Activation of sub-bituminous coal with dolomite to improve chemical properties and palm oil growth on ultisols

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Abstract. Sub-bituminous coal [SC] activation with dolomite is the future technology in utilizing coal as an alternative organic material [Humic Substance]. This study aims to study the effect of SC activated with dolomite in improving the chemical properties of Ultisols and palm oil growth at the main-nursery stage [Elaeis guineensis Jacq.] in Dharmasraya. The experimental design was in Randomized Completely Block Design with three replications consisting of 6 treatments : A = 150g SC planting hole⁻¹; B = 300g SC planting hole⁻¹; C = 450g SC planting hole⁻¹; D = 150g SC + 10% [15g] dolomite planting hole⁻¹; E = 300g + 10% [30g] dolomite planting hole⁻¹ and F = 450g SC + 10% [45g] dolomite planting hole⁻¹. The results showed that the effect of activation on SC differs from those treatments without activation with dolomite. Effect of 450g SC activated with dolomite planting hole⁻¹ is significant on the chemical properties of Ultisols, such as increasing in pH, available P, organic C, total N, CEC [Cation exchange capacity], and K, Ca, Exch-Mg, by 0.44 units, 1.33 ppm P, 0.44% C, 0.04% N, 0.25, 0.27, and 0.29 cmol·kg⁻¹, compared to 450g SC without activator and an increase in palm oil growth on height [12.33cm], stem diameter [0.84cm] and N, P, and K nutrient concentration from leaf of plant [0.014% N, 0.004% P, 0.002% K], compared to 450g SC without activator.

Keywords: activation, dolomite, palm oil, sub-bituminous coal, ultisols.
1. Introduction
Palm oil is the largest plantation commodity in Indonesia in terms of the country's economic income. [1]. Dharmasraya has an area of palm oil of 31.842 ha with a production of 108.673 tonnes. However, this is inversely proportional to the quality of land that is not promising for palm oil production. The type of soil dominated is Ultisols which have low fertility. [2] Ultisols in Pulau Punjung, Dharmasraya have low pH by 4.60 units and have relatively low availability of P by 6.13ppm P, CEC by 11.65 cmol.kg⁻¹, and the base cations [K, Ca, Mg, and Na] in this soil are also relatively low, by 0.10; 2.25; 0.42 and 0.11 cmol.kg⁻¹. Ultisols also have low organic matter, the content of organic C and N total is also low by 1.35% C and 0.12% N which shows a low level of soil fertility.

An alternative technology that is economical, through the provision of organic materials by utilizing a Humic Substance [HS] from low-rank coal [sub-bituminous coal] activated with dolomite. According to [3] that SC can be used as a source of organic matter in increasing marginal land productivity. [2] Activated SC with dolomite can increase pH, organic C, available P of Ultisols by 0.163 units; 0.36% C; 2.22 ppm P and decreased Exch-Al by 0.87 cmol.kg⁻¹ and increased the N total of palm oil in the pre-nursery stage by 0.034% N, compared without activators. Thus, it is necessary to carry out further research at the main-nursery stage in the field. This study aims to study the effect of SC activated with dolomite in improving the chemical properties of Ultisols and palm oil growth at the main-nursery stage in Dharmasraya.

2. Materials and methods
This research was conducted in Nagari Sungai Dareh, Pulau Punjung, Dharmasraya West Sumatra, and the Laboratory of Soil Science, Agricultural Faculty, Andalas University, Padang from December 2018 to December 2019.

2.1 Experimental design
The experimental design was in Randomized Completely Block Design with three replications consisting of 6 treatments: A = 150g SC planting hole⁻¹; B = 300g SC planting hole⁻¹; C = 450g SC planting hole⁻¹ and D = 150g SC + 10% [15g] dolomite planting hole⁻¹; E = 300g SC + 10% [30g] dolomite planting hole⁻¹ and F = 450g SC + 10% [45g] dolomite 10% planting hole⁻¹.

2.2 The activation of Sub-bituminous coal and Incubation process
The land is cleared of weeds and initial soil sampling is carried out. The planting hole is prepared with size 50 cm x 30 cm x 60 cm with a spacing of 9 m. Sub-bituminous Coal was activated with dolomite at each dose of treatment, to which was added water until field capacity, evenly mixed, and incubated for 10 days. After that, the results of SC activation were homogenized with soil per volume of soil and watered to field capacity, next incubated for 2-weeks. The Ultisols sample is taken for soil chemical properties analysis after treatment. The palm oil seedlings used are 9-month-old seeds. Seedlings are planted when the incubation period is complete and subsequent growth of palm oil seedlings is observed in the field. Urea, KCl, and SP-36 fertilizers are given according to recommendations of the Indonesian oil palm research institute.

2.3 Analysis of soil and plant
Ultisols analyzed included: the soil pH H₂O [1:1] using the electrometric method, CEC with leaching method, basic cations [K, Ca and Exch-Mg], organic C with Walkley and Black method, total N with Kjeldahl method, available P with Bray II method, Exch-Al with the volumetric method. The vegetative stage of the plant was harvested for the analysis of the nutrient concentration of N, P, and K from leaf of plant [4]. Observation of plants includes plant height measured when plant aged 2-months after planting, stem diameter, and the number of midribs measured 1-month after planting and so on until the 6th-month. The statistical analysis has carried the software of Statistix 8. It submitted to an analysis of variance [ANOVA].
3. Results and Discussion

Figure 1 shows the effect of the application of SC activated with dolomite. The results of the analysis of variance of SC activated with dolomite had a very significant effect on pH, available P, organic C, N total, CEC, and cation bases [K, Ca, and Exch-Mg] of Ultisols.

![Figure 1](image)

**Figure 1.** Effect of Sub-bituminous coal activated with dolomite on [a] pH and Exch-Al; [b] available P; [c] organic C; [d] total N; [e] CEC; and [f] cation base [K, Ca and Exch-Mg] on Ultisols

The increase in pH corresponds to the increasing of SC dose and increases with the activation process with dolomite. In Figure 1a, it can be seen that applying 450g SC + 10% dolomite is the best treatment in increasing soil pH, compared to other treatments. It is assumed that the SC activation process with dolomite can donate OH− ions in the soil solution. [5] Hydrolyzed lime will produce
hydroxyl which can reduce soil acidity. Based on this, it is inversely proportional to the content of Exch-Al on Ultisols. The Exch-Al declines from 3.34 to undetected level. This indicates that applying 450g SC + 10% dolomite is the best treatment in reducing Al-exch and increase pH soil.

The effect of applying 450g SC activated with Dolomite can increase the content of available P, organic C, and N total of Ultisol by 1.31 ppm P, 0.44% C, and 0.04% N compared to without activation at the same rate of SC and looks different from other treatments [Figures 1b, c and d]. The increase in P occurs due to an increase in pH and a decrease in Al in the soil through the activation process carried out. As soil pH increases, the density of negative charges is found higher in soil colloids along with decreased P adsorption [6]. Furthermore, the increase in Organic C content by activation with dolomite can activate carbon in SC through the dissociation of H⁺ in phenol and carboxyl bonds. The activation process carried out with dolomite against SC as an organic material can also maximize the distribution of N in SC into the soil.

![Figure 2](image-url)  
**Figure 2.** Effect of Sub-bituminous coal activated with dolomite [SC] with dolomite [D] on height; [b] the number of midrib; [c] stem diameter and [d] the nutrient concentration from leaf of palm oil *Elaeis guineensis* Jacq.

The addition of lime and organic matter can be used as a reference to improve the chemical properties of the soil and change the index depending on the amount of liming material and the frequency of application used, and Liming and applying organic matter is an economical technology to increase carbon sequestration in the soil. The effect of soil acidity regulates the rate of mineralization of organic matter, which has an impact on the release of carbon [C] and nitrogen [N] from soil organic matter. An increase in soil organic C is also influenced by biological or physicochemical factors and is related to N in the soil as a result of enzyme activity and carbon mineralization [7-8], [9-10] The availability of N increases due to low soil acidity which causes an increase in the activity of
microorganisms in the soil. The availability of N increases due to low soil acidity causing an increase in the activity of microorganisms in the soil. In general, nitrogen has a major role in various physiological and biochemical processes in the soil [11-13].

In Figure 1e, it can be seen that SC activated by dolomite was able to increase the CEC content by 2.62 cmol·kg⁻¹, compared to without activation at 450g SC and was the best treatment compared to other treatments. It is also seen that 450g SC activated with dolomite can increase K, Ca, and Exch-Mg on Ultisol by 0.25; 0.27, and 0.29 cmol·kg⁻¹ compared unactivated at 450g SC [Fig. 1f]. [5] With the increase in negative charge in the soil, the ability to absorb and exchange cations is also higher. [14] HS increases the fixation of potassium in the soil by dissolving minerals containing K. [9-10] Ca and Mg levels increase after the application of lime and humic acid.

Figure 2 shows the effect of the application of SC activated with dolomite. The results of the analysis of variance of SC activated with dolomite had a very significant effect on height, the number of the midrib, stem diameter, and nutrient concentration from total biomass [N, P, and K] of palm oil [Elaeis guineensis Jacq.]. The SC activated by dolomite at a dose of 450 g SC had a significant effect on plant height of 12.33cm, compared to without activator, while the effect of an activation without at a dose of 450g SC was seen to be the same on the number of the midrib. This is also seen in the stem diameter of palm oil at 24 weeks after treatment. Oil palm nutrient uptake looks different due to the effect of activation with dolomite than without activation. The increase in P and K nutrient concentration from leaf of palm oil was seen at 450 g SC which was activated with dolomite of 0.023% P and 0.025% K, compared to other treatments, while N was the same at the 450g SC and 300g SC doses that were activated with dolomite of 0.056 and 0.054 % N, compared to other treatments. The increase in plant height occurs because the soil nutrient content [C, N, P, K, Ca, and Mg] needed by plants can be available. This is following the results of soil analysis in Figure 1. [15] Humic compounds with lime can improve soil chemical conditions in the root environment so that the roots will develop better and the nutrients provided can be absorbed by the roots so that plant growth is better. [2] Provided sufficient amounts of nutrients during vegetative growth, the photosynthetic process will run actively, so that the process of cell division, elongation, and differentiation will run well and increase plant productivity.

4. Conclusions
The application of 450 g SC activated with 10% [45 g] dolomite is significantly increasing pH, available P, organic C, total-N, and CEC, as well as palm oil growth [height, the number of the midrib, stem diameter, and the nutrient concentration from leaf of palm oil] on Ultisols.

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