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IMPACT OF COASTAL SEDIMENT FOR RECLAMATION OF PEATLANDS IN KUBU RAYA DISTRICT, INDONESIA

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Abstract

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The primary purpose of this study was to examine the use of coastal sediment as an alternative to peatland reclamation material for maize. Coastal sea sediment is a material composed of partly dissolved precipitated solid particles found along the coastline, and based on some previous researches, the application of coastal sediment can increase the pH and base saturation of peat soil. Thus, to test the accuracy of the coastal sediment, two experiments were conducted in 2014 and 2015. The first step was identifying alternative sources of coastal sediment, as ameliorant, with chemical analysis (pH and texture) and incubation experiments. Five locations of coastal sediment from Kubu Raya District and one from Kijing were assessed for peat reclamation. Next, field experiments were conducted related to the addition of the best coastal sediment regarding pH and texture on the production of shelled cobs of maize plants in peat soils with different degrees of thickness. This study was conducted on two types of peat soil thickness (less than 2 m and more than 2 m). The coastal sediment, which was sourced from Kijing beach, was used at three dose levels based on the percentage of weight. All treatments were conducted in triplicate, and the corresponding corn productions were evaluated. The result showed that 10% coastal sediment improves corn production.

Key words: coastal sediment; peat soil; incubation; pH and corn production

Introduction

The global peatland area is estimated at 400 million ha. Indonesia has the fourth largest peat swamp in the world, covering around 17.2 million ha, behind Canada at 170 million ha, the Soviet Union at 150 million ha, and the United States with 40 million ha (Euroconsult, 1984). However, from the various reports, Indonesia has the largest tropical peat in the world, which covers between 13.5 to 26.5 million ha (20 million ha average). If the area of the Indonesian peat is 20 million ha, about 50% of the world's tropical peat covers approximately 40 million ha in Indonesia. Up to now, the peatland area data in Indonesia is not standardized and hence, it can range from 13.5–26.5 million ha. The extent of peat and its complex functions, highlight its importance for human life.

Peatlands are typically found on large islands, such as Sumatra, Kalimantan and Papua. According to Subiksa et al. (2009), tropical peatlands are large, both spatially and vertically, with diverse physical and chemical properties. Characteristics are determined by the thickness of the peat, mineral soil substratum or below the peat, maturity, and presence or absence of enrichment of the surrounding river overflow.

The peat soils are very acidic in nature, with a pH of 3.7 (Melling et al., 2002). Some previous researches suggest the application of coastal sediment can increase the

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pH and base saturation of peat soil. Moreover, improving the peat soil properties enhanced the growth and production of crops, such as soybean and maize (Sagiman and Pujianto, 1994; Suyadi, 1995; Sagiman, 2001; Suswati, 2012).

Therefore, this study aimed to obtain the percentage of coastal sediment that can provide the best production of corn in two different thicknesses of peat soil (< 2 m and > 2 m).

Materials and Methods

Duration and Sites

This 2-year research involved a preliminary survey of peat locations, a soil survey and land evaluation, soil and coastal sediment sampling, maize production, and laboratory and data analyses.

A series of experiments were done in the laboratory and field. Laboratory experiments were undertaken at the Analytical Laboratories, Faculty of Agriculture, Tanjungpura University, Indonesia. Field research was conducted at the Kubu Raya District of West Kalimantan Province, Indonesia. Two alternative sources of ameliorant were acquired, which included coastal sediment from Kubu Raya District and Kijing (Mempawah District), respectively.

Research Stages

Classification of peatlands

KEMA, a smart grid comprehensive system, was used to obtain the depth, peat soil type, and water depth. During the pilot study, locations along the route were surveyed and the drilling of stubs conducted, with observations made at specific points along the length of the stubs.

Identification of alternative sources of marine mud as ameliorant material and incubation of coastal sediment

Coastal sediment sources were collected from different locations along the coast of Kubu Raya. All samples were analyzed in the laboratory for pH and texture, to obtain a specimen of the best coastal sediment, as an alternative peat soil ameliorant material. The coastal sediment sample with the best texture and pH was incubated at various doses in peat soil with two different levels of thickness (> 2 m and < 2 m) in plastic pots (polybag). Dolomite was used as a comparison. The pH was recorded every week for 4 weeks.

Field research

Field experiments were undertaken to assess the addition of the best coastal sediment, regarding pH and texture, on the yield of shelled cobs of corn plants in peat soils with different degrees of thickness.

Factorial experiments (distance to the drainage channel as a differentiating factor) were conducted in this study, as follows: two peat soil thickness (T_1: shallow < 2 m; T_2: deep > 2 m), and coastal sediment added at four doses (percentage by weight – L0: 0% weight or without coastal sediment, as the control; L1: 5% weight; L2: 10% weight, and L3: 15%), with 10% dolomite lime used as a comparison. The experiments were repeated in triplicate.

Results and Discussion

Classification of peatlands

From the first step of the study (peat soil evaluation to find out the peat soil thickness), two categories of land were identified in the field (i.e., that with peat soil thickness < 2 m and > 2 m, respectively) (Figure 1, Table 1).

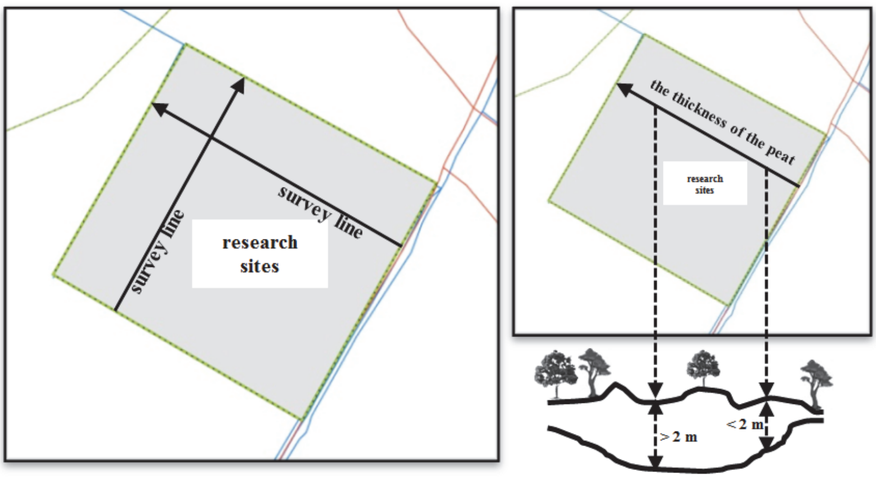

Fig. 1. Illustration of survey track and results of the peat thickness at the study site

Table 1
Laboratory analysis of peat soil samples

Parameter analysis of the soil	Peat				
	soil layer	shallow (< 2m)		deep (> 2m)	
		measure	assess-ment	measure	assess-ment
pH H_2O	ts	3.47	va	3.85	va
	ss	3.26	va	3.94	va
pH KCl	ts	2.59	va	2.42	va
	ss	2.32	va	2.60	va
C-Org (%)	ts	56.26	vh	57.31	vh
	ss	56.48	vh	57.34	vh
N-Total (%)	ts	1.64	vh	1.59	vh
	ss	1.52	vh	1.60	vh
C/N	ts	34.3	vh	36.04	vh
	ss	37.16	vh	35.84	vh
P_2O_5	ts	38.44	vh	53.21	vh
	ss	28.60	h	108.86	vh
K	ts	0.38	vl	0.85	vh
	ss	0.44	vl	0.94	vh
Na	ts	0.46	m	0.79	h
	ss	0.38	l	0.85	h
Ca	ts	3.35	l	2.48	l
	ss	2.19	l	1.57	vl
Mg	ts	0.52	l	0.43	l
	ss	0.44	l	0.43	l
KTK	ts	110.70	vh	110.61	vh
	ss	105.21	vh	111.38	vh
KB (%)	ts	4.25	vh	4.11	vl
	ss	3.28	vh	3.40	vl
Al-dd	ts	0.68	vl	0.72	vl
	ss	0.80	vl	0.73	vl

ts = topsoil, ss = subsoil, va = very acid, vl = very low, l = low, m = moderate, h = high, vh = very high (Source 1: Assessment Criteria of Soil Chemical Properties https://nasih.wordpress.com/2010/11/01/uji-kimia-tanah/)
Source: Analysis undertaken at the Chemistry and Soil Fertility Laboratory, Faculty of Agriculture, Tanjungpura University, Indonesia

A soil survey and land evaluation at the research location characterized the area as having a peat-shaped dome that stretched from the edge of the river flow toward the middle of the field, and back thinning on the opposite side. Farmers usually prefer to plant food crops on land with a shallow peat soil thickness, while plantation crops, such as rubber and oil palm.

Hence, to achieve a productive agricultural site, the management of peatland may involve the use of ameliorants, such as manure, compost/bokashi, lime, mineral soil, coastal sediment and ash (Najiyati et al., 2005; Suntoro, 2014).

Identification of alternative sources of marine mud as ameliorant material and incubation of coastal sediment

In the second phase of the research, coastal sediment was collected from several locations, followed by laboratory analysis to determine the physical and chemical characteristics. The data acquired revealed coastal sediment from Kijing Beach (Mempawah District) had appropriate physical (finely textured) and chemical characteristics (high pH) as ameliorate (Table 2, Figure 2).

Table 2
Texture and pH of coastal sediment from several locations in Kubu Raya District, Indonesia

Number	Coastal Location	Parameters analysis				
		pH		texture (%)		
		H_2O	KCl	Sand	Silt	Clay
1.	Muara Dabong 1	5.50	5.14	2.53	55.71	41.76
2.	Muara Dabong 2	5.67	5.28	37.04	29.13	33.83
3.	Muara Dabong 3	5.77	5.37	53.79	20.31	25.90
4.	Kijing	8.03	7.73	0.71	51.58	47.71
5.	Muara Kubu	5.80	5.45	2.89	53.37	43.74
6.	Tanjung Radak	4.20	4.07	0.28	53.01	46.71

Source: Analysis was performed at the Chemistry and Soil Fertility Laboratory, Faculty of Agriculture, Tanjungpura University, Indonesia

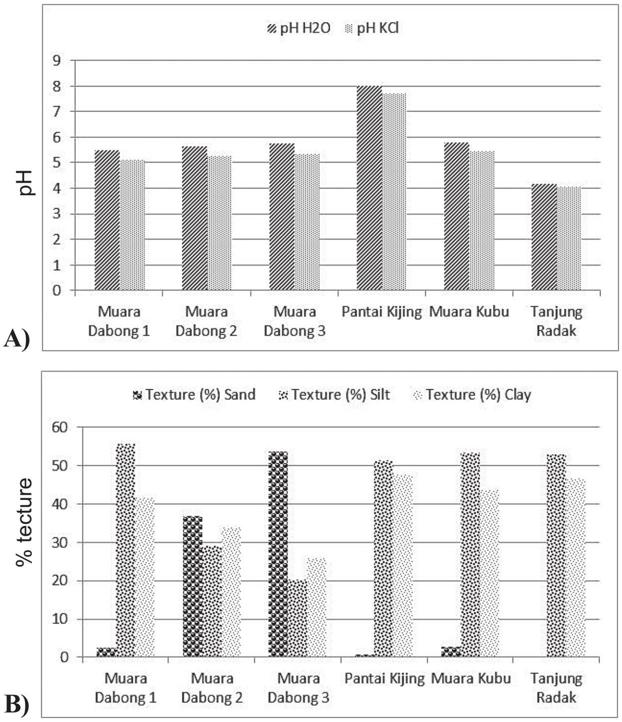

Fig. 2. Characteristic pH (A) and texture (B) of coastal sediment (Analytical Laboratories, Faculty of Agriculture, Tanjungpura University, 2014)

Based on the pH and texture analysis, coastal sediment from two sources, Kubu Raya District and Kijing Beach, were incubated with shallow (< 2 m) and deep (> 2 m) peat, respectively, for 4 weeks. Dolomite lime was used for comparison (Figure 3).

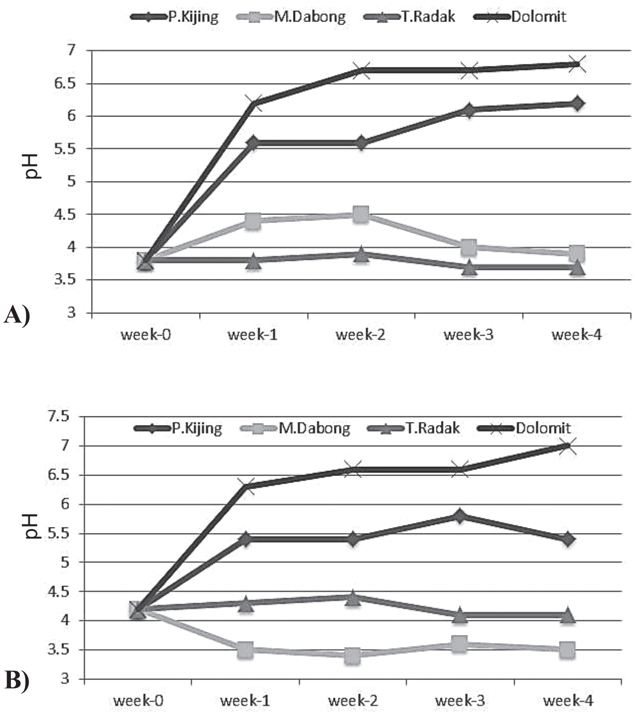

Fig. 3. Changes in pH during incubation of coastal sediment with shallow (A) and deep (B) peat at a dose of 10% weight basis

Incubation showed that coastal sediment from Kijing Beach beneficially increased the pH of peat soil samples relative to that sourced from Kubu Raya District (Figure 4).

Incubation also showed that 10% coastal sediment from Kijing Beach raised the pH of the peat soil samples more effectively compared to the other doses examined. The incubation duration (4 weeks in total) had no significant impact on the pH, but the largest increase in the pH value occurred in the first week.

Field research

Data obtained from investigating the peat soil improvement for plant growth demonstrated that the use of coastal sediment had the same effect in supporting the maize harvest grown in peat soil like that in lime (Table 3, Figure 5).

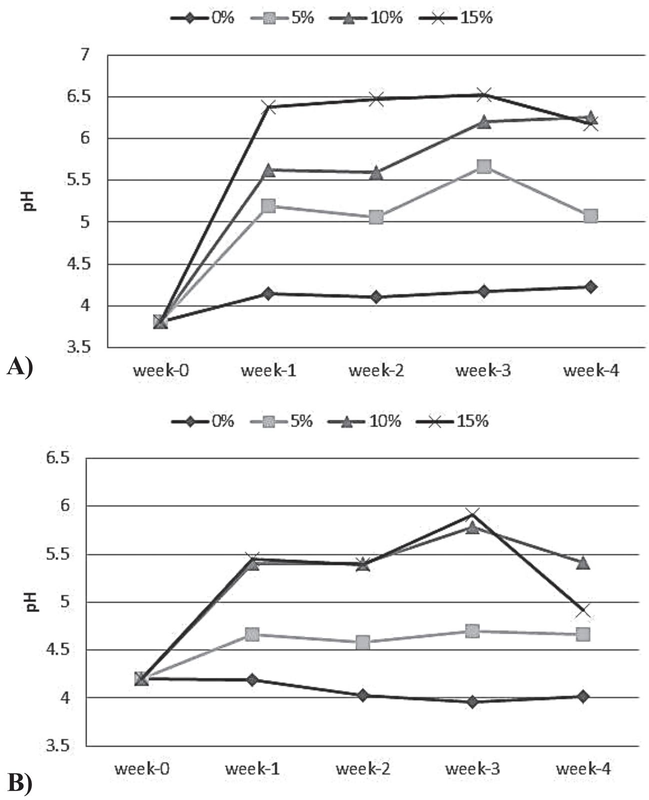

Fig. 4. Changes in pH during incubation of Kijing coastal sediment with shallow (A) and deep (B) peat at different doses

Coastal sediment as treatment for T_1 (peat soil thickness less than 2 m) reclamation with 10%, give the best effect on corn yield. The grafic show that corn yield increasing from lime to 10% coastal sedimen than decrease in 15%. But for T_2 (peat soil thickness more than 2 m) show reclamation with 5% is highes. Chart shows also that for T_2 coastal sedimen or lime must give or essential to support the growth of corn harvest. This can be seen in the treatment without giving coastal sediment (L0) have very low results (Figure 6).

The yields indicated that overall the coastal sediment could increase the maize crop yield (6.8 ton/ha) compared to the control. Moreover, there was increased production in the land with deeper peat relative to the shallow peatlands. This trend is strongly associated with the chemical characteristics of the peat, where deeper peatlands has a higher pH than shallow peatlands. However, in crop plants would have to be anticipated tendency of lodging (the influence of lack of land capacity on plant growth is high).

A comparative analysis of farming corn per hectare using coastal sediment and dolomite as the ameliorant in peatlands showed that using coastal sediment was more profitable (Table 4).

Table 3
Corn yields with the use of coastal sediment as a treatment in peat soil reclamation

Peat Soil thickness	Treatment	Corn cob (kg)	Shelled corn (kg)	Peat Soil thickness	Treatment	Corn cob (kg)	Shelled corn (kg)
T_1 (less than 2 m)	D-1	5920	3520	T_2 (more than 2 m)	D-1	6400	4080
	D-2	6000	3680		D-2	7280	5040
	D-3	6160	3760		D-3	6960	4560
	L_0-1	5600	3200		L_0-1	6160	3760
	L_0-2	6880	4560		L_0-2	6080	3680
	L_0-3	6960	4560		L_0-3	5920	3520
	L_1-1	5440	3040		L_1-1	7680	5280
	L_1-2	8080	6400		L_1-2	8240	6240
	L_1-3	6000	3600		L_1-3	8160	5360
	L_2-1	6160	3760		L_2-1	7760	5360
	L_2-2	8000	5760		L_2-2	8240	5840
	L_2-3	6320	3920		L_2-3	8160	5360
	L_3-1	6240	3840		L_3-1	7920	5520
	L_3-2	7600	5280		L_3-2	7680	5280
	L_3-3	6160	3760		L_3-3	8160	5760

L_0: 0% weight basis or without coastal sediment (as control); 2) L_1: 5% weight coastal sediment from Kijing Beach; 3) L_2: 10% weight coastal sediment from Kijing Beach, and 4) L_3: 15% weight coastal sediment from Kijing Beach. Lime (D) as a comparison (10% weight)

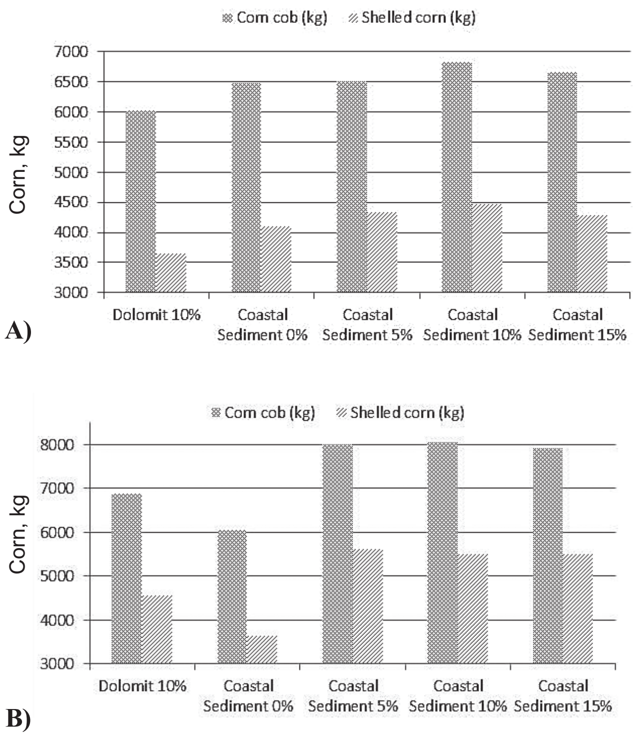

Fig. 5. Corn yields with the use of coastal sediment as a treatment on shallow (A) and deep (B) peat at different doses

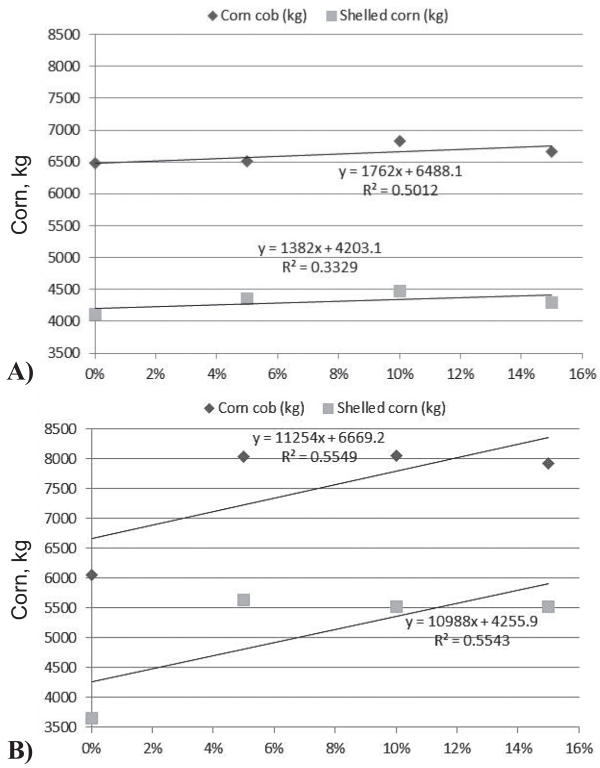

Fig. 6. Production of corn yields with the use of coastal sediment as a treatment on shallow (A) and deep (B) peat at different doses

Table 4
Comparative analysis of farming corn per hectare using ameliorant sea with dolomite lime mud in shallow peatlands

Activity	Coastal Sediment		Dolomite	
	Unit	Price	Unit	Price
in thousands of rupiah				
Costs:				
Arneliorant	4 ton	840	4 ton	3200
Urea Fertilizer	400 kg	800	400 kg	800
SP36 Fertilizer	200 kg	600	200 kg	600
KCI Fertilizer	100 kg	550	100 kg	550
Land lease	1 hektar	400	1 hektar	400
Land clearing	1 hektar	700	1 hektar	700
Preparation of planting	1 hektar	700	1 hektar	700
Applications arneliorant	4 DoW	400	4 DoW	400
Cultivation	4 DoW	400	4 DoW	400
Fertilization	12 DoW	1200	12 DoW	1200
Maintenance	3 mounth	2100	3 mounth	2100
Pesticide	1 package	200	1 package	200
Seed	14 kg	840	14 kg	840
Harvest	4 DoW	400	4 DoW	400
Processing	4 DoW	400	4 DoW	400
Total Costs		10530		12890
Income:				
Yields	6,8 ton		6,1 ton	
Sales		20400		18120
Total Income		9870		5230
R/C ratio		1.9		1.4

kg: kilogram; DoW: day of work

Conclusion

The thickness of the peat could be grouped into 1) shallow peat with a thickness < 2 m, and 2) deep peat with a thickness > 2 m.

Peat classification by subgroup level show 1) shallow peat as subgroups Typic Haplohemist (other Histolos with the maturity level Hemis) and 2) subgroup Typic Haplofibrist (other Histolos with the maturity level Fibris).

An inventory of alternative sources of coastal sediment from Kubu Raya District includes five locations: Muara Dabong, Muara Dabong 1, Muara Dabong 2, Muara Kubu, and Tanjung Radak.

Incubation showed that the coastal sediment from Kijing Beach is better than that from Kubu Raya District in increasing the pH of peat soil samples during incubation with doses up to 10% by weight.

Field experiments showed that addition of coastal sediment could increase corn production.

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