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# Improvement of Sand Tailing Fertility Derived from Post Tin Mining Using Leguminous Crop Applied by Compost and Mineral Soil

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## ABSTRACT

The research was aimed to study the potency of two leguminous cover crops in enhancing tailing fertility of post tin mining with and without addition of mineral soil and compost. This pot experiment was carried out in Greenhouse of Soil Science Department, Faculty of Agriculture, Sriwijaya University from November 2011 until March 2012. Design experiment used was a Completly Randomized Design (CRD) factorial with two factors. The first factor was type of cover corps which were *Centrosema pubescens* and *Pueraria javanica*. The second factor was plant media composition which were 100% sand tailing, 60% sand tailing + 40% mineral soil, and 95% sand tailing + 5% compost. The result showed that N content on sand tailing after harvesting applied by compost and mineral soil was not significant by difference. Meanwhile, P content on sand tailing applied by compost was higher than mineral soil application and/or control (100% sand tailing).

***Keywords**:* Compost, legominous crop, N and P nutrients, sand tailing

## INTRODUCTION

Tin mining is widely distributed in Bangka Belitung Island Province. The impact of this activity causes degraded land amounting to 1,645,414 ha, and resulting in 887 *kolong* (water logging) or *lombong* in Malaysia (Ang 2002) with total area about 1,712.62 ha. Soils derived from post tin mining generally contain particle distribution about more than 90 % sand, less than below 3% clay, very low organic matter content (Mokhtaruddin and Norhayati 1995; Ang 2002), low water holding capacity, high soil permeability and very low microba (Budianta *et al*. 2010). Moreover, laboratory analysis showed that tailings have low fertility with acidic pH, low CEC, low organic C and nutrient content (Ang 2002; Sinar Tani 2008). Sand is very infertile and is not suitable for cultivation (Ang 2002).

Reclamation of this tailing is one of effort to prepare post tin mining to make better for plant growth (Mokhtaruddin and Norhayati 1995). Reclamation is principally to make post tin mining able to be used for cultivation in environmentally (Mokhtaruddin and Norhayati 1995; Yani 2005). However, revegetation on this tailing is always difficult due to high acidity (Ye *et al*. 2002). Practically, post tin mining reclamation in Bangka Island has been conducted through revegetation using Acacia crop, however, revegetation has not shown statisfaction result (Ye *et al*. 2002; Budianta *et al.* 2010). To that respect it is needed to choose the crops which have better economic and ecology aspects.

Utilization of leguminous that has fast growth can become option that can be expected the soil regeening will be faster compared to other crop. Application of compost on revegetation of tailing is very effective in determining and maintaining crop growth and biomass production and also in decreasing heavy metal sorption by crop (Kelly *in* Purwantari 2007). Revegetation done soon is needed to make balance on tailing production and/or to inhibit environtmental degradation (Purwantari 2007).

Type of leguminous cover crop such as *Centrosema pubescens* and *Pueraria javanica* have high toleran planted on land marginal like as tailing. *C. pubescens* is mostly found in tailing derived from gold mining. Syarif *et al*. (2009) reported that this crop absorbed cyanide from tailing of PT ANTAM Cikotok with value of 22.09 mg $kg^{-1}$. Meanwhile *P. javanica* is used for reclamation of coal mining (Djunaedi and Djabar 2003).

This current result used two types of leguminous crops which were *C. pubescens* and

*P. javanica* with application of two amendements which were compost and mineral soil.The mineral soil would be expected to increase clay fraction incorporated on sand tailing, while organic matarial would suply nutrient that could improve soil chemistry of tailing and it could be used to particle binding and to prepare micro agregate form resulting in improving soil structure and finally the crop could grow properly (Sitorus *et al.* 2005).

This research was expected to be able to give alternative informaton concerning improvement of sand tailing fertility on post tin mining, thus this tailing could be used for food crop production consumed by animal and human.

## MATERIALS AND METHODS

### Study Site

This experiment was conducted in Greenhouse of Soil Science Department, Faculty of Agriculture, Sriwijaya University. Pot experiments were set up and placed in greenhouse. Time of excecution was scheduled on November 2011 up to March 2012. Tailing and plant analysis were done in laboratory of chemistry, biology and soil fertility of Soil Science Department, Faculty of Agriculture, Sriwijaya University.

### Experimental Design

Material used in this experiment was sand tailing with 10 years old after post tin mining, top soil (0-20 cm), compost, seed of *C. pubescens* and *P. javanica*. The experiment was done in pot experiment and designed in a CRD factorial with two factors which were type of crop (*C. pubescens* and *P. javanica*) and soil media (V/V) (100% sand tailing (as control), 60% sand tailing + 40% mineral soil, 95% sand tailing + 5% compost). Total was 6 treatments. Each treatment combination was repeated 3 times, thus total pot experiment was 18 unit after amendment application, plant media were incubated for 2 weeks before sowing. Planting were done by placing 5 seeds per pot. After one week of sowing, one crop per pot was growed until harvesting. Harvesting was done after 12 weeks planting.

### Variable and Statistial Analysis

Variables observed for sand tailing and mineral soil were soil pH, organic-C, total-N, availability of P and K, and soil texture. Growth parameters were plant height, leave amount, wet and dry biomass. Soil pH was measured 4 times during planting. Nitrogen and P contents were measured after harvesting included N and P sorption by crop. Data obtained were analysed using ANOVA and followed by Duncan analysis, if F test had significantly effect.

## RESULTS AND DISCUSSION

### Charasteristics of Sand Tailing and Mineral Soil

Characteristics of sand tailing and mineral soil were very low (Pusat Penelitian Tanah 1983). As shown by the macro elements of N, P, K and organic C that were very low. Some physical and chemical properties of sand tailing and mineral soil are presented on Table 1.

The low of sand tailing fertility was due to there was not top mineral soil layers covering sand tailing that had generally fertile and it was lost caused by tin mining process. In addition, tailing has also low pH (Table 1). Sopian (2009) reported that post mining was generally acidic due to change in its structure as resulted in exposuring and mixing rock as parent material in sub soil layer and acidic compound was going upto soil surface layer.

The low of sand tailing fertility was also characterised by sand texture class. Actualy tailing and mineral soil were dominated by sand fraction with value of 100% for tailing and 84.49% for mineral soil, thus the texture was categorised by sand texture class according to triangle of USDA texture class. Practically, after washing and sieving of soil during tin mining process it will be leaving for 100% sand fraction (Mustikarini *et al.* 2010).

Sitorus dan Badri (2008) reported that sand texture class would have small area surface, less fertile and had big macro pores. Thus water would be absorbed by this texture in small amount during

Table 1. Some physical and chemical properties of sand tailing and mineral soil.

| Variable | Sand Tailing | Mineral Soil |
|---|---|---|
| pH | 4,04 (Va) | 4,08 (Va) |
| C-Organic (%) | 0,10 (Vl) | 1,30 (L) |
| N-Total (%) | 0,10 (Vl) | 0,70 (Vl) |
| P-Bray-I (mg $kg^{-1}$) | 0,45 (Vl) | 29,55 (Vh) |
| K-Exch (cmol (+) $kg^{-1}$) | 0,06 (Vl) | 0,13 (L) |
| Particles distribution : | | |
| Sand (%) | 100 | 84,49 |
| Silt (%) | 0 | 8,25 |
| clay (%) | 0 | 7,26 |

L = Low, Va= Very acidic, Vl = Very low, and Vh = Very high.

dry season. Rahyunah (2011) stated that low water content resulted in low consentration of nutrient in soil solution. Texture of tailing which was dominated by sand also affected the availability of nutrients. Sand tailing had very low CEC caused by high leaching nutrients (Awang edited by Inonu *et al.* 2010). Therefore, it will be affecting the plant growth in that tailing.

**Soil pH in Plant Media**

Changes on soil pH weekly due to different plant media composition are presented in Figure 1. It was shown that plant media applied by compost had higher soil pH than media applied by mineral soil and control (tailing only). The significance difference was obtained when plant media was applied by compost compared to the application of mineral soil and or control (without ameliorant).

There were fluctuation of soil pHs due to application of two different soil ameliorants to the sand tailing. The highest change of pH was found when compost was applied to the tailing (Figure 1). pH values of plant media were significantly different started from two weeks of incubation or start sowing, meanwhile application of mineral soil did not change tailing pH. Mineral soil that was mixed with sand tailing did not significantly change pH of tailing because of how pH of mineral soil (4,8). Soil pH can be used as an indicator for soil fertility. It is known that availability of some nutrients were also depended on soil pH, whereas the optimum of nutrient availability was taken place in soil pH with value of 6-7 (Setyorini and Ladiyani 2004). The correction of soil pH will be replenishing more nutrients required by crop for better growing.

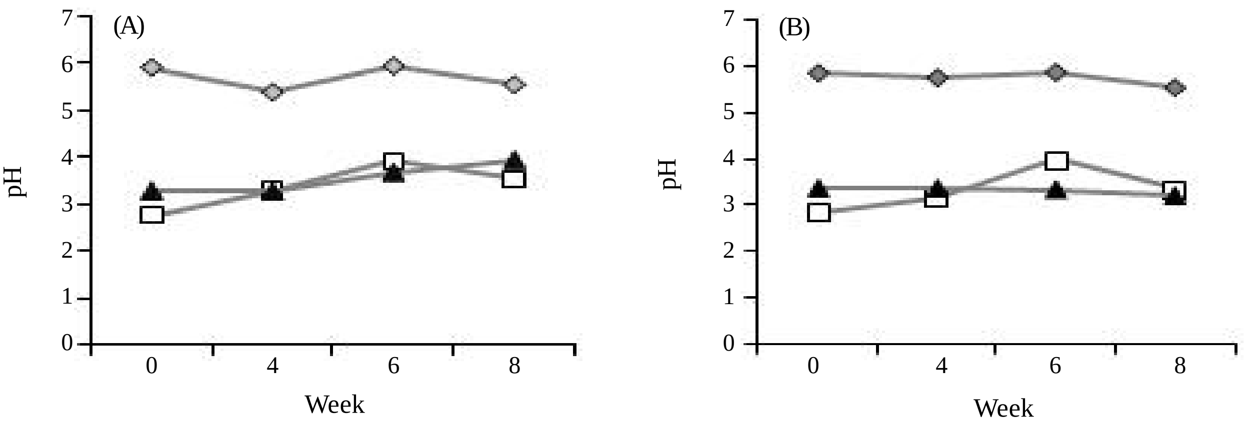


Figure 1. Changes of pH media growth with (A) *C. pubescens* and (B) *P. javanica.* 100% sand tailing (—□—), 60% sand tailing + 40% mineral soil (—▲—), 95% sand tailing + 5% compost (—◆—).

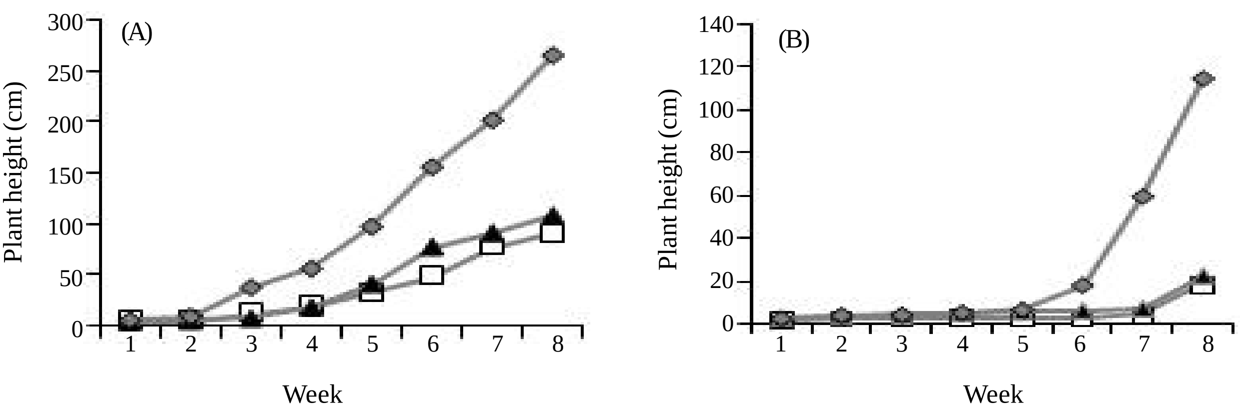


Figure 2. Plant height of (A) *C. pubescens* and (B) *P. javanica* growth under different plant media composition. 100% sand tailing (—□—), 60% sand tailing + 40% mineral soil (—▲—), 95% sand tailing + 5% compost (—◆—).

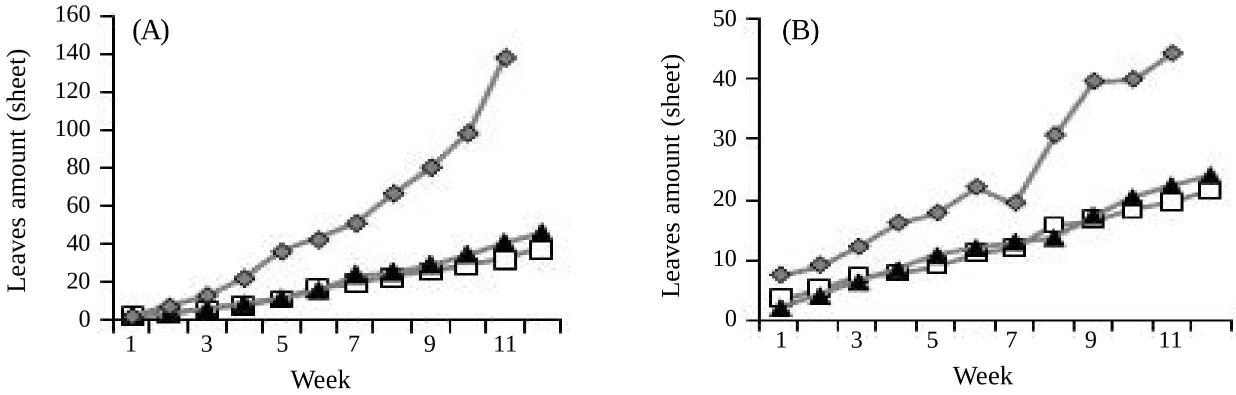


Figure 3. Leaves amount of (A) *C. pubescens* and (B) *P. javanica* growth under different plant media composition. 100 % sand tailing (—□—), 60 % sand tailing + 40 % mineral soil (—▲—), 95 % sand tailing + 5 % compost (—◆—).

## Growth of Leguminous Crop

Results of plant growth showed that application of compost provided the best plant growth. All variables observed which were plant height, leaves amount, wet and dry biomass showed higher values compared to other treatments.

## Plant Height

Different ameliorant application resulted in significance different on plant height. The highest plant height was obtained when compost was applied. It was showed that *C. pubescens* had higher plant height than *P. javanica*. Plant height measured across the time is shown in Figure 2.

The two cover crops planted on this tailing had different response on plant height *C. pubescens* was more reponsive than *P. javanica*. Effect of compost application on the growth of *C. pubescens* had appeared on two weeks after planting, however *P javanica* was on seven weeks after planting.

## Leaves Amount

As shown in Figure 3, *C. pubescens* had more amount of leaves than *P. javanica* eventhough *P. javanica* had greater leaves surface area. Comparison of leaves amount among treatment can be seen in Figure 3.

Statistical analysis showed that composition of plant media had a significant effect on leaves amount of *C. pubescens* after three weeks of sowing until the end of obervation. While, *P. javanica* has shown significant effect started from one week after planting but the sigificant effect was not going until harvesting. Application of compost produced the highes amount of leaves of the two corps (Figure 3).

The growth of the two cover crops was different due to the difference of crop growth properties. *P. javanica* had initial growth slowly but after growing it had retained in long time and it resisted from light shadow compared to *C. mucunoides* and *C. pubescent*. Furthermore *C. pubescent* had initial growth faster but it did not stay longer it did not resist from light shadow (Risza 1995).

## Total Biomass

Application of ameliorant significantly affected total wet weight of *C. pubescens*. However, *P. javanica* was significant effect only on shoot weight not for root. As shown on Table 2, application of compost was better treatment in increasing total wet biomass of two cover crops. Furthermore, compost application was able to increase ten times total wet biomass for *C. pubescens* and only four times for *P. javanica* compared to control.

*C. pubescens* was able to produce biomass 34.48 g pot$^{-1}$ and *P. javanica* 24.36 g pot$^{-1}$ if these crops were planted in non land mining. This yield was higher than in post mining which only produced 14.55 g pot$^{-1}$ for *C. pubescens* and 9.62 g pot$^{-1}$ for *P. javanica*.

## Total Dry Biomass

Total dry biomass was weighed by placing biomass in the oven with temperature 70 $^{o}$C for 48 hours. Effect of ameliorant application on total dry biomass is presented in Table 2.

As shown in Table 2 that application of compost had highest total dry biomass and it was able to increase total dry biomass six times for *C.*

Table 2. Average of biomass for two cover crops.

| Treatment | Biomass weight | | | |
|---|---|---|---|---|
| | Wet (g) | | Dry (g) | |
| | Shoot | Root | Shoot | Root |
| | ..........……*Centrosema pubescens*.……….…..... | | | |
| 100% s. tailing | 1.46 a | 0.41 a | 0.73 a | 0.28 a |
| 60% s. tailing + 40% min soil | 1.91 a | 0.54 a | 0.75 a | 0.24 a |
| 95% s. tailing+ 5% compost | 14.55 b | 2.06 b | 6.07 b | 1.07 b |
| | ..........……..*Pueraria javanica*.…….............. | | | |
| 100% s. tailing | 2.41 a | 0.95 | 0.72 a | 0.27 |
| 60% s. tailing + 40% min soil | 1.52 a | 0.26 | 0.54 a | 0.16 |
| 95% s. tailing+ 5% compost | 9.62 b | 1.42 | 2.71 b | 0.47 |

Values followed by same small letter in the same column are not significant by difference by Duncan 5%; a 100% tailing is used as a reference plot or control

Table 3. Average of N and P uptake by crops.

| Treatment | Nurient uptake on Shoot | |
|---|---|---|
| | N (mg crop$^{-1}$) | P (mg crop$^{-1}$) |
| | ..........…..*Centrosema pubescens*.................. | |
| 100% s. tailing | 1.76 a | 0.64 a |
| 60% s. tailing + 40% min soil | 2.01 a | 0.33 a |
| 95% s. tailing + 5% compost | 19.62 b | 7.89 b |
| | ….................*Pueraria javanica*.……….......… | |
| 100% s. tailing | 1.59 a | 0.47 a |
| 60% s. tailing + 40% min soil | 1.42 a | 0.29 a |
| 95% s. tailing + 5% compost | 9.70 b | 7.04 b |

Values followed by same small letter in the same column are not significant by difference by Duncan 5%; a 100% tailing is used as a reference plot or control

*pubescens* and three times for *P. javanica* compared to control (without ameliorant). However, mineral soil application was likely to decrease the biomass of two crops. Comparable effect was found when tailing was not incorporated by any amendment (Table 2).

**N and P uptake**

Nutrien uptake was calculated by multiplying concentration of nutrient with dry biomass. Results of N and P uptake are presented in Table 3. The highest N and P uptake was obtained by application of compost. Nutrient uptake is affected by many factors. Hakim *et al.* (1986) stated that all factors that affecting plant metabolism are also affecting nutrient uptake directly, this is due to energy produced by metabolism. One factor which can be considered affecting nutrient uptake is compost application. Application of compost resulted in the highest nutrient uptake of two cover crops used in this experiment. Nitrogen upatke of *C. pubescens* was 19.62 mg crop$^{-1}$ and for *P. javanica* was 9.70 mg crop$^{-1}$. Meanwhile, P uptake of *C. pubescens* was 7.89 mg crop$^{-1}$ and *P javanica* was 7.04 mg crop$^{-1}$. Higher availability of nutrient was obtained in tailing applied by compost than mineral soil that causing higher plant nutrient uptake. Compost was able to increase pH of tailing. Sudaryono (2009) mentioned that soil pH can affect the availability of nutrient and soil quality.

**Nitrogen and Phosphorus Content of Tailing**

Application of ameliorant significantly affected N and P of tailing. Results showed that N and P in plant media after harvesting increased compared to before planting. The higher increasing was found

Table 4. Average of N and P plant media after harvesting

| Treatment | Nutrient | |
|---|---|---|
| | N (g $kg^{-1}$) | P (mg $kg^{-1}$) |
| | ……*Centrosema pubescens......* | |
| 100% s. tailing | 0.1 a | 0.26 a |
| 60% s. tailing + 40% min soil | 0.3 b | 5.33 a |
| 95% s. Taiing + 5% compost | 0.2 b | 27.70 b |
| | ….......*Pueraria javanica…………* | |
| 100% s. tailing | 0.1 a | 0.26 a |
| 60% s. tailing + 40% min soil | 0.2 b | 5.32 a |
| 95% s. tailing + 5% compost | 0.2 b | 26.45 b |

Values followed by same small letter in the same column were not significant difference by Duncan 5%, 100% tailing is used as a reference plot or control.

when tailing was applied by compost. The increase of N ranged from 2–3 times compared to tailing without ameliorant (Table 4). However, N content obtained was in very low concentration (Pusat Penelitian Tanah 1983).

Increasing of P content was higher than N concentration. Prior to planting, P concentration was in very low content and changing in medium up to very high content (Table 4) as a result of P supply from compost. Phosphorus is immobil in soil, this is due to fixation process by oxide, clay mineral and organic material. Because of immobile in soil, P is easy to detect in soil (Setyorini and Ladiyani 2004). There was not increasing of N tailing, because N is more mobile compared to P. Suwandi (2009) stated that N is easy to lose from the soil through volatilisation or percolation by water, easy to change and easy to be absorped by crop. Nitrogen in $NO_3^-$ and $NH_4^+$ forms are soluble and lose to other zone due to not to binding by soil (Saptiningsih 2007). The low content of N tailing was also caused by N removal by crop. From this result it showed that N was more absorbed by cover crop compared to P.

Cover crop without ameliorant has not been able to increase nutrient of tailing. Planting of cover crop tendend to decrease nutrient of tailing. Nitrogen and P in original tailing before application of ameliorant were amounting to 0.1 g $kg^{-1}$ and 0.45 mg $kg^{-1}$, respectively (Table 1). However, after harvesting N value was similar (0.1 g $kg^{-1}$) but P value decreased (0.26 mg $kg^{-1}$) (Table 4). The decreasing of nutrient in tailing was due to absorbing of nutrient by crop for its growing. Application of ameliorant was needed to make better growth of cover crop. The better growth of crops will supply more nutrient to the soil due to decomposition of plant tissue which is falling down to the soil.

When the decomposition has done completely, *C. pubescens* without ameliorant will supply N as much as 1.76 kg $ha^{-1}$ per year and amounting to 0.64 kg $ha^{-1}$ per year for P. Moreover, *P. javanica* supplied N amounting to 1.59 kg $ha^{-1}$ per year and P 0.47 kg $ha^{-1}$ per year. Application of compost on *C. pubescens* increased N amounting to 19.62 kg $ha^{-1}$ per year and P 7.89 kg $ha^{-1}$ per year, meanwhile *P. javanica* supplied 9.70 kg N and 7.04 kg P $ha^{-1}$ per year. *C. pubescens* was able to produce organic material amounting to 40 Mg $ha^{-1}$ for 10 months which was equal to 41 kg N and 20 kg $P_2O_5$ if the soil and climate were condusively (Yani 2005).

## CONCLUSIONS

It can be concluded that compost application significantly improved growth of cover crop compared to mineral soil and control. Application of cover crop and compost was able to increase sorption of N and P significantly compared to mineral soil and control. Non significant effect was found when compost and mineral soil were applied to the tailing planted by cover crop. P content of tailing applied by compost was significantly higher than mineral soil and control. Application of compost on *C. pubescens* was able to supply N on tailing as 19.62 kg $ha^{-1}$ $yr^{-1}$ and P 7.89 kg $ha^{-1}$ $yr^{-1}$, mean while *Pueraria javanica* was 9.70 kg $ha^{-1}$ N and 7.04 kg $ha^{-1}$ P $yr^{-1}$.

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