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Use of several ameliorants to improve the fertility status of post-burning peat soils

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Abstract. Land fires are one of the potential disasters that often occur on peatlands. It has numerous detrimental effects on the environment, particularly concerning the degradation of soil fertility status. This research was carried out in Sceening house at Agriculture Faculty Universitas Sumatera Utara, used peat soil samples from Perbangunan Village, Sei Kepayang District, Asahan Regency has experienced fires several times in the last 5 years. Design of experimental is a Non-Factorial Randomized Block Design consisting of 9 treatments, namely: control; Boiler ash 125 g / 5 kg; Boiler ash 250 g / 5 kg peat; Palm Shell and Fiber Biochar 125 g / 5 kg peat; Palm Shell and Fiber Biochar 250 g / 5 kg peat; Dolomite 125 g / 5 kg; Dolomite 250 g / 5 kg peat; Zeolite 125 g / 5 kg; and Zeolite 250 g / 5 kg. Further tests were analyzed using the Duncan Multiple Range Test (DMRT) at the 5% level. The result showed that certain ameliorants enhanced soil properties, including pH, Na-exc, and CEC, and they also increased soil fertility. When it comes to boosting soil fertility through the development of indicator plants, boiler ash works best.

1. Introduction

Traditionally, peat is defined as soil formed from plant tissue that has become carbonized through the decomposition of various plants and mosses under wet conditions [1]

The main thing that forms the basis for determining organic soil is the minimum organic material content and its minimum thickness [2]. Organic soil is defined as soil that contains more than 20% organic material if the soil does not contain clay or more than 30% if it contains 60% or more clay and its cumulative thickness is more than 40 cm [3].

In Sumatra Utara, the area of peatland reaches 325,295 ha, most of which is ombrogenous peat, especially spread across Asahan, Labuhan Batu, Tapanuli Tengah and Tapanuli Selatan Regencies [4] and upland peat covering an area of 2,358 ha in Dairi and Humbang Hasundutan Regencies [5-6].

Sumatra Utara, Indonesia, is home to the fourth largest peatland area in the country, covering approximately 325,296 hectares. The majority of these peatlands are situated on the east coast, predominantly in the Labuhan Batu and Asahan Regencies, which together account for about 192,000 hectares or 59% of the total area. Additionally, on the west coast, peatlands in Tapanuli Selatan Regency cover 86,000 hectares (26.3%), while Tapanuli Tengah Regency has approximately 17,000 hectares (5.2%) [7].

Land fires are one of the potential disasters that often occur on peatlands that have been reclaimed into dry land for agriculture and plantations. Preventing fires is the best thing to do, but improving peat fertility after they have burned is also important.

Perbangunan Village, located in the Sei Kepayang District of Asahan Regency, features peatland that has been subjected to multiple fire incidents over the past five years, specifically occurring in September 2019, March 2020, and February 2023 [8, 9]. The peat soil in the area is



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classified as hemic peat, characterized by a water content of 645%, an organic matter content of 75%, an ash content of 25%, and a fiber content of 23% [10].

Amelioration plays a role in improving peat soil fertility, namely improving the root environment for plant growth by increasing pH, increasing nutrient availability, and reducing organic acids and toxic ions [11]. This study aims to investigate how certain ameliorates can enhance the fertility of post-burning peat soil.

2. Materials and Methods

This study was carried out in the Faculty of Agriculture's screen house University of Sumatra Utara. From March to July 2023, soil samples were examined at the PT. Socfin Indonesia Laboratory and the Research and Technology Laboratory of the Faculty of Agriculture University of Sumatra Utara.

Peat soil samples were taken from Sei Kepayang District, Asahan Regency, using boiler ash, dolomite, palm kernel shell biochar, and palm fiber as ameliorants. Base fertilizers used were urea 2.77 g/pot (200 kg/ha), SP-36 1.38 g/pot (100 kg/ha), and KCl 1.38 g/pot (100 kg/ha), each pot containing 5 kg of wet peat soil. Hybrid corn were used as indicator plants.

This study used a Non-Factorial Randomized Block Design consisting of 9 treatments, namely: C = control; BA1 = Boiler ash 125 g / 5 kg (2.5% of the wet peat's weight); BA2 = Boiler ash 250 g / 5 kg peat (5% of the wet peat's weight); BC1 = Palm Shell and Fiber Biochar 125 g / 5 kg peat (2.5% of the wet peat's weight); BC2 = Palm Shell and Fiber Biochar 250 g / 5 kg peat (5% of the wet peat's weight); Do1 = Dolomite 125 g / 5 kg (2.5% of the wet peat's weight); Do2 = Dolomite 250 g / 5 kg peat (5% of the wet peat's weight) Ze1 = Zeolite 125 g / 5 kg (2.5% of the wet peat's weight); Ze2 = Zeolite 250 g / 5 kg (5% of the wet peat's weight). Further tests were analyzed using the Duncan Multiple Range Test (DMRT) at the 5% level.

The parameters observed were: soil pH H₂O (electrometry); C-Organic (ashing method); N-total (Kjeldahl); Exchangeable Base (1 N NH₄OAc extraction pH 4.8); Cation Exchange Capacity (CEC) (1 N NH₄OAc extraction pH 4.8); Base Saturation (BS) [12]; Soil samples were taken 6 weeks after ameliorant incubation. Plant height; shoot dry weight and roots dry weight at the end of vegetative (8 weeks after planted) of corn, to find out the improvements in soil properties that have occurred.

3. Results and Discussion

As indicated in Tables 1 and 2 below, the laboratory results of the soil property study revealed changes in soil characteristics as a result of the application of various ameliorants.

Table 1. pH, C organic and N-total soil as resulting of several types of soil ameliorants.

Treatments	pH	C-org	N-total
	-	%	%
1 Control	4.27 ef	38.33	0.45
2 Boiler Ash 125 g	4.90 d	30.85	0.58
3 Boiler Ash 250 g	5.27 c	32.15	0.49
4 Palm Fibre + Shell Biochar 125 g	4.45 ef	39.12	0.61
5 Palm Fibre + Shell Biochar 250 g	4.63 de	34.76	0.62
6 Dolomite 125 g	6.33 b	39.22	0.50
7 Dolomite 250 g	6.70 a	38.01	0.45
8 Zeolite 125 g	4.18 f	29.90	0.46
9 Zeolite 250 g	4.46 ef	29.96	0.55

Note: Duncan's Multiple Range Test at the 5% level indicates that there is no substantial difference between numbers followed by the same notation in the same column and row.

Table 2. Exchangeable Bases, CEC and Base Saturation (BS) as resulting of several types of soil ameliorants.

Treatments	Na-exc	K-exc	Ca-exc	Mg-exc	CEC	BS
	me%	me%	me%	me%	me%	%
1 Control	0.49 bc	1.29	1.9	4.74	66.53 abc	12.16
2 Boiler Ash 125 g	0.54 bc	1.44	2.09	5.72	57.21 c	18.35
3 Boiler Ash 250 g	0.74 bc	0.95	2.39	6.00	60.31 bc	18.06
4 Palm Fibre + Shell Biochar 125 g	0.47 bc	2.98	1.25	3.68	76.92 a	11.02
5 Palm Fibre + Shell Biochar 250 g	0.96 bc	1.52	2.32	3.62	68.22 abc	12.09
6 Dolomite 125 g	0.68 bc	1.09	4.78	5.44	69.76 abc	17.23
7 Dolomite 250 g	0.40 c	0.81	4.33	3.68	69.44 abc	13.22
8 Zeolite 125 g	2.09 a	1.90	2.44	4.01	72.49 ab	14.12
9 Zeolite 250 g	1.60 ab	2.39	2.01	3.7	79.59 a	12.19

Note: Duncan's Multiple Range Test at the 5% level indicates that there is no substantial difference between numbers followed by the same notation in the same column and row.

The tables above shows that several types of ameliorants significantly impact soil pH, Na exchange, and cation exchange capacity. Dolomite, added at 250 g per pot, provided the highest pH. Zeolite supplied the highest Na-exc, and boiler ash significantly reduced soil CEC, thereby increasing the low base saturation in peat soil.

Boiler ash that turns organik into inorganic material will lose its colloidal properties, so it does not contribute a negative charge that causes the soil CEC to decrease but boiler ash supplies the elements Ca, Mg, Na and K in available form so that there is an increase in soil pH and base saturation value.

Biochar has alkaline properties due to the presence of alkali metals contained in the raw material which do not evaporate during the pyrolysis process [13].

Dolomite is used as a form of lime to raise soil pH and supply essential nutrients, natural source of both calcium and magnesium carbonate. It increases soil pH through a hydrolysis reaction that produces hydroxide and bicarbonate ions which then neutralize the acidic hydrogen ions in the soil.

Table 3. Corn plant growth due to the application of several types of ameliorants

No	Treatments	Plant High	Dry Plant Weight	Dry Root Weight
		cm	g	g
1	Control	145.67 e	26.69 c	3.35 c
2	Boiler Ash 125 g	186.00 ab	86.31 a	14.87 ab
3	Boiler Ash 250 g	193.33 a	95.97 a	18.29 a
4	Palm Fibre + Shell Biochar 125 g	168.67 bcd	38.53 bc	5.04 bc
5	Palm Fibre + Shell Biochar 250 g	173.00 abc	48.11 bc	14.82 ab
6	Dolomite 125 g	155.67 cde	34.34 bc	3.82 c
7	Dolomite 250 g	174.00 abc	54.36 b	8.76 abc
8	Zeolite 125 g	140.33 e	29.31 c	3.81 c
9	Zeolite 250 g	150.67 de	26.95 c	4.70 bc

Note: Duncan's Multiple Range Test at the 5% level indicates that there is no substantial difference between numbers followed by the same notation in the same column and row.

Table 3 above shows that the type of ameliorant significantly affected plant growth through parameters such as plant height, plant dry weight, and root dry weight. Boiler ash provided the best effect, especially at 250 g per pot of boiler ash. Boiler ash from palm oil mills contains 58.02% SiO₂; 8.7% Al₂O₃; 32.6% Fe₂O₃; 12.56% CaO; 4.23% MgO; 0.41% Na₂O; 0.72% K₂O, and 1.97% H₂O [14]. The high silica content in boiler ash plays a role in increasing plant root oxidation and the activity of enzymes involved in photosynthesis, which in turn enhances plant growth [15].

There is a relationship between changes in soil CEC values and changes in plant growth, which is indicated by changes in the dry weight of plants and roots, as shown in Figure 1 below.

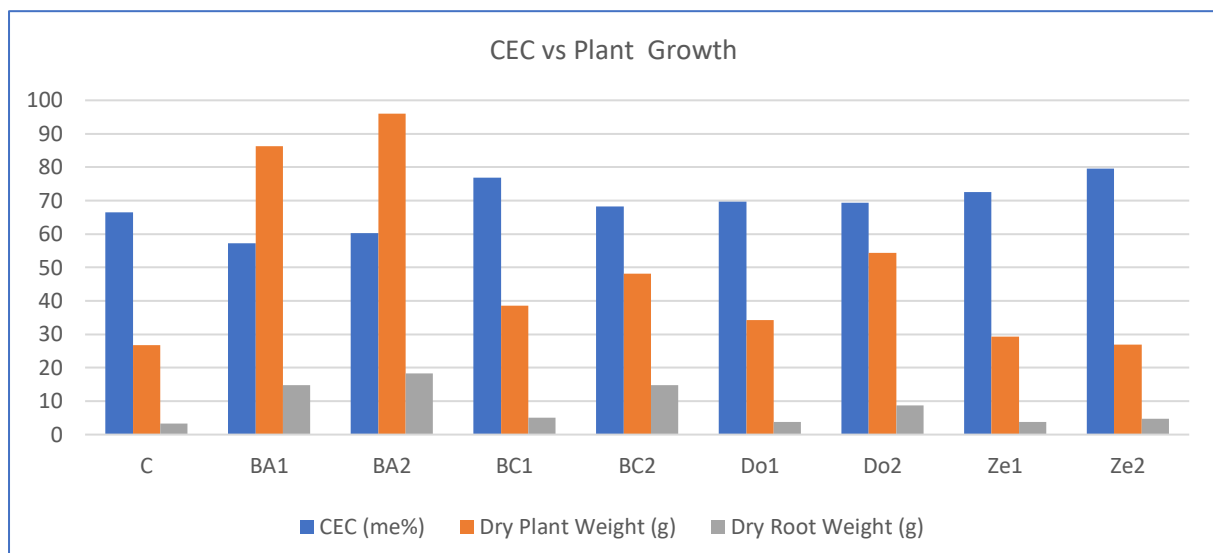


Figure 1. Comparison of soil CEC values to dry weight of plants and roots

The application of boiler ash ameliorant, while contributing available nutrients to plants, also reduced the naturally high CEC of peat soil. A lower CEC will increase base saturation levels, thus increasing nutrient availability. CEC and base saturation are important parameters for determining soil fertility. That's why recommendations are always higher.

4. Conclusion

Several types of ameliorants can positively impact to soil properties to increased the fertility of peatlands that have experienced fires, thereby improving plant growth. Boiler ash, especially at a dose of 250 g per pot, resulted in the highest growth rate of corn plants, as indicator of the fertility of peatlands that have experienced fires.

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