addition of organic matter that increases microbial activity in producing organic anions. These anions compete with orthophosphate and release bound phosphate, thereby increasing overall soil potential P.

Application of rock phosphate at doses of 200 kg/ha (F1) and 400 kg/ha (F2) increased soil potential P compared to the control (F0), although there was no significant difference between F1 and F2. Rock phosphate functions as both a phosphorus source and a soil acidity neutralizer due to its calcium carbonate ($CaCO_3$) content. The mechanism of increasing potential P in Latosol soil by rock phosphate occurs through neutralization of H^+ ions by carbonate (CO_3^{2-}) and hydroxide (OH^-) ions, which form insoluble $Al(OH)_3$ and $Fe(OH)_3$ compounds, thereby reducing phosphate fixation by Al^{3+} and Fe^{3+}. Additionally, the release of Ca^{2+} ions also helps improve the chemical conditions of acidic soil. With reduced phosphate fixation, phosphorus availability in the soil increases, thus raising soil potential P (Djuniwati *et al*., 2007).

G. The Effect of Filter Cake Fertilizer and Rock Phosphate on Soil Phosphorus Fixation Capacity (KPPT)

This analysis aims to determine the effect of the combined treatment of filter cake fertilizer and rock phosphate on the parameter of soil phosphorus fixation capacity (KPPT).

Table 7. Treatments of filter cake fertilizer and rock phosphate on KPPT

Filter Cake Fertilizer	Rock Phosphate			Average (*)
	F0	F1	F2	
B0	264,67 a	261,73 b	261,87 b	262,75
B1	262,55 b	261,37 bc	260,09 d	261,34
B2	261,98 b	260,34 cd	259,79 d	260,70
B3	260,20 d	260,04 d	257,99 e	259,41
Average (**)	262,35	260,87	259,93	(+)

Explanation:
Means followed by the same letter in columns (*) or rows (**) are not significantly different based on Duncan’s Multiple Range Test (DMRT) at the 5% significance level. (–) indicates no significant interaction between treatments.
B0 = 0 ton/ha filter cake fertilizer
B1 = 5 ton/ha filter cake fertilizer
B2 = 10 ton/ha filter cake fertilizer
B3 = 15 ton/ha filter cake fertilizer
F0 = 0 kg/ha rock phosphate
F1 = 200 kg/ha rock phosphate
F2 = 400 kg/ha rock phosphate

Kemampuan Penyematan P Tanah (KPPT) merupakan indikator kemampuan tanah dalam mengikat unsur hara fosfor (P) pada kompleks jerapan. KPPT dipengaruhi oleh berbagai faktor, antara lain pH tanah, kejenuhan kation, kandungan bahan organik, serta jenis dan jumlah komponen tanah seperti oksida Fe dan Al (seskuioksida), koloida amorfus, dan tipe mineral lempung silikat. Tanah dengan kandungan tinggi seskuioksida dan koloida amorfus memiliki kapasitas penyematan P yang lebih besar. Pada tanah masam, fosfat bereaksi dengan Al^{3+} dan Fe^{3+} membentuk senyawa Al-P dan Fe-P yang sukar larut, sehingga menurunkan ketersediaan P bagi tanaman.

Soil Phosphorus Fixation Capacity (KPPT) is an indicator of soil's ability to bind phosphorus nutrients (P) in the adsorption complex. KPPT is influenced by various factors including soil pH, cation saturation, organic matter content, and the type and amount of soil components such as Fe and Al oxides (sesquioxides), amorphous colloids, and silicate clay mineral types. Soils with high sesquioxide and amorphous colloid content have higher phosphorus fixation capacity. In acidic soils, phosphate reacts with Al^{3+} and Fe^{3+} to form Al-P and Fe-P compounds which are poorly soluble, thereby reducing P availability for plants.

Based on the research, treatments with filter cake fertilizer and rock phosphate significantly reduced the soil phosphorus fixation capacity (KPPT) in Latosol soil. There was a significant interaction between the two treatments in reducing KPPT (Table 7). The best combined treatment was at a dose of 15 tons/ha filter cake fertilizer and 400 kg/ha rock phosphate (B3F2), with the lowest KPPT value of 257.99 ppm. This value indicates a 2.65% decrease compared to untreated soil, showing the effectiveness of this combination in reducing P binding by the soil and increasing phosphorus availability.

The reduction in KPPT by filter cake fertilizer and rock phosphate is caused by an increase in soil pH due to the application of rock phosphate, where the release of hydroxide ions (OH^-) during phosphate adsorption by Al and Fe minerals contributes to raising soil pH. The increase in pH decreases Al^{3+} and Fe^{3+} activity through precipitation as $Al(OH)_3$ and $Fe(OH)_3$, and reduces phosphate fixation. OH^- ions also compete with phosphate for adsorption sites, thus helping release phosphate from bonding with soil minerals (La Habi et al., 2018). In addition, filter cake fertilizer application reduces KPPT through the role of organic anions such as humic acid, fulvic acid, and carboxylate compounds formed during organic matter decomposition. These anions can form complexes with Al^{3+} and Fe^{3+} ions, inhibiting the formation of insoluble phosphate compounds and directly competing with phosphate for adsorption sites (Yulnafatmawita et al., 2005). This mechanism increases phosphate solubility and availability in the soil.

However, although filter cake fertilizer and rock phosphate treatments reduce KPPT and increase soil potential P, the KPPT values in Latosol soil remain in the very high category. This is due to the natural characteristics of Latosol soil, which is rich in sesquioxides (Al and Fe) and dominated by kaolinite minerals, which have many positively charged adsorption sites. Therefore, P availability in the soil remains limited due to strong fixation by these soil components.

CONCLUSION

1. The application of filter cake fertilizer has a significant effect and is able to reduce the soil phosphorus fixation capacity (KPPT) of Latosol soil by 2.12%, from 265.02 ppm to 259.41 ppm.
2. The application of rock phosphate has a significant effect and is able to reduce the soil phosphorus fixation capacity (KPPT) of Latosol soil by 1.92%, from 265.02 ppm to 259.93 ppm.
3. The combination treatment of filter cake fertilizer and rock phosphate has a significant effect and is able to reduce the soil phosphorus fixation capacity (KPPT) of Latosol soil by 2.65%, from 265.02 ppm to 257.99 ppm.

REFERENCES

Aprilianda, D. 2012. The Effect of NPK Compound Fertilizer on Growth, Production, and Nutrient Uptake of Corn (*Zea mays* L.) on Darmaga Latosol. *Undergraduate Thesis*. Faculty of Agriculture, Bogor Agricultural Institute. Bogor.

Djuniwati, S., Hartono, A., & Indriyati, L. T. 2003. The Effect of Organic Matter (*Pueraria javanica*) and Rock Phosphate on Growth and P Uptake of Corn (*Zea mays*) on Sarongge Sandy Andisol. *Journal of Soil Science and Environment*, 5(1), 17-22.

Djuniwati, S., & Pulunggono, H. B. 2007. The Effect of Organic Matter (*Centrosema pubescens*) and Rock Phosphate Application on Phosphatase Activity and P Fraction of Latosol Soil in Darmaga, Bogor. *Journal of Soil Science and Environment*, 9(1), 10-15.

Fangohoi, L., dan Wandansari, N. R. 2017. Utilization of Sugarcane Filter Cake Waste into Quality Organic Fertilizer. *Triton Journal*, 8(2), 58-67

Faridah, A., Sumiyati, S., & Handayani, D. S. 2014. Comparative Study of the Effect of Agri Simba Activator and Banana Stalk Molasses on Macronutrient Content (C, N, P, K) of Compost from Sugarcane Filter Cake with Coffee Peel Addition (Case Study: PT. Nusantara Sugar Industry). *Doctoral Dissertation*. Diponegoro University.

Fikdalillah, F., Basir, M., & Wahyudi, I. 2016. The Effect of Cow Manure Fertilizer on Phosphorus Uptake and Yield of Chinese Cabbage (*Brassica pekinensis*) on Sideral Entisols. *Agrotekbis: Journal of Agricultural Science*, 4(5), 491-499.

Hardjowigeno, S. 2007. *Soil Science*. Akademika Pressindo, Jakarta.

Hardjowigeno, S. 2015. *Soil Science*. Akademika Pressindo, Jakarta.

Hasanudin and Gonggo, B. M. 2004. Utilization of Phosphate Solubilizing Microbes and Mycorrhiza for Improvement of Available Phosphorus, Soil Phosphorus Uptake (Ultisol), and Corn Yield (on Ultisol). *Indonesian Journal of Agricultural Sciences*, 6(1), 8-13.

Kaya, E. (2012). The Effect of Potassium and Phosphate Fertilizer on Phosphate Availability and Uptake of Peanut (*Arachis hypogaea* L.) on Brunizem Soil. *Agrologia*, 1(2), 113-118.

La Habi, M. 2012. Phosphate Availability, Phosphate Uptake, and Corn Yield Resulting from Ela Sagu Bokashi and Phosphate Fertilizer Application on Inceptisols. *Buana Sains*, 12(1), 63-70.

La Habi, M., Nendissa, J. I., Marasabessy, D., & Kalay, A. M. 2018. Phosphate Availability, Phosphate Uptake, and Corn Yield (*Zea mays* L.) Due to Granulated Ela Sagu Compost and Phosphate Fertilizer Application on Inceptisols. *Agrologia*, 7(1), 288-775.

Nopsagiarti, T., Okalia, D., dan Marlina, G. 2020. Analysis of Organic Carbon, Nitrogen, and C/N Ratio of Soil at Beken Jaya Agro-tourism Area. *Journal of Agroscience and Technology*, 5(1), 11-18.

Santoso, B., Sastrosupadi, A., dan Djumali. 2003. Utilization of Filter Cake and Rock Phosphate on Roselle Plant in Yellow Podzolic Soil of South Kalimantan. *Journal of Industrial Crop Research*, 9(3), 109-115.

Saptiningsih, E. 2015. Utilization of FiCellulose and Lignin Content of Various Organic Matter Sources after Decomposition on Latosol Soil. *Bulletin of Anatomy and Physiology of Cells*, 23(2), 34-42.

Supari, S., Taufik, T., & Gunawan, B. 2015. Chemical Analysis of Organic Fertilizer from Sugarcane Filter Cake Waste from Trangkil Sugar Factory. *In Proceedings of the National Science and Technology Seminar*, 1(1), 10-13.

Sutarwi, P. Bambang, Supriyadi. 2013. Effect of Phosphate Fertilizer Dosage on Growth and Yield of Several Peanut Varieties (*Arachis hypogaea* (L.) Merr) in Agroforestry Systems. *El-Vivo Journal*, 1(1), 42-48.

Winarso, S. 2005. *Soil Fertility: The Basis of Soil Health and Quality*. Gava Media, Yogyakarta.

Yulnafatmawita, Y., Maira, L., Junaidi, J., Yusmini, Y., & Hakim, N. 2005. The Role of Organic Matter in the Release of Bound Phosphorus in Andisol Soil. *Journal of Solum*, 2(2), 69-73.