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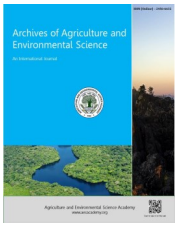

ORIGINAL RESEARCH ARTICLE

Growth response of mahagony seedling (*Swietenia macrophylla* King.) to addition of coconut shell charcoal and compost on ex-sand mining site of West Java Province in Indonesia

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ABSTRACT

Riverbank is the area that is frequently being used for sand mining site. Overexploited and poorly-managed sand mining will give negative impacts to environment. To prevent and to reduce worse environmental damage, efforts to control the negative effects should be done. One of efforts that can be implemented is revegetation on the damaged land by sand mining activities, thus it needs the type of vegetation that could adapt to its environment. Mahagony (*Swietenia macrophylla* King.) is a plant that could adapt to ex-sand mining site environment. This research was carried out to assess the effect of adding compost manure and coconut shell charcoal for the growth of mahagony seedling (*S. macrophylla*) on ex-sand minig site and to identify proper dose for the coconut shell charcoal and compost manure to condition of the site. This research uses complete random design (CRD) factorial. The result of this research shows that giving coconut shell charcoal and compost manure does not have significant effect to all parameter viz height, diameter, total wet weight (TWW), total dry weight (TDW), and root apex ratio (RAR) of *S. macrophylla*. Giving compost manure partially has significant effect to high parameter, total wet weight, total dry weight, and root apex ratio of *S. macrophylla* with the best dose amounting to 100 g. The addition dose of coconut shell charcoal 20 g give the best response to total wet weight parameter of *S. macrophylla*.

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INTRODUCTION

Riverbank is the area that is frequently being used for sand mining site. Overexploited and poorly-managed sand mining will give negative impacts to environment (Herry Pinatik and Dedie Tooy, 2014). Environmental There are some impacts to environment due to sand mining activities, which are decrease of soil productivity, solubility of heavy metals, declain of clay soil, soil solidification, sedimentation, landslide, damage to flora and fauna, damage to security and health of population, and also micro climate change (Sulaksono and Hadiyan 2015; Kamboj *et al.,* 2017; Suyatna *et al.,* 2017). Those impacts catalyze critical state of ex-sand mining site, thus the efforts should be done to recover soil productivity (Marschner, 2005; Aloa and Shuaibu, 2013). To prevent and to reduce excess environmental damage, efforts to minimalize the impacts should be made. One of the efforts is by revegetation of the land (Marjenah, 2007; Yuniwati *et al.,* 2012). Revegetation on riverbank can be done after mining sand that is likely to cause disturbance to environment. Revegetation is replanting activities on ex-sand mining site to recover biodiversity and to prevent erosion and runoff (Setiadi, 2006; Pitri Yandri, 2013), Choosing the right plants for revegetation is one of successful key in revegatating the critical land due to sand mining, thus suitable plant that can adapt and soil recovery efforts (such as recovering biological, chemical and physical content) are needed. One of proper plants to be chosen is mahagony.

Mahagony is one of suitable plants that can survive on lack of nutrient soil content. Mahagony also increases nutrients to recover soil structure (Mindawati and Megawati, 2013). Those will support revegetation on ex-sand mining site. For mahagony, one of treatment that can be done is by giving extra compost and coconut shell charcoal to optimalise the growth (Gusmailina, 2002; Herianto and Siregar, 2004; Wasis and Fathia, 2011). Keeping in view the present investigation was conducted to assess the

effects of adding compost and coconut shell charcoal to the growth of mahagony (*Swietenia macrophylla* King.) on ex -sand mining site and also to assess the correct dose of compost and coconut shell charcoal to be given effectively and efficiently on the site.

MATERIALS AND METHODS

Research duration and place: The research was conducted from March to May 2016 in Department of Silviculture, IPB's green house, forest influental laboratory, and Department of Soil Science and Soil Resource Laboratory Bogor Agricultural University (BAU/IPB). Location of ex-sand mining site is in Ciomas Sub-district, Bogor, West Java Province. Indonesia

Research tools and materials: Tools used in this research are calipers, hoe, 20cm x20 cm polybag, timbangan ohose, 60 cm ruler and camera. Materials needed are 4 months mahagony seedling, ex-sand mining site media, compost, and coconut shell charcoal.

Research methodology: Research was conducted in few steps, which are prepation for the media, weaning process, preservation, observation, collecting data with analyzing nutrient, designing experiment and alayzing comprehensive data. There are description for each process:

Preparation: Preparation step is by preparing media and mahagony seelding, collecting the site sample for media in Ciomas Sub-district, Bogor. Prepared media consists of structured compositions of coconut shell charcoal, compost, and ex-sand mining sample media. They are weighted using weighing mechine, with adjusted measure. After getting the correct composition, each material was inserted in polybag. The measurable composition for control is 1 kg sand and compositions for compost are 25 g/polybag, 50 g/polybag, 75 g/polybag, and 100 g/polybag. Meanwhile, coconut shell charcoal compositions are 0 g/polybag (control)m 20 g/ polybag, 40g/polybag, and 60 g/polybag. Preparation for mahagony seedling was conducted by choosing healthy seedling, with miscelanous fresh, free of pest and diseases for height and diameter of the seedling.

Weaning process: Four months mahagony seedling was moved into polybags that have been treated. The proper time for weaning process is in the morning for reducing stress level and for preventing evaporation of the seedling.

Maintenance: Weaned mahagony (*S. macrophylla*) seedlings were put in green house for 3 months. They were sprayed every morning and every evening, which it must consider the condition for each media in the polybag, if it was wet then not sprayed.

Data collection: Data was collected every week with measurable parameter, which are height and diameter of (*S. macrophylla*) seedlings. The height of *S. macrophylla* seedlings were measured using ruler and the diameter of *S. macrophylla* seedlings was measured using digital caliper. Wet weight and dry weight for apex and root data of *S. macrophylla* seedlings were harvested in the harvest time. The procedure was by separating apex and root, weighing them, and drying them in microwave with temperature of 80^{o}C for 24 hours and weighing them again afterwards (Wasis and Fathia, 2011). Measuring soil nutrient was in the last week. Two soil samples were control and treated samples measured for getting the best growth.

Experiment design and data analysis: Used experiment design in this research is complete random design (CRD) factorial with two factors. The first factor is composts consisting of 5 steps treatment. The second sample is coconut shell charcoal with 4 steps treatment. Each step of treatments consists of 3 repetitions and each repetition consists of one seedling. Therefore, there were 60 seedlings used in this research.

Obtained data based on measurement of height, diameter, total wet weight (TWW), total dry weight (TDW), and root apex ratio (RAR) was analyzed by using linear model (Mattjik and Sumertajaya, 2013; Stell and Torries, 1991; Wibisono, 2009). Only if there is significant effect, Duncan's Multiple Range Test will be measured for getting further statistic data.

RESULTS AND DISCUSSION

Observed parameter in this research is height, diameter, total wet weight (TWW), total dry weight (TDW), and root apex ratio (RAR) of mahagony (*S. macrophylla*) seedling on ex-sand mining site with addition of compost and coconut shell charcoal. Response from adding compost and coconut shell charcoal to measured parameter could be identified with variety print analysis. Recapitulation result of variety print analysis is shown in Table 1.

Variety print result in Table 1 shows that the addition of compost gives significant effect to the growth of height, TWW, TDW, and RAR of mahagony (*S. macrophylla*) seedlings with 95% trust range. The addition of cocount shell charcoal only give significant effect to TWW of the seedlings of *S. macrophylla* with 95% trust range. Meanwhile, interaction between compost and coconut shell charcoal does not give significant effect to all parameter with 95% trust range.

Height growth: Growth is the addition of dimension to plants due to fission that will become grown plants. The growth of plants is affected by genetic factor and environmental factor. Geneticc factor is carried by directly -inherited plants or its gen. Meanwhile, environmental factor was modified from its location or ith habitat. The height addition is primary groth in meristem tip or in the apex. This meristem tissue keeps it fission for growing its root and its stem, thus there are addition to its height (Darmawan and Baharsjah, 2012).

Based on variety print result (Table 1), it shows that adding compost and coconut shell charcoal treatment in ex -sand mining site does not give any significant effect to the growth of *S. macrophylla* seedlings. However, The addiition of each compost or coconut shell charcoal gives significant effect to measured parameter (height) of *S. macrophylla* seedlings. The result of Duncan test for adding compost treatment could be seen in Table 2.

Based on duncan test in Table 2, it shows that 100 g compost treatment does not show significat differences in the height growth of mahogany (*S. macrophylla*) seedling by adding 75 g and does give significant effect by not giving compost. The best treatment was shown by adding 100 g compost with height growth of mahogany (*S. macrophylla*) seedling amounting to 5.09 cm and

percentage of increase to control 62.06%. Meanwhile, the smallest height growth rate is by not giving compost with the height growth of mahogany (*S. macrophylla*) seedling accounting for 3.14 cm and the percentage to control 0%. Giving addition of 100 g will affect to the height growth of mahogany (*S. macrophylla*) seedling significantly (Ningrum, 2015). The height growth of mahagony seedling for 12 weeks is shown in Figure 1.

Figure 1 shows height growth rate (cm) graph of mahagony (*S. macrophylla*) seedling for 12 in 12 weeks, which shows the increasing rate for each week. The best height growth of mahagony (*S. macrophylla*) is A4B0 treatment (100 g compost with 0 g coconut shell charcoal), which can be seen in the graph of A4B0 that shows highest growth compared to the others. Compost is organic manure containing complete macro and micro nutrient needed for supporting the growth (Setiadi and Cakyayanti, 2014; Wasis and Noviani, 2010; Wibisono, 2009). The addition of compost in a media help increase soil fertility and catalyze the root growth (Putri and Nurhasybi, 2010; Wasis and Fathia, 2011). Compost also protect the function of soil to support the seedling. There are few benefits for plants, which are giving nutrient, recovering soil structure, increasing kation change ability, adding soil ability to keep water, increasing soil biologonical activities, increasing pH in acid soil, and increasing stock of micro nutrients (Phillip *et al.,* 2015).

Growth of cambium: Diameter growth is the growth of cambium tissue and cause the horizontal growth (Mandella, 2010). Variety print result in Table 2 shows that the addition of compost,coconut shell charcoal, or compination of both treatment does not give any significant effects to diameter parameter of *S. macrophylla*. Therefore, duncan test is not necessary.

Total wet weight: Total wet weight (TWW) is one of indicators used to assess water content and the need of plants for water. TTW can be affected by the length of root, the number or leaves, the height of the plants, and the number of buds. Result of duncan tes shows that the addition of compost or coconut shell sharcoal to the paramaeter for mahagony (*S. macrophylla*) seedling is illustrated in Tables 3 and 4.

Based on duncan test in Table 3, it shows that adding 100 g compost does not have any significant difference compared to adding 75 g compost and have significant difference compared to 0, 25, and 50 g compost. The best treatment is shown by the addition of 100 g compost with the rate of TWW accounting for 27,21 g and with the percentage of increase amounting to 39,75%. Meanwhile, the rate of the least TWW is by not giving compost with TWW of mahagony (*S. macrophylla*) seedling accounting for 19,47 g and with the percentage amounting to 0%.

Based on duncan test in Table 4, it shows that adding 20 g treatment does not have any significant effect compared to 40 g and has significant difference compared to 0 g for TWW parameter for mahagony (*S. macrophylla*) seedling. The best treatment is shown by the addition of coconut shell charcoal amounting to 20 g with TWW rate accounting for 24,92 g and the perentage of increase to control 16,88%. Meanwhile, giving compost accounting for 60 g give slightly negative effect to TWW parameter with TWW rate amounting to 21,09 g and with -1,07% to control.

Total dry weight: Total dry weight (TDW) is one of parameters used to identify responses of the plants in using existing nutrients in a measured growing media (Gusmailina, 2002). TDW parameter show the accumulation of cumulative nutrients in a plant (Herianto and Siregar, 2014). Result of duncan test for isentifying proper effect of adding compost to TDW of mahagony (*S. macrophylla*) seedling is shown in Table 5.

Based on duncan test in Table 5, it shows that addition of 100 g compost treatment does not have significant difference compared to 75 g and has significant effect compared to addition of 0, 25 and 50 g for TDW growth parameter of mahagony (*S. macrophylla*) seedling. High TDW indicates good quality of the growth (Putri and Nurhasybi, 2010). The best treatment is shown by the addition of 100 g, with the rate of TDS accounting for 9,90 g and with the percentage amounting 31,12% to control sample. Meanwhile the least TDW rate is shown by the addition of 0 gram compost with TDW of mahagony (*S. macrophylla*) seedling rate amounting to 7,55 g and with the percentage accounting for 0%.

Root apex ratio: The value of root apex ratio (RAR) of a plant can show physical condition of it related to the resistence of seedling if it is replaced to different field (Santosa *et al.,* 2013) . Result of duncan test towards the addition of compost to RAR parameter of mahagony (*S. macrophylla*) seedling is illustrated in Table 6.

Based on duncan tes in Table 6, it shows that addion of 100 gram does not have any significant difference compared to 75 g and has significant difference to 0, 25, 50 g to RAR parameter of mahagony (*S. macrophylla*) seedling. The best treatment is shown by the addition of 100 g with RAR rate amounting to 2,77 g and with the percentage accounting for 34,46%. Meanwhile, the least RAR rate is shown by not giving compost with RAR rate amounting to 2,06 g (0%).

RAR is affected by few factors, which are genetic of the plants, availability of nutrients, and light competition for photosystesis (Mokany *et al.,* 2006). Plants that lack of water and nutrients will try to form more roots to increase the ability to absorb, which catalyze lower number of RAR parameter of *S. macrophylla*. Low RAR number indicates the preparedness of the plants due to they have lot of roots to absorb nutrients and water when they are replaced to other fields (Hardjowigeno, 2003; Munawar, 2011).

Chemical characteristics of soil: Soil chemical analysis is to identify soil nutrient condition. Sand mining activity will affect physical, chemical, biological soil condition by evaporation of the surface. Ex-sand mining soil is likely to have unoptimal physical and chemical characteristic for the growth of plants (As'ad, 2005). Soil laboratory test result shows that the comparison between nutrient of compost and coconut shell charcoal and control sample (ex-sand mining soil). It shows that there are significant differences betweem them. Table 7 shows the result of the soil characteristics used for the cultivation of *S. macrophylla*.

The addition of organic manure in measured composition

have significant function in recovering chemical, physical, and biological soil content, ang also nutrient for plants Bonifas and Lindquist (2009). In addition, charcoal have an important role in recovering physical, chemical, and biological conten. It also can provide habitat for microbes (Santi and Goenadi, 2010). Table 7 shows that the addition of compost and charcoal can improve nutrient availabilities. from 6,36 pH (slight acid) to 7,12 pH (neutral). exchange rate capacity of soil is also improven from 5,94 me/100g to 7,92/100g, yet the increase is not significant and the value itself is low.

Result of the soil chemical content analysis in Table 7 shows that there is no increase for C-org from both treatment (charcoal and compost), which are from 0,07% to 0,91%. Macro nutrients, such as NP,K,Ca, and Mg, are also improved compared to control. Meanwhile, the increase is not high enough to be clasified as significant effect, thus the increase proves that there is beneficial effect given by compost and coconut shell charcoal to the ex-sand mining soil sample for mahagony seedling growth. Micro nutrient is needed nutrient in few number. Examples of micro nutrients are Fe and Cu. Micro nutrients hold important complex role for plants. Spesifically, it is needed for photosynthesis and metabolisme. Table 7 shows that compost and charcoal treatment help increase micro nutrient availabilities in soil. Fe increases from 27,50 ppm to 42,95 ppm. Cu is the essential component especially in some enzimes of plants. The proper availability of Cu will activate enzimes in plants spesifically by helping the development and the growth of plants. Excess micro nutrients, however, catalyze toxic for plants (Tan, 1994; Hardjowigeno, 2003; Lakitan, 2012).

Table 1. Recapitulation result of variety print with different treatment to the growth parameter of mahagony (*S. macrophylla*).

Parameter	Treatment		
	Compost	Coconut shell charcoal	Compost × Coconut shell charcoal
Height	0.0056*	0.4840tn	0.4716tn
Diameter	0.7043tn	0.1660tn	0.8241tn
TWW	0.0047*	0.0454*	0.7660tn
TDW	0.0209*	0.0529tn	0.8423tn
RAR	0.0235*	0.8928tn	0.3693tn

*= Factual treatment with trust range 95%, significant value (Pr<F) 0.05 (α) tn = unfactual trreatment with trusst range 95% (Pr>F) 0.05 (α).

Table 2. Duncan test result by adding compost to identify the height growth of mahogany (*S. macrophylla*) seedling.

Treatment	Rate of height growth (cm)	Increase (%)
Compost 0 g	3.14b	0
Compost 25 g	4.02ab	27.95
Compost 50 g	3.87ab	23.34
Compost 75 g	5.03a	60.21
Compost 100 g	5.09a	62.06

*Nuumber with the same alphabet shows insignificant treatment with 95% trust range.

Table 3. Result of Duncan test for identifying effects of compost to TWW growat of mahagony (*S. macrophylla*) seedling.

Treatment	TWW rate	Increase (%)
Compost 0 g	19.47b	0
Compost 25 g	23.44ab	20.39
Compost 50 g	22.26b	14.32
Compost 75 g	22.40b	15.04
Compost 100 g	27.21a	39.75

*Number followed by the same alphabet to show insignificant treatment with 95% trust range.

Table 4. Result of Duncan test for identying the effects of coconut shell charcoal for TWW of mahagony (*S. macrophylla*) seedling.

Treatment	Rate of TWW	Increase (%)
Charcoal 0 g	21.32b	0
Charcoal 20 g	24.92a	16.88
Charcoal 40 g	24.50ab	14.91
Charcoal 60 g	21.09ab	-1.07

*Number with the same alphabet to show insignificant effect with 95% trust range.

Table 5. Result of Duncan test for indentifying the effect of adding compost to TDW growth of mahagony (*S. macrophylla*) seedling.

Treatment	TDW rate (g)	Increase (%)
Compost 0 g	7.55b	0
Compost 25 g	8.62b	14.17
Compost 50 g	8.30b	9.93
Compost 75 g	8.12ab	7.54
Compost 100 g	9.90a	31.12

Note: Number with the same alphabet to show insignificant effect with 95% trust range.

Table 6. Result of Duncan test for identifying the effects of of compost to RAR parameter of mahagony (*S. macrophylla*) seedling.

Treatment	RAR rate	Increase (%)
Compost 0 g	2.06c	0
Compost 25 g	2.26bc	9.70
Compost 50 g	2.39abc	16.01
Compost 75 g	2.60ab	26.21
Compost 100 g	2.77a	34.46

Note: Number with the same alphabet to show insignificant effect with 95% trust range.

Table 7. Chemical characteristics of the soil used for the cultivation of *S. macrophylla*.

Treatment	Control	Criteria*	Compost and charcoal	Criteria*
pH	6.36	Acid	7.12	Neutral
C-Organic (%)	0.07	Very low	0.91	Very low
N-total (%)	0.06	Very low	0.10	Low
P-available	4.12	Very low	46.20	High
Ca (me/100g)	3.35	Low	10.67	Medium
Mg (me/100g)	1.83	Low	3.01	Medium
K (me/100g)	0.26	Low	0.95	High
KTK (me/100g)	5.94	Low	7.92	Low
Fe (ppm)	27.50		42.95	
Cu (ppm)	1.55		2.73	
Texture (%) Sand	90.74		90.24	
Silt	6.44		7.25	
Clay	2.82		2.51	

*Criteria from the soil research center Bogor (1983), Bogor-Indonesia

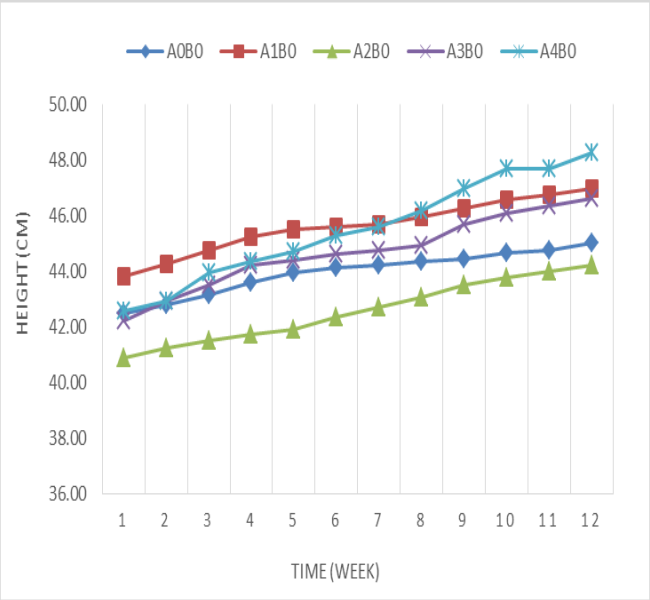

Figure 1. *Height growth rate figure (cm) of mahagony (S. macrophylla) seedling for different addition dose of compost.*

Conclusions

The addition of compost gives significant effects to height, total wet weight, total dry weight and root apex ratio.The addition of coconut shell charcoal only significantly affects total wet weight parameter of *S. macrophylla*. The addition of 100 g coconut shell charcoal gives the best response to all parameters, except diameter of *S. macrophylla*. The addition of 20 g charcoal gives the best response of TWW parameter of *S. macrophylla*.

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