Turkish Journal of Agriculture - Food Science and Technology, 7(7): 1082-1087, 2019
DOI: https://doi.org/10.24925/turjaf.v7i7.1082-1087.2539

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology

Effect of Amelioran Material on Soil Chemical Properties of Incubated Peat Planting Media in Polybag

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ARTICLE INFO

Research Article

Received : 17/03/2019
Accepted : 13/05/2019

Keywords:
Ameliorant materials
Dolomite
Rock phosphate
Mineral soil
Peat

ABSTRACT

The aim of this study was to obtain the best combination of types and doses of ameliorant materials: dolomite, rock phosphate, and mineral soil to improve the chemical properties of soil which was incubated for one year in peat media in polybag. The research was conducted in May 2015 - April 2016 in the experimental garden in the village of Sijambi, Tanjungbalai, North Sumatra. Elevation 3 m above sea level, with the C2 (Oldeman) climate type. The experiment was compiled using a Randomized Block Design, with 3 treatments of ameliorant material. The three ameliorant materials were tested for 3 doses. The addition of dolomite treatment: A1=0.45 kg polybag^{-1}; A2=0.90 kg polybag^{-1}; A3=1.35 kg polybag^{-1}. The addition of rock phosphate treatment: A4=0.45 kg polybag^{-1}; A5=0.90 kg polybag^{-1}; A6=1.35 kg of polybag^{-1}. The addition of mineral soil treatment: A7=0.45 kg polybag^{-1}; A8=0.90 kg polybag^{-1}; and A9=1.35 kg polybag^{-1}.The results shown that the highest dose of dolomite (1.35 kg polybag^{-1}) improved soil chemical properties, including soil pH and alkali cations (K, Ca and Mg) on incubated peat soil. Addition of rock phosphate with the highest dose of 1.35 kg polybag^{-1} (A6) increases available phosphorus and soil CEC. Addition of mineral soil dose of 0.90 kg polybag^{-1} (A8) increases soil CEC. In the analysis of total soil nitrogen, the highest increase was obtained by adding dolomite dose of 0.45 kg.polibag-1 (A1).

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Introduction

Indonesia is a country with the largest peat area in Asia, which is around 20 million ha spread across Sumatra, Kalimantan and Papua (Noor, 2010). Of this area around 9.5 million ha has the potential of being agricultural land and around 4.2 million ha has been reclaimed for various uses, including 1.7 million ha for oil palm plantation expansion (Sopiawati, et al., 2012, Barus et al., 2012).

Efforts to use peat land often cause controversy because the characteristics of peat soils found in lowland swamps are easily damaged if disturbed, flammable because peat is fragile, light and loose. Has the potential to emit greenhouse gases if oxidized in aerobic conditions that trigger decomposition of organic matter. Generally peat soils are less fertile, especially for deep peat which has low buffering because it has a low action density (BD<1 g cc^{-1}), irreversible drying, has a low pH because it is dominated by organic acids, especially phenolic acids (Barchia, 2006; Tsutsaki, 1984).

According to Noor (2010) Peat land in Indonesia consists of peatland with <0.5 m thick layer of 1.60 million ha and Peat land with >0.5 m thick layer of 20 million ha. Peatlands and shallow peat (0.5 m-1 m thick) are suitable for the cultivation of food crops, such as rice and secondary crops. Medium / rather deep peat (1m - 2m thick) suitable for vegetable and horticulture cultivation. Deep peat (<4 m thick) is suitable for plantations with limited cultivation. And very deep peat (>4 m) is used as a protected area.

The level of fertility of peatlands is very diverse. Its properties and characteristics are influenced by ecosystems, chemical properties, physics and biology. In general, the chemical characteristics of peat soil react acid (pH 3-5). Having high levels of organic acids, especially acids, are toxic to plants. Alkaline cations (K, Ca and Mg) are low, N-total is very high, P fixation is very strong due to very slow organic P mineralization (C/P≥300) so that P availability for plants is low. Micro nutrients such as Cu, Zn, B and Fe are low, ash content varies (6-65%) and soil

CEC is high (40-300 me. 100 g^{-1}) (Noor, 2010; Barchia, 2006; Hartatik and Suriadikarta, 2006).

To overcome the problem of high acidity and nutrient deficiencies on peat land, the soil needs to be given ameliorant and fertilizing materials. Ameliorants that can be used include dolomite, rock phosphate and mineral soil. Giving ameliorant materials such as dolomite and rock phosphate, can overcome the problems of acidity and poisoning of Al and other metal cations by increasing soil pH. Ameliorants can also supply a number of nutrient cations. Dolomite as a source of Ca and Mg nutrients, rock phosphate as a source of nutrients P and Ca.

Adding mineral soils is also important in the formation of complex organo metallic reactions (Subardja, et al., 2006; Hartatik, 2012). Materials that are rich in polyvalent cations such as mineral soils can be used to improve the stability of peatlands in overcoming the dangers of organic acids. Adding ameliorant materials derived from mineral soils on peatlands can increase nutrients in the soil and plant nutrient ion levels and increase plant dry weight (Stevenson and Vitch, 1997; Hartatik, et al., 2004).

Based on the explanation above, the purpose of this study was to obtain the best combination of the types and doses of several ameliorant materials: dolomite, rock phosphate, and mineral soil to improve soil chemical properties. The ameliorant material was incubated for one year in peat growing media in polybag.

Research Methods

Place and Time

The study was conducted for one year, from May 2015 to April 2016. The study was conducted in the experimental garden of the Sijambi Village in the Tanjungbalai City, North Sumatra province. The 3 m elevation above sea level, with the C2 climate type, has 2-3 dry months and 5-6 wet months (Oldeman) (Tanjungbalai City Central Bureau of Statistics, 2007).

Research Materials

Peat soil as a planting medium originates from the plantation peat land of the Grahadura Company located in Sukarame Baru village, Kualuh Hulu Aek Kanopan sub-district, Labuhan Batu Utara Regency. Mineral soil originating from Ultisol soil originated from the KongsiAnam Village, Aek Natas sub-district, Labuhan Batu Utara regency, North Sumatra - Indonesia. Dolomite and rock phosphate are obtained from Fertilizer Trading in the Kisaran City. Peat soil samples and mineral soils before treatment were analyzed in the Soil and Plant Laboratory of the Palm Oil Research Center (PPKS) Medan. Analysis of dolomite, rock phosphate and incubation soil was carried out at the Laboratory of the Asian Agri Company, Bahilang Tebing Tinggi, North Sumatra.

Experimental Design

The experiment was compiled using a Randomized Block Design, with 3 treatments of ameliorant material. The three ameliorant materials were tested for 3 doses. The three treatments of ameliorant material are dolomite, rock phosphate, and mineral soil. The addition of dolomite treatment: A1=0.45 kg $polybag^{-1}$; A2=0.90 kg $polybag^{-1}$; A3=1.35 kg $polybag^{-1}$. The addition of rock phosphate treatment: A4=0.45 kg $polybag^{-1}$; A5=0.90 kg $polybag^{-1}$; A6=1.35 kg of $polybag^{-1}$. The addition of mineral soil treatment: A7=0.45 kg $polybag^{-1}$; A8=0.90 kg $polybag^{-1}$; and A9=1.35 kg $polybag^{-1}$.Composition of dolomite (19% MgO; 34% CaO; 0.1% Fe_2O_3); rock phosphate (22.5% P_2O_5; 33.5% CaO; 2.47% Fe_2O_3); and mineral soils (polyvalent cation sources).

Research Parameters

The variables observed in this study included soil pH, N-total soil, P-available, alkali cations (K, Ca, Mg) and soil CEC.

Data Analysis

The data obtained were analysed statically using analysis of variance (F test). If the results of the F Test show there are significant differences, then proceed with Duncan Multiple Range Test (Gomez and Gomez, 1995).

Research Procedure

The land used for research is cleaned and trimmed as a polybag upright seat. Furthermore, the peat soil used is cleaned and sifted to avoid coarse-sized materials that are carried during collection. The types and doses of ameliorant (dolomite; rock phosphate; and mineral soil) requirements for each treatment were weighed and packed. The packaged ameliorant material is then filled / mixed with peat planting media in polybag according to the treatment dose. The planting media that has been inserted into the polybag is then shaken so that the soil in the polybag becomes solid. Polybags are arranged according to experimental treatment. The mixed media was then incubated for one year.

Results and Discussion

Soil Reaction (pH)

The results of variance on the analysis of peat planting media soil in polybag which was incubated for one year showed that giving dolomite at a dose of 1.35 kg $polybag^{-1}$ had an effect on soil pH. The average observation ofsoil pH level is presented in table 1.

Table 1 shows that dolomite treatment with a dose of 1.35 kg $polybag^{-1}$ (A3) increased soil pH of 6.63, or increased 1.84 times compared to the analysis of Initial Peat Soil (IPS) [A3 vs IPS], or increased 1.61 times (A3 vs A7).

Hardjowigeno (2010) explains that dolomite is one of the lime materials that can be used to increase soil pH. Increasing soil pH in dolomite treatment because dolomite can form compounds of calcium bicarbonate Ca $(HCO_3)_2$ which can increase soil pH. Dolomite can also deactivate metal cations such as Fe and Al which can form insoluble Al and Fe bicarbonate. Bicarbonate ions bind with H ions to form water and carbon dioxide which causes the soil pH level to increase.

N-Total Soil (%)

Table 2 shows that the addition of dolomite dose of 0.45 kg $polybag^{-1}$ (A1) gives the highest N content, which is 1.30% N-total. In rock phosphate treatment, the best dose to increase soil N content is 0.45 kg rock phosphate $polybag^{-1}$ (A4), which is 1.05% N-total. While the addition of mineral soil, the best dose is 0.45 kg $polybag^{-1}$ (A7), which is 1.12% N-total.

Table 1 Soil pH analysis due to the treatment of types and dosages of ameliorant materials in peat planting media in polybag

Treatment of ameliorant material	pH	Soil Characteristics
A1 (0.45 kg dolomite polybag^{-1})	6.15^{c}	slightly acidic
A2 (0.90 kg dolomite polybag^{-1})	6.40^{b}	slightly acidic
A3 (1.35 kg dolomite polybag^{-1})	6.63^{a}	netral
A4 (0.45 kg rock phosphatepolybag^{-1})	4.51^{f}	acidic
A5 (0.90 kg rock phosphatepolybag^{-1})	4.96^{e}	acidic
A6 (1.35 kg rock phosphatepolybag^{-1})	5.65^{d}	slightly acidic
A7(0.45 kg mineral soil polybag^{-1})	4.13^{h}	very acidic
A8 (0.90 kg mineral soil polybag^{-1})	4.24^{g}	very acidic
A9 (1.35 kg mineral soilpolybag^{-1})	4.28^{g}	very acidic
coefficient of variation	(CV) = 1.21 %	

Explanation: 1. Numbers followed by the same letters in the same column show no significant difference at the level of 5% according to the Duncan Multiple Range Test, 2. Criteria for Assessing the Nature of Land based on the Staff of the Centre for Soil Research (1983) and the Agricultural Research Agency of Medan (1982).

Table 2 Results of N-total soil analysis (%) due to treatment of types and dosages of ameliorant materials in peat planting media incubated in polybag

Treatment of ameliorant material	N-total soil (%)	Criteria
A1 (0.45 kg dolomite polybag^{-1})	1.30^{a}	Very high
A2 (0.90 kg dolomite polybag^{-1})	0.89^{d}	Very high
A3 (1.35 kg dolomite polybag^{-1})	0.37^{e}	Medium
A4 (0.45 kg rock phosphatepolybag^{-1})	1.05^{bc}	Very high
A5 (0.90 kg rock phosphatepolybag^{-1})	0.95^{cd}	Very high
A6 (1.35 kg rock phosphatepolybag^{-1})	0.73^{e}	High
A7(0.45 kg mineral soil polybag^{-1})	1.12^{b}	Very high
A8 (0.90 kg mineral soil polybag^{-1})	0.88^{d}	Very high
A9 (1.35 kg mineral soilpolybag^{-1})	0.74^{e}	Medium
coefficient of variation	(CV) = 7.08 %	

Explanation: 1.Numbers followed by the same letters in the same column show no significant difference at the level of 5% according to the Duncan Multiple Range Test, 2. Criteria for Assessing the Nature of Land based on the Staff of the Centre for Soil Research (1983) and the Agricultural Research Agency of Medan (1982).

Table 3 P-available (ppm) analysis due to the treatment of types and dosages of ameliorant materials in peat planting media in polybag

Treatment of ameliorant material	P-available (ppm)	Criteria
A1 (0.45 kg dolomite polybag^{-1})	23.01^{d}	Medium
A2 (0.90 kg dolomite polybag^{-1})	54.14^{d}	Very high
A3 (1.35 kg dolomite polybag^{-1})	56.20^{d}	Very high
A4 (0.45 kg rock phosphatepolybag^{-1})	906.91^{c}	Very high
A5 (0.90 kg rock phosphatepolybag^{-1})	1,135.17^{b}	Very high
A6 (1.35 kg rock phosphatepolybag^{-1})	1,314.91^{a}	Very high
A7(0.45 kg mineral soil polybag^{-1})	51.79^{d}	Very high
A8 (0.90 kg mineral soil polybag^{-1})	64.06^{d}	Very high
A9 (1.35 kg mineral soilpolybag^{-1})	92.56^{d}	Very high
coefficient of variation	(CV) = 9.78 %	

Explanation: 1.Numbers followed by the same letters in the same column show no significant difference at the level of 5% according to the Duncan Multiple Range Test, 2. Criteria for Assessing the Nature of Land based on the Staff of the Center for Soil Research (1983) and the Agricultural Research Agency of Medan (1982).

The increase in Ca in the treatment of dolomite, rock phosphate and mineral soil with high doses of 1.35 kg polybag^{-1} (A3, A6 and A7) was not followed by an increase in the N-total content of the soil. Bohn (1993) explains that the high availability of Ca nutrients in soil solutions can inhibit nutrient availability of N, due to the effect of nutrient antagonism, which causes the availability of other nutrients to be less available/inhibited.

Phosphorus Available (Ppm)

Table 3 shows that the highest P-available is found in the addition of rock phosphate at a dose of 1.35 kg per polybag (A6) which is 1,314.91 ppm P, an increase of 57.15 times (A6 vs A1), and 300.89 times higher when compared with the analysis of the initial peat soil (A6 vs IPS). Different from the two treatments given rock phosphate ameliorant with a dose of 0.45 kg polybag-1 (A4) and a dose of 0.90 kg polybag-1 (A5).

Increasing the P-available level of soil at the above treatment dose because the availability of orthophosphate ions ($H_2PO_4^{(-)}$ or $H_2O_4P^{-}$) in the soil is strongly influenced by the ionization results of the given rock phosphate. Munawar (2011) explains that the concentration of P ions in soil is strongly influenced by the source of P in the soil. Besides being able to through the giving of ameliorant materials, fertilizers, it can also come from the decomposition of P-organic, in the form of plant residues, fauna and microbes in the soil.

Table 4 Potassium exchange cation on soil (me 100 g^{-1}) due to three types of treatment and ameliorant dosage in peat planting media in polybag

Treatment of ameliorant material	Potassium exchange cation (me100 g^{-1})	Criteria
A1 (0.45 kg dolomite polybag^{-1})	0.35^{d}	Medium
A2 (0.90 kg dolomite polybag^{-1})	0.39^{cd}	Medium
A3 (1.35 kg dolomite polybag^{-1})	0.55^{a}	Medium
A4 (0.45 kg rock phosphatepolybag^{-1})	0.25^{e}	Low
A5 (0.90 kg rock phosphatepolybag^{-1})	0.39^{cd}	Medium
A6 (1.35 kg rock phosphatepolybag^{-1})	0.49^{b}	Medium
A7(0.45 kg mineral soil polybag^{-1})	0.40^{cd}	Medium
A8 (0.90 kg mineral soil polybag^{-1})	0.43^{bc}	Medium
A9 (1.35 kg mineral soilpolybag^{-1})	0.48^{b}	Medium
coefficient of variation	(CV) = 7.64 %	

Explanation: 1.Numbers followed by the same letters in the same column show no significant difference at the level of 5% according to the Duncan Multiple Range Test, 2. Criteria for Assessing the Nature of Land based on the Staff of the Center for Soil Research (1983) and the Agricultural Research Agency of Medan (1982).

Table 5 Calcium exchange cation content (me 100 g^{-1}) due to the treatment of types and doses of ameliorants in peat planting media incubated in polybag

Treatment of ameliorant material	Calcium exchange cation (me100 g^{-1})	Criteria
A1 (0.45 kg dolomite polybag^{-1})	25.65^{b}	Very high
A2 (0.90 kg dolomite polybag^{-1})	27.41^{b}	Very high
A3 (1.35 kg dolomite polybag^{-1})	29.61^{a}	Very high
A4 (0.45 kg rock phosphatepolybag^{-1})	10.49^{e}	Medium
A5 (0.90 kg rock phosphatepolybag^{-1})	13.48^{d}	High
A6 (1.35 kg rock phosphatepolybag^{-1})	17.31^{c}	High
A7(0.45 kg mineral soil polybag^{-1})	3.48^{f}	Low
A8 (0.90 kg mineral soil polybag^{-1})	3.81^{f}	Low
A9 (1.35 kg mineral soilpolybag^{-1})	3.99^{f}	Low
coefficient of variation	(CV) = 6.16 %	

Explanation: 1.Numbers followed by the same letters in the same column show no significant difference at the level of 5% according to the Duncan Multiple Range Test, 2. Criteria for Assessing the Nature of Land based on the Staff of the Center for Soil Research (1983) and the Agricultural Research Agency of Medan (1982).

Potassium exchange Cation (me100 g^{-1})

Table 4 shows that the highest potassium exchange cation of soil was found in the addition of dolomite dose of 1.35 kg polybag^{-1} (A3) which was 0.55 me 100 g^{-1}, increased 2.20 times (A3 vs A4) and increased by 6.11 times (A3 vs IPS). Increased potassium exchange cation content of soil due to the contribution of K derived from decomposition of organic matter / plant tissue in peat soil.

Calcium Exchange Cation (me100 g^{-1})

Table 5 shows that the highest calcium content was found in giving of dolomite treatment with a dose of 1.35 kg polybag^{-1} (A3) which was 29.61 me 100 g^{-1}, increased by 2.02 times (A3 vs IPS) and increased by 8.51 times (A3 vs A7). Increased levels of calcium exchange cation content in the soil incubated due to the contribution of Ca, and Mg cations into soil solutions derived from ionization of dolomite so that the concentration increased. If the highest level of calcium exchange cation in the soil is seen compared to the highest CEC level of 48.23 me 100 g^{-1} (A8) and the Initial Peat Soil Analysis (IPS) CEC which is 155.30 me 100 g^{-1}, the Ca saturation ranges between 19.07-61.39 me 100 g^{-1} which is considered ideal for supporting plant growth.

Magnesium Exchange Cation (me100 g^{-1})

Table 6 shows that the highest magnesium exchange cation content was found in the treatment of dolomite with a dose of 1.35 kg polybag^{-1} (A3) which was 20.99 me 100 g^{-1}, an increase of 7.77 times (A3 vs IPS) and an increase of 15.90 times (A3 vs A7). Increasing magnesium exchange cation content because of its availability in soil solutions is strongly influenced by the presence of Mg cations derived from ionization of dolomite which can also contribute Ca and Fe cations. When viewed from the highest levels of magnesium exchange cation content in the soil compared to the highest level of soil CEC 48.23 me 100 g^{-1} (A8) and analysis of Initial Peat Soil CEC (IPS) 155,30 me 100 g^{-1} obtained saturation Mg ranges between 13.52% -43.52% which is considered ideal to support the growth of plants.

Cation exchange Capacity (me 100 g^{-1})

Table 7 shows that the highest soil CEC is found in the treatment of mineral soil doses of 1.35 kg polybag^{-1} (A9) which is 49.54 me 100 g^{-1}, increased by 2.01 times (A9 vs A1), but lower / decreased by 68.10% when compared with the analysis of Initial Peat Soil (A9 vs IPS), as well as for both types and doses of other ameliorant materials (A1-A3 and A4-A6).

Increased level soil CEC due to the contribution of a number of alkaline and colloidal mineral cations originating from mineral soils which can absorb alkali cations (Ca, Mg, K and Na) originating from relatively high peat soils which suppress the occurrence of exchangeable alkaline migration / washing.

Tan (1993) explains that soil CEC levels are strongly influenced by soil pH, alkaline saturation, alkaline cations that are absorbed on the surface of colloids, colloidal types (minerals / humus) and soil types (classified as high activity clay or low activity clay).

Table 6 Magnesium exchange cation (me 100 g-1) due to the type and dosage treatment of ameliorant materials on peat planting media in polybags

Treatment of ameliorant material	Magnesium exchange cation (me100 g^{-1})	Criteria
A1 (0.45 kg dolomite polybag-1)	13.29[c]	Very high
A2 (0.90 kg dolomite polybag-1)	16.42[b]	Very high
A3 (1.35 kg dolomite polybag-1)	20.99[a]	Very high
A4 (0.45 kg rock phosphatepolybag-1)	1.54[e]	Medium
A5 (0.90 kg rock phosphatepolybag-1)	2.71[e]	High
A6 (1.35 kg rock phosphatepolybag-1)	7.65[d]	High
A7(0.45 kg mineral soil polybag-1)	1.32[e]	Medium
A8 (0.90 kg mineral soil polybag-1)	1.74[e]	Medium
A9 (1.35 kg mineral soilpolybag-1)	2.78[e]	High
coefficient of variation	(CV) = 12.89 %	

Explanation: 1.Numbers followed by the same letters in the same column show no significant difference at the level of 5% according to the Duncan Multiple Range Test, 2. Criteria for Assessing the Nature of Land based on the Staff of the Centre for Soil Research (1983) and the Agricultural Research Agency of Medan (1982).

Table 7 Soil CEC (me 100 g^{-1}) due to treatment of type and dosage of ameliorant material in peat planting media incubated in polybag

Treatment of ameliorant material	Cation exchange capacity (me 100 g^{-1})	Criteria
A1 (0.45 kg dolomite polybag^{-1})	24.65[e]	Medium
A2 (0.90 kg dolomite polybag^{-1})	35.62[c]	High
A3 (1.35 kg dolomite polybag^{-1})	37.11[c]	High
A4 (0.45 kg rock phosphatepolybag^{-1})	32.31[d]	High
A5 (0.90 kg rock phosphatepolybag^{-1})	35.70[c]	High
A6 (1.35 kg rock phosphatepolybag^{-1})	40.41[b]	Very high
A7(0.45 kg mineral soil polybag^{-1})	36.47[c]	High
A8 (0.90 kg mineral soil polybag^{-1})	48.23[a]	High
A9 (1.35 kg mineral soilpolybag^{-1})	49.54[a]	Very high
coefficient of variation	(CV) = 12.89 %	

Explanation: 1.Numbers followed by the same letters in the same column show no significant difference at the level of 5% according to the Duncan Multiple Range Test, 2. Criteria for Assessing the Nature of Land based on the Staff of the Centre for Soil Research (1983) and the Agricultural Research Agency of Medan (1982).

Conclusion

Giving three types and doses of ameliorant materials (dolomite, rock phosphate and mineral soil) on peat growing media incubated for one year in polybag can improve soil chemical properties when compared with the initial soil conditions. These improvements include soil pH, P- available and alkaline exchange cations (K, Ca, Mg)

The highest N-total soil is found in the treatment of dolomite dose 0.45 kg polybag^{-1} (A1) which is 1.30% N. The highest soil CEC is found in the treatment of mineral soil dose of 1.35 kg polybag^{-1} (A9) which is 49.54 me 100 g^{-1}.

Further research is needed on the effect of giving the three types and doses of ameliorant materials used (dolomite, rock phosphate and mineral soils) and other ameliorant materials on peat growing media in polybag on changes / improvements in chemical, physical and biological properties of soils and nutrient uptake.

Given that the soil pH of the peat growing media in the polybag is classified as very acidic (pH 3.60) with very low nutrient content P, K and alkali cations, it is recommended that a combination of planting media in polybag is recommended by giving ameliorant material.

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