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Activation of Sub-bituminous Powder with Urea and Dolomite to Improve Nutrient Content of Ultisols and the Growth of Oil Palm (*Elaeis guineensis* Jacq) Seedlings

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ABSTRACT

This study aimed to examine the interaction effects of sub-bituminous powder and an activator to improve the chemical properties of Ultisols and the growth of oil palm (*Elaeis guineensis* Jacq) seedlings. This research was done in the Laboratory of Soil Chemistry and Experimental Garden of the Agricultural Faculty of Andalas University from December 2016 to June 2017. A 2-factor factorial Completely Random Design (CRD) was used with three replications. The first factor was the activator: (A_0) without activator, (A_1) 10% urea, and (A_2) 10% dolomite. The second factor was the dose of sub-bituminous powder: (B_1) 10 ton.ha^{-1}, (B_2) 20 ton. ha^{-1} and (B_3) 30 ton.ha^{-1}. The results showed that the : (1) added sub-bituminous powder interacted with the activator to increase total-N of soil and plant height, with the highest achieved by the dose of 30 ton.ha^{-1} sub-bituminous powder with urea as activator; (2) The addition of sub-bituminous powder at a dose of 30 ton. ha^{-1} was able to increase pH, organic-C, available-P, CEC of the Ultisol and the level of plant N and P at 0.03% and 0.05% compared with the dose of 10 ton ha^{-1}; (3) The addition of urea as an activator increased pH by 0.09 unit, organic-C by 0.18%, available-P in Ultisol by 0.92 ppm, and CEC of 2.10 cmol $^{(+)}$/kg, as well as decreased Al-exchange by 0.49 cmol $^{(+)}$/kg and increased plant nitrogen by 0.07%, leaf number by 1.64 leaves, seedling dry weight by 9.19 g compared with treatment without activator.

Keywords: **Sub-bituminous, Ultisols, urea, dolomite, oil-palm seedlings**

INTRODUCTION

Ultisols are marginal soils in Indonesia that have a wide distribution of 45.8 million ha or about 25% of total land area of Indonesia (Subagyo *et al*. 2004). Though Ultisols have good potential to be developed for agriculture, its utilisation has been constrained by several factors that hinder plant growth, such as low pH (<5.0) with high Al saturation (>42%), low organic-C (<1.15%), low nutrient content with the range of N and P content being 0.14% and 5.80 ppm respectively, and low base saturation of 29% (Rusli 2016).

Efforts to solve this problem include adding organic material as it contains substances which have the ability to bind soluble Al, Fe and Mn in soil to form

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complex compounds or organometallic chelate compounds (Stevenson 1994). An organic material that can be utilised is unproductive coal (sub-bituminous) which has low energy level and therefore cannot be used as an energy source. Sub-bituminous coal has high percentage of moisture content and loss of ignition with 18% and 80.49% respectively (Mohamad *et al*, 2013). Therefore, sub-bituminous powder can be used as a source of humic material to improve soil chemical properties.

Herviyanti *et al.* (2012) mentioned that the addition of humic material originating from sub-bituminous powder at a dose of 800 ppm (1.6 ton/ha) was able to increase available-P and CEC of soil amounting to 22.16 ppm and 8.42 cmol$^{(+)}$/kg while also increasing soil Al-exchange to 0.83 cmol $^{(+)}$/kg compared to non-humic material. Sub-bituminous powder provides more benefits if it is activated using urea, KCl, NaCl, NaOH and dolomite ($CaMg(CO_3)_2$) thus increasing CEC. Herviyanti *et al.* (2014) examined the level of sub-bituminous powder activity with urea fertiliser as an activator. Optimal results were obtained at a recommended urea concentration of 125%. At that concentration, a relatively neutral pH value (7.25), quite a high CEC of 60.68 cmol$^{(+)}$/kg, powder solubility of 12.37%, total-N of 5.78%, K-exchange value of 5.25 cmol$^{(+)}$/kg, Cl concentration of 0.23% and Na-exchange concentration of 4.08 cmol$^{(+)}$/kg were obtained.

Urea is a relatively cheap fertiliser that is more easily available. It reacts to alkaline as in the case of dolomite. Therefore dolomite may be used as the activator of sub-bituminous powder. Hydrolysed dolomite produces OH- which further activates sub-bituminous coal powder. Sub-bituminous powder has been applied in food crop such as rice and maize. In this study, sub-bituminous powder was applied to plantation crop like oil palm. Oil palm is one of the plantation crops that has high economic value and continues to be the largest foreign exchange earner for Indonesia compared to other plantation crops (Sunarko 2007).

A limiting factor in the high production of oil palm is seedling production. As seedling production activity is the basis for the preparation of good planting material, seedling production activity should be managed well. Several factors to be considered in the seedling production process of oil palm are watering, fertilising (basic fertiliser) and plant disturbing organisms (PDO). The purpose of this study was to examine the interaction between activator factors and sub-bituminous powder and the main effect of each factor in improving the chemical properties of the Ultisols towards promoting the growth of oil palm seedlings.

MATERIALS AND METHODS

This research was conducted in the Laboratory of Soil Chemistry and Fertility of the Soil Department and Experimental Garden of the Agricultural Faculty, Andalas University, Padang from December 2016 to June 2017. It was a pot experiment using 3 x 3 Factorial Completely Random Design (CRD) with 3 replications. The first factor was activator (A) which was added at three dose levels:

A0 = Without activator
A1 = 10 % urea of the weight of sub-bituminous powder
A2 = 10 % dolomite of the weight of sub-bituminous powder

The second factor was the dose of sub-bituminous powder which was also added at three dose levels:
B1 = 40g/pot equal to 10 $ton.ha^{-1}$
B2 = 80g/pot equal to 20 $ton.ha^{-1}$
B3 = 120g/pot equal to 30 $ton.ha^{-1}$

The data were analysed statistically with the F-test. However, if the F-test of treatment was higher than the level of 5%, a further DNMRT analysis was carried with the level of significance set at 5%. .

Research Method
Sub-bituminous coal was collected at 1-2 m depth below the soil surface in Ganggo Mudiak Nagari, Pasaman Regency of West Sumatera. The sub-bituminous coal was cleaned, crued, and sieved using 100 µm mesh siever. Composite Ultisol soil materials were taken from Dharmasraya Regency at a depth of 0-20 cm, air dried, and further sieved using a 2-mm sieve. The sub-bituminous powder was activated with urea and dolomite at each dose of treatment, to which was added water until field capacity, and evenly mixed. Later, samples were incubated within the soil (soil weight of 8 kg equals to oven dry weight) for 10 days. Changes in the chemical properties of the Ultisol analysed included pH of H_2O using the electrometric method, CEC with leaching method, organic-C with Walkley and Black method, total-N with Kjedhal method, available-P with Bray method, and Al-exchange with volumetric method. Later, 4-month old oil palm pre-nursery seedlings were planted, maintained, and observed for their growth over a period of 4 months (main-nursery). The vegetative stage of the plant was harvested for the analysis of nutrient level of N and P.

RESULTS AND DISCUSSION

Chemical Properties of Ultisols in Nagari Gunung Selasih, Sub-district of Pulau Punjung, Regency of Dharmasraya
Based on the pre-analysis results (Table 1), it can be seen that the chemical properties of the Ultisol indicate low fertility. Based on soil pH, it was classified as an acid soil. Cation Exchange Capacity (CEC) and content of total N, P and base cations were considered low, while Al-exchange was high. These results are in line with those of Rusli (2016) that Ultisols have constrains of low pH (acid) of <5.0 with high Al saturation of >42%, low organic material of <1.15%, low nutrient with N at 0.14%, P at 5.80 ppm, and CEC at 12.6 me/100 g.

It can be seen in Table 1, that the Al-exchange content of the Ultisol was a high of 2.08 $cmol^{(+)}/kg$) . It is easy for Al in soil colloids to be hydrolysed to

TABLE 1
Pre-analysis results of several chemical properties of the Ultisol in Nagari Gunung Selasih of Pulau Punjung Sub-district, Dharmasraya Regency

No	Analysis	Value	Criteria
1	pH of H_2O (1:1)	4.60	Acid*
2	Al-exchange (cmol $^{(+)}$/kg)	2.08	-
3	K- exchange (cmol $^{(+)}$/kg)	0.10	Low*
4	Ca- exchange (cmol $^{(+)}$/kg)	2.25	Low*
5	Mg- exchange (cmol $^{(+)}$/kg)	0.42	Low*
6	Na- exchange (cmol $^{(+)}$/kg)	0.11	Low*
7	CEC (cmol $^{(+)}$/kg)	11.65	Low*
8	Total-N (%)	0.12	Low*
9	Organic-C (%)	1.35	Low*
10	Available-P (ppm)	6.13	Low*
11	Al Saturation (%)	41.93	High*
12	C/N	10.75	Low*

**Source*: Hardjowigeno (2010)

produce H^+ ion in the soil. However, the increasing H^+ ion concentrations result in an acid reaction in soil (Hakim 2006). If H^+ concentration continues to increase, soil pH will decrease. As presented in Table 1, it can be seen that pH of the Ultisol was acidic as the value was 4.60. The low pH of soil causes the P element to be more easily bound to soil colloids which are protonised due to H^+ dissociation. Moreover, the low P content of 6.13 ppm is due to P being bound by the oxide of Al. The CEC of the Ultisol was also low as it was affected by low organic carbon content of the soil. According to McCauley *et al.* (2017), the consistent benefit of soil organic matter is that it buffers soil pH change. Availability of nutrients for plant uptake varies depending on soil pH.

Low organic content decrease the loss of base cations as seen in Table 1 where the base cations are low, with the Ca content being 2.25 cmol$^{(+)}$/kg, Mg-exchange at 0.42 cmol$^{(+)}$/kg , Na-exchange at 0.11 cmol$^{(+)}$/kg and K-exchange at 0.10 cmol$^{(+)}$/kg. The availability of cation nutrients is often hindered by increased susceptibility to leaching or erosion losses in acidic soils. Organic carbon content is the main factor that determines the level of soil fertility, both physically, chemically, and biologically, particularly in terms of metal cation binding that is available for plant growth. Low organic carbon content influences total nitrogen as seen in Table 1 which shows a low total N in the soil. This is because N content is easily lost in the form of leached nitrate (NO_3^-) because soil is rapidly lost due to high rainfall in tropical climates (Rosmarkam and Yuwono 2002).

Effect of Sub-Bituminous to Improve Nutrient Content of the Ultisol and the Growth of Oil Palm Seedlings

Table 2 shows that the addition of sub-bituminous powder resulted in significant effects on soil properties of the Ultisol. The higher dose of sub-bituminous powder increased soil pH, organic carbon content, available-P and CEC. In general, the addition of sub-bituminous powder increased nutrient content of the Ultisol as the humic material functions as an active substance which is able to improve the ability of soil colloids in carrying out nutrient exchange. Several studies found that soil fertility is determined by soil humic acid content as it contains high CEC and oxygen and better water holding capacity. Furthermore, humic acid is able to bind insoluble metal ions, oxide, and hydroxide and release it slowly.

TABLE 2

Effects of adding sub-bituminous and type of activator to improve nutrient content of the Ultisol

Parameter	Dose of sub-bituminous powder		
	10 ton/ha	20 $ton.ha^{-1}$	30 $ton.ha^{-1}$
pH of H_2O (unit)	4.73 C	4.99 B	5.13 A
Al-exch (cmol $^{(+)}$/kg)	1.42 A	1.13 B	1.22 B
K-exch (cmol $^{(+)}$/kg)	0.11 C	0.13 B	0.15 A
Ca-exch (cmol $^{(+)}$/kg)	4.68 B	5.59 A	6.01 A
Mg-exch (cmol $^{(+)}$/kg)	0.49 B	0.58 A	0.59 A
CEC (cmol $^{(+)}$/kg)	13.61 C	16.61 B	21.02 A
Organic-C (%)	1.75 C	1.99 B	2.10 A
Available-P (ppm)	7.43 C	8.45 B	9.52 A
	Type of activator		
	Without activator	Urea	Dolomite
pH of H_2O (unit)	4.86 B	4.95 AB	5.03 A
Al-exch (cmol $^{(+)}$/kg)	1.71 C	1.22 B	0.84 A
K-exch (cmol $^{(+)}$/kg)	0.12 B	0.13 B	0.15 A
Ca-exch (cmol $^{(+)}$/kg)	4.93 C	5.42 B	5.92 A
Mg-exch (cmol $^{(+)}$/kg)	0.51 C	0.56 B	0.60 A
CEC (cmol $^{(+)}$/kg)	16.18 B	18.28 A	16.78 B
Organic-C (%)	1.77 C	1.95 B	2.10 A
Available-P (ppm)	7.42 C	8.34 B	9.63 A

Values in the same row followed by capital letters are not significantly different based on DNMRT at a significance level of 5%.

pH increased due to the increasing dose of sub-bituminous powder which results in a rise in active carboxylic and phenolic groups. Both these groups suppress the concentration of Al^{3+} in soil solution. According to Huang and Schnitzer (1997) an increase in the does of the humic acid will result in an increase in the functional group of humic acid, resulting in a complex substance being formed through the functional (-COOH) and phenolic (-OH) group. The increase in organic-C is caused by the addition of C from the sub-bituminous powder which contains high carbon content. Poertadji *et al*. (2006) state that carbon content of sub-bituminous coal is 46.3 %, while Tan (2010) reports that humic acid is rich in carbon at a range of 41-57%.

Table 2 shows that a decrease in Al-exchange occurred along with the addition of a dose of sub-bituminous powder. It was found that the humic acid contained in the sub-bituminous powder was able to chelate Al. The addition of sub-bituminous powder with the activator had a significantly different effect on Al-exchange, Ca-exchange, Mg-exchange, organic-C and available-P of the Ultisol. In line with the results reported by and Muktamar *et al.* (1998), several organic acids released from sub-bituminous powder are able to bind Al, forming a complex compound (organometallic complex) which is hard to dissolve. The group that plays a role in the complex compound formation is a functional group such as carboxyl, hydroxyl, and phenol that originate from organic acid.

The increase in Al content and pH impacts the availability of Ca and Mg. The increase in available-P contents along with the decreasing Al concentration in the Ultisol (Table 2) is due to the addition of dolomite as an alkaline activator which donates OH- ion causing P to be bound by Al which will be exchanged with OH- resulting in P being released from Al-P compound and available in soil as in the reaction below:

$$Al(OH)_2H_2PO_4 + OH^- \rightarrow Al(OH)_3 + H_2PO_4^-$$

Urea as an activator was able to increase the level of organic-C of soil as seen in Table 2, to about 0.18 % compared with treatment without activator. Ammonium from urea may be expected to be bound at the active side of soil colloids from sub-bituminous carbon. Dolomite was also able to increase organic-C of soil of 0.36 % compared to treatment without activator and dolomite was found to be a better activator than urea. This is because dolomite reaction accelerates organic-C from sub-bituminous powder because of its high pH in the soil. Herviyanti *et al*. (2014) state that powder dissolved in urea will be rapidly dissociated in the soil as urea and H_2O in the soil will donate CO_2 and NH_4OH.

The addition of urea could increase pH of the Ultisol by 0.09 unit compared to treatment without activator. It is expected that urea with its base solvent characteristic is hydrolysed and will form ammonium carbonate as seen in the reaction below:

$$CO(NH_2)_2 + 2H_2O \rightarrow (NH_4)_2CO_3 \rightarrow NH_3 + CO_2$$
$$NH_3 + H_2O \rightarrow NH_4OH \rightarrow NH_4^+ + OH^-$$

Ammonium carbonate is an unstable compound that is decomposed into ammonia and carbon dioxide (Tisdale and Nelson 1975). Ammonia compound, if it reacts with water, will form ammonium and hydroxide. The existence of OH^- ion produced will decrease the concentration of H^+ ion thus increasing soil pH.

Dolomite as an activator was able to increase the pH value of the Ultisol oby 0.17 unit compared to treatment without activator, a value which was also higher than the value obtained by urea as activator, by about 0.08 unit. This is expected as the hydrolysed dolomite will provide more OH^- ion that will neutralise Al^{3+} in soil solution; if OH^- residue is high, the pH in soil will increase. This condition is in accordance with the hydrolysis reaction as follows:

$$CaMg\,(CO_3)_2 + H_2O \quad \rightarrow \quad Ca^{2+} + Mg^{2+} + 2HCO_3^- + 2OH^-$$

In Table 2, it is seen that the addition of the sub-bituminous powder with dolomite as an activator produced a soil CEC that was not significantly different from treatment without activator. Moreover, urea as an activator produced a higher CEC than dolomite, 16.78 to 18.28 cmol $^{(+)}$/kg. This can be attributed to urea having the ability to increase negative charge which results in increasing the CEC. An increase in cation exchange of Ultisol with the addition of sub-bituminous powder and activator was also noted. This is because there is dissociation of proton or H+ ions in aromatic, aliphatic, carboxyl and phenolic groups from the sub-bituminous powder and activator (Herviyanti *et al.* 2014). The extent of the cation exchange capacity in humic material depends on pH of solvent which increases with increasing pH, resulting in H+ dissociation derived from the carboxyl group when pH is low and the phenolic group when pH is high (Tan 2010).

The addition of sub-bituminous powder with activator was able to increase the chemical properties of the Ultisol such as pH, organic-C, available-P, total-N of soil, CEC, Ca, Mg and K exchanges (Table 2) as well as decrease Al-exchange. An improvement in soil chemical properties will lead to an increase in plant height, number of leaves, seedling dry weight, level of N and P in plant (Table 2), all of which indicate that the plant root is well developed and supported by available nutrients.

Effect of Sub-Bituminous Powder and Activator on the Growth of Oil Palm Seedlings

Improvement in soil chemical properties supports plant growth such as plant height, number of leaves, seedling dry weight, level of N and P in plant. Roots develop well to ensure better nutrient absorption which is supported by the availability of nutrients. In Table 3, the addition of the activator was found to provide a significantly different effect on the increasing level of N. The level of N and plant height with urea as an activator increased to about 0.069 % compared to treatment with dolomite or without activator (0.034%).

The addition of sub-bituminous powder at a dose of 20 ton/ha increased N value by 0.02 % compared with the dose of 10 ton.ha^{-1} (Table 3). The increase in N level occurred due to increasing pH, organic-C level, available-P, total-N and decreasing Al-exchange content (Table 2). Thus better root growth was achieved. Root development continued to increase and was better able to absorb nutrients, particularly N as an essential nutrient for plant growth. Costa *et al*. (2002) reported

TABLE 3
Effect of sub-bituminous and type of activator towards the growth of oil palm seedling in the Ultisol

Parameter	Dose of sub-bituminous powder		
	10 ton/ha	20 ton/ha	30 ton/ha
Plant N content (%)	0.19 B	0.21 A	0.22 A
Plant P content (%)	0.022 B	0.022 B	0.027 A
Number of leaves	10.78 B	11.55 A	12.22 A
Dry weight (g)	50.63 B	52.11 AB	53.79 A
	Type of activator		
	Without activator	Urea	Dolomite
Plant N content (%)	0.17 C	0.24 A	0.21 B
Plant P content (%)	0.023 A	0.023 A	0.025 A
Number of leaf (leaves)	10.78 B	12.44 A	11.33 B
Dry weight (g)	47.46 C	56.65 B	52.43 A

Values in the same row followed by capital letter are not significantly different based on DNMRT test at of 5% level of significance.

that root length and root surface area increase under intermediate N levels and that root growth is reduced under both higher and lower fertilisation levels.

Addition of sub-bituminous powder with urea as an activator led to the highest value of N content compared to dolomite and without the activator. It is because urea contains 45 % of N. In Table 2, it can be seen that total-N content in soil also increased along with the addition of sub-bituminous powder with the activator. Thahirna (2010) notes that humic material have better ability to improve chemical properties in rhizosphere, leading to better root development and nutrient absorption.

Availability of N element for plant is affected by the environment as plants may obtain nitrogen from the air, and water and organic materials from the soil. Hardjowigeno (2010) also states that N in soil originates from organic material in the soil and fixation of microorganism while N in the air, originates from fertiliser and rain water.

In Table 3, the addition of sub-bituminous powder with the activator did not significantly affect the level of P in plants. Sub-bituminous powder at doses of 10 ton/ha and 20 ton/ha was not significantly different but a dose of 30 ton/ha resulted in a significant difference with the highest value of plant-P being obtained.. This finding is inversely proportional to P content that is available in soil, as seen in Table 2 where the addition of sub-bituminous powder with the activator increased available P in soil.

Arsyad *et al.* (2012) stated that P in soil is usually stable, not easily carried away by water as P is strongly bound to soil components. The addition of high amounts of phosphate will change phosphate into a fraction that has high binding power on red soils and is hard to dissolve since P forms phosphate-Al and phosphate-Fe fractions. Phosphate in soil is similar to nitrogen in organic form, they are both hard to dissolve and not available for plants as their availability is affected by soil pH. Therefore, in order to ensure that plants obtain phosphate from soil based on their need, the amount of phosphate applied should exceed its fixation capacity. Leiwakabessy *et al*. (2004) stated that phosphorus is the second most important element for plants after nitrogen.

The effect of addition of sub-bituminous powder with urea as the activator resulted in a higher number of leaves compared with without the activator and dolomite (Table 3). This is because urea contains 40-45 % N and has a function in leaf formation (during the vegetative phase). The effect of the addition of sub-bituminous powder at a dose of 20 and 30 ton/ha was almost similar, yet it was significantly different at a dose of 10 ton.ha^{-1}. It is expected that similar amounts of nutrients is absorbed by plants at a dose of 20 and 30 ton/ha. However, in terms of value, the higher the dose of sub-bituminous powder, the higher the number of plant leaves. It is because sub-bituminous powder contains humic material which is able to improve the chemical properties of the soil. Thus plant roots will absorb more available nutrients and support vegetative growth of plant.

Fitter and Hay (1981) mentioned that the number of leaves and leaf area are the main determinants of the growth rate of leaves based on the assumption that a higher number of wide leaves means faster growth. Parman (2007) in a study on potatoes (*Solanum tuberosum* L) reported that the potato plant experienced an increase in leaf number from 196 to 344 leaves after the addition of organic fertilisers. The addition of organic fertiliser or manure accelerates the synthesis of amino acid and protein, thus stimulating plant growth.

Interaction of the Addition of Activated Sub-Bituminous Powder on Total-N of Ultisol

Addition of sub-bituminous powder with urea and dolomite as activator showed significant interaction with total-N of soil. The addition of the activator resulted in a significant effect on increasing the total-N content of Ultisol. At a dose of 10 ton/ha sub-bituminous powder, the addition of dolomite and urea succeeded in increasing total-N of soil to 0.12 % and 0.12 %, while at a dose of 20 ton/ha, it was able to increase to 0.10 and 0.13 % compared with treatment without the activator. Moreover, at a dose of 30 ton.ha^{-1}, the urea increased total-N to a level higher than treatments with dolomite and without the activator. Though the addition of dolomite and without the activator generated fairly similar results on the three dose of sub-bituminous powder, the addition of urea at a dose of 30 ton/ha was able to increase total-N by 0.22 % and 0.13 % compared to treatments without activator and dolomite.

Urea-as an activator and sub-bituminous powder at a dose of 30 ton/ha obtained the highest total-N value with N from urea contributing to 45% of total N; an increase in the dose of sub-bituminous powder is also expected to provide higher N contribution. Shelly (2014) notes that sub-bituminous powder activated with urea at 125% (375 kg ha^{-1}) is expected to increase total-N of sub-bituminous powder to 5.61%. As presented in Table 4, dolomite as an activator was able

TABLE 4
Effect of addition of sub-bituminous powder activated with urea and dolomite on total-N of the Ultisol

Activator	Dose of sub-bituminous powder		
	10 ton/ha	20 ton ha^{-1}	30 ton ha^{-1}
	……………………Total-N (%) ..…………………		
Without Activator	0.14 b A	0.16 b A	0.17 c A
Urea	0.26 a B	0.29 a B	0.39 a A
Dolomite	0.26 a A	0.26 a A	0.26 b A
CC	13.47 %		

Values in the same row followed by similar capital letters and in the same column followed by similar subscripts are not significantly different based on the result of DMRT at 5% significance level.

to increase total-N of soil compared to without the activator. This is because dolomite is able to activate the humic acid of the sub-bituminous powder.

Interaction of the Addition of Activated Sub-bituminous Powder with Plant Height

The interaction between the added activator and sub-bituminous powder resulted in an increase in plant height. The single effect of the activator addition to sub-bituminous powder towards plant height was found to be significant as seen in Table 5.

At a dose 10 ton/ha of sub-bituminous powder, the addition of dolomite and urea was able to increase plant height by 3 and 4.83 cm, respectively. At a dose of 20 ton/ha, plant height increased by 3.2 and 7.9 cm compared to treatment without the activator. But at a dose of 30 ton/ha, urea increased plant height to a level higher than in treatment with dolomite and without the activator. The addition of dolomite and without the activator generated almost similar results in the three doses of sub-bituminous powder, but with the addition of urea at a dose of 30 ton/

TABLE 5.
Effect of addition of sub-bituminous powder with urea and dolomite as activator on oil palm height (cm)

Activator	Dose of sub-bituminous powder		
	10 ton ha^{-1}	20 ton ha^{-1}	30 ton ha^{-1}
	……………………plant height (cm) …………………		
Without Activator	52.07 a A	53.43 b A	52.67 b A
Urea	56.90 a B	61.33 a B	67.07 a A
Dolomite	55.07 a A	56.63 ab A	56.73 b A
CC	4.01 %		

Values in the same row followed by similar capital letters and in the same column followed by similar subscripts are not significantly different based on the results of DMRT test at a level of 5%.

ha was able to increase plant height by14.40 and 10.34 cm compared to treatment without the activator and with dolomite.

The use of urea as the activator and sub-bituminous powder at a dose of 30 ton/ha produced the highest plant height. The increase in plant height was an expected result of the treatment which has the ability to increase soil pH, provide nutrients in soil, and contain various cations or other micro elements, thus supporting growth and development of the plant. The addition of dolomite as an activator was also able to increase plant height because Ca and Mg elements in dolomite are utilised by the plant during vegetative growth.

N element is an essential requirement for plant vegetative growth such as root, stem, and leaves; thus increasing N element will further increase plant height. According to Setyamidjaja (2006), N is important for plants to compose amino acid, amide, nucleotide, and also essential for cell division and cell growth (enlargement), which has an impact on increasing plant height. Leiwakabessy *et al*. (2004) added that nitrogen is needed by plant growth both in vegetative and generative phase, and this nutrient is mobile within the plant. Plant height figures are presented in Figure 1.

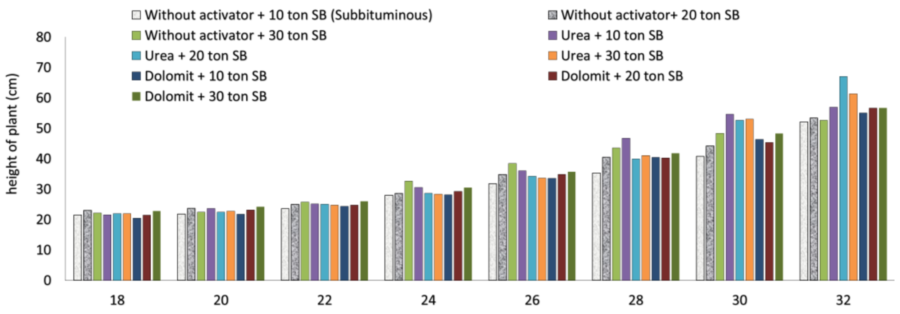

Figure 1: Height of oil palm seedlings after 18 weeks.

In Figure 1, it is seen that sub-bituminous powder with the activator was able to increase plant height compared to treatment without the activator along with the observation of oil palm seedling growth. Organic material from the sub-bituminous powder has a positive impact on increasing plant height due to the availability of essential macro nutrients (K-exchange) which greatly affect the development and growth of the plant. As confirmed by Rosmarkam and Yuwono (2002), potassium (K) plays a role in increasing enzyme activity during the reaction of photosynthesis and respiration.

CONCLUSIONS

Based on the results obtained, it could be concluded that: (1) the addition of sub-bituminous powder was found to interact with the activator in increasing total N of soil and plant height, with the highest total-N and plant height being obtained in the treatment of sub-bituminous powder at a dose of 30 ton.ha-1 with urea as the activator; (2) the addition of sub-bituminous powder at a dose of 30 ton/ha increased pH, organic-C, available-P, and CEC of Ultisol to 0.4 unit, 0.35 %, 2.09, 7.41 cmol $^{(+)}$/kg , respectively, as well as increased the level of N and P in plant by 0.03% and 0.05% compared with a dose of 10 ton/ha; (3) the addition of activator (urea) increased pH by 0.09 unit, organic-C by 0.18 %, and available-P in the Ultisol by 0.92 ppm, decreased Al-exchange by 0.49 cmol $^{(+)}$/kg and increased N level in plant by 0.07%, leaf number by 1.64 leaves, seedling dry weight by 9.19 g compared to treatment without the activator, and increased CEC of the Ultisol by 1.5 cmol $^{(+)}$/kg compared to the treatment with dolomite.

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