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The response of seedling growth of *Rhizophora apiculuta* to various concentrations of Sidoarjo mud

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Abstract. This study aims to determine the effect of some concentration of *Lusi* mud (Sidoarjo mud) as a medium to grow mangrove plants on the growth of *Rhizophora apiculuta* seedlings. A total of 24 experimental units arranged in a randomized block design with treatment were *Lusi* mud concentration on planting medium, ie: 10%, 20%, 30%, 40%, and 50%.The variables observed were plant height, stem diameter, long root leaf area and wet weight and dry weight of plant. Data obtained were analyzed statistically by an analysis of variance and HSD test were used to indicate the significant differences between the mean values ($p<0.05$). The results showed that the 10% *Lusi* mud concentration responded to the growth of canopy, root length, and wet weight and dry weight of *R. apiculuta* plants similar to those in the control treatment. At concentrations of 20%, 30%, 40%, up to 50% of *Lusi* mud, plants are able to grow well despite lower growth rates comparedwith no *Lusi* mud

1. Introduction

Hot mud eruption in Renokenongo village, Porong sub-district, Sidoardjo regency, East Java that produce masive mudflow has threatened the existence of agricultural land and mangrove area around it. At the beginning of the mud volume reaches about 100,000 m^3 per day with a composition of 70% in the form of sand and 30% liquid and about six years later the overflow volume only reaches 30,000 m3 per day [1]. Since 2012 Sidoarjo mud material (*Lusi*) consists of the 84.47% delicate soil which is dominated by clay size particles about 54.47% of total dry weight and classified as high plastic mud [2]. Sediments act as sinks and sources of contaminants in aquatic systems due to their physical and chemical properties[3], [4]. The results of the analysis of mud materials in villages within the affected area of *Lusi* were found to contain heavy metals (Cu, Cd, Pb), sulphides, and phenols above the permitted maximum threshold [5]. Heavy metals of cadmium (Cd) and lead (Pb) are known as toxic metals [6]–[8] that can get into food chain and resulting in various adverse effects in animals and humans[9], [10].

The overflowing mud flows through the Porong River to the sea which will produce sediment and accumulate pollutants contained in *Lusi* in almost part of the coastline of Sidoarjo Regency which is a mangrove area. Under normal conditions, mangroves in addition to the role of protecting the land from tidal and rob, as a habitat and spawning ground for fish and other aquatic organisms, can also recover the coast from pollutants carried over the river [11], [12]. The mangrove rehabilitation and

conservation will fail and the damage can not be avoided not only caused by human activities but also by natural phenomena [13], including in the case of this *Lusi* mudflow. To protect and conserve land and mangrove areas a systematic conservation and restoration strategy is required by utilizing all data that can be considered in the decision making [14]. In addition to build regional capacity and shoreline protection, developing technology and the role of mangrove seedling are being concern in the past five decades [15]. One type of mangrove plant that developed population in order to accelerate the mangrove rehabilitation process as part of the effort to mitigate the threat of *Lusi* sediment accumulation is *Rhizophora apiculuta*. Therefore it is necessary to test the ability to grow *R. apiculata* to various concentrations of *Lusi* mud that may be accumulated in the coastline. This study aims to determine the effect of several concentrations of Sidoarjo mud as a medium for growing mangrove plants to the growth of *R. apiculuta*.

2. Experimental Method

Three months *R. apiculuta* seedlings from a special seedling of mangrove plants in Mojokerto, Indonesia, from a uniform population were randomly selected to be used as test plants. Meanwhile, prepared planting media which is a mixture of *Lusi* mud and mud indigenous mangrove habitat that is not polluted by any pollutant with the following composition: 0% and 100%, 10% and 90%, 20% and 80%, 30% and 70%, 40% and 60%, and 50% and 50% respectively. Each was repeated 4 times, so that 24 units of experiments were obtained. Into the polybags that already contain the mixed plant media of these two kinds of sludge seeded *R. apiculata* seedlings from the nursery. Taking into account environmental conditions, the experiments are arranged in a Randomized Block Design. Every day, morning (at 7:00) and afternoon (at 17:00), Every day, morning (7:00) and evening (17:00 o'clock), plants watered with sea water which free from heavy metals to keep the condition resembling the nature that is always wetted until submerged in water. The variables observed in this experiment were: (i) plant height (cm) measured from the root end of the root to the growing point every week starting 7 days after planting (DAP), (ii) stem diameter (cm) measured weekly using a vernier calipers, (iii) leaf area (cm^2), calculated every 2 weeks by converting them in the form of drawings using millimeter block paper, (iv) root length (cm), calculated by measuring the length from the root tip to the root root (cm) at the end of the observation, (v) the wet weight of the plant (gr) is calculated by weighing the total weight of leaves, stems and roots from the tip of the observation, and (vi) dry weight of the plant (gr) calculated by weighing the wet weight of the cured plant until the constant weight at the end of the observation. All observation data were analyzed by using variance analysis (ANOVA) followed by 5% HSD test to know the difference between treatments.

3. Results and Discussion

The result of variance analysis showed that the difference of mud sidoarjo concentration had significant effect ($p < 0.05$) on plant height since 21 DAP. The mean of plantheight in response to planting medium is presented in Table 1.

Table 1. The mean of plant height in response to the *Lusi* mud at 7-14 DAP (cm)

Treatment	Observation time (DAP)							
	7	14	21	28	35	42	49	56
Lusi 0%	26,78	27,30	27.80b	28.43c	28.85d	29.33c	30.13c	30.48c
Lusi 10%	26.85	27.33	27.83b	28.28bc	28.73cd	29.25c	29.83bc	30.50c
Lusi 20%	26.05	27.05	27.48b	27.85abc	28.23bc	28.58bc	29.00b	29.45bc
Lusi 30%	25.68	26.23	26.53ab	26.83abc	27.13abc	27.43ab	27.78ab	28.23ab
Lusi 40%	25.68	26.15	26.53ab	26.70ab	26.78ab	27.05ab	27.35a	27.48a
Lusi 50%	25.55	25.70	25.85a	26.50a	26.58a	26.80a	26.95a	27.03a

Means followed by the same letter in the same row are not significantly different at p<0.05.

The result of variance analysis showed a significant effect (p <0.05) treatment of Sidoarjo mud content difference on observation of stem diameter of *R. apiculuta* on 28-56 DAP. **Table 2** shows the average diameter of 7-56 DAP stem.

Table 2. The mean of stem diameter in response to the *Lusi* mud at 7-56 DAP (cm)

Treatment	Observation time (DAP)							
	7	14	21	28	35	42	49	56
Lusi 0%	0.42	0,42	0,44	0.45ab	0.47b	0.48b	0.49b	0.48b
Lusi 10%	0.42	0.43	0.43	0.44ab	0.45b	0.46b	0.47b	0.47ab
Lusi 20%	0.39	0.39	0.39	0.41ab	0.42ab	0.43ab	0.44ab	0.45ab
Lusi 30%	0.36	0.36	0.37	0.38a	0.39a	0.39a	0.40a	0.40a
Lusi 40%	0.36	0.36	0.37	0.37a	0.38a	0.39a	0.39a	0.40a
Lusi 50%	0.36	0.37	0.37	0.38a	0.38a	0.39a	0.39a	0.40a

Means followed by the same letter in the same row are not significantly different at p<0.05.

The result of variance analysis showed that the difference of *Lusi* mud content was not significant (p> 0.05) to mangrove leaf area. The mean of leaf area at 14-56 DAP is shown in **Table 3**.

Table 3. The mean of leaf area in response to the *Lusi* mud at14-56 DAP (cm^2)

Treatment	Observation time (DAP)			
	14	28	42	56
Lusi 0%	5.35	5.87	6.39	6.79
Lusi 10%	5.01	5.43	5.74	6.07
Lusi 20%	5.06	5.23	5.54	5.66
Lusi 30%	4.81	4.96	5.26	5.38
Lusi 40%	4.77	4.85	5.09	5.18
Lusi 50%	4.46	4.66	5.07	5.12

Variation analysis also showed significant effect (p <0.05). The difference of *Lusi* mud concentration to root length and wet weight and dry weight of *R. apiculuta* with mean value of each treatment is shown in **Table 4**.

Table 4. The mean of root length and wet weight and dry weight of the plant in response to the *Lusi* mud

Treatment	root length (cm)	wet weight (g)	dry weight (g)
Lusi 0%	29.63 e	13.37 c	4.05 d
Lusi 10%	29.15 e	12.90 b	3.92 cd
Lusi 20%	24.25 d	12.66 ab	3.72 bc
Lusi 30%	20.63 c	12.58 ab	3.58 b
Lusi 40%	16.13 b	12.50 ab	3.49 b
Lusi 50%	12.63 a	12.43 a	3.08 a

Means followed by the same letter in the same row are not significantly different at p <0.05.

Except for leaf area, all plant growth variables grown at *Lusi* mud concentration above 10% indicate lower value than without *Lusi* mud. This suggests that heavy metals, sulphides, phenols, and various other toxic compounds inhibit root growth and normal nutrient uptake. In the original mangrove muddy media used in this experiment was dominated by sand and a little organic material [1]which had little ability to bind or retain heavy metals [16]; thus the higher the mud content the disturbance to the roots and growth of the higher the plant. Plants have developed mechanisms for sustaining growth under mud-covered conditions as indicated by equally identical leaf area between Lusi mud treatments and all treatment concentrations (**Table 3**). Young plants have high growth potential due to high sucrose support [17] obtained from photosynthetic processes that depend on water and sunlight. The sugars of photosynthesis are very important in the growth of juvenile phase crop tissues [18], so as shown in Table 2 and 4 that the stem diameter and biomass of plants treated by *Lusi* mud are quite high.

4. Conclusion

The difference of Sidoarjo mud concentration significantly influence the growth of plant height, stem diameter, root length and wet weight and dry weight of *Rhizophoraapiculuta* plant. The 10% sidoarjo mud concentration provided normal growth for *R. apiculuta* as in the control treatment, while at concentrations of 20%, 30%, 40%, up to 50% of Sidoarjo mud crops are able to grow well despite the relatively lower growth response compared with no Sidoarjo mud.

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