

Research Article

The effect of application of oil palm empty fruit bunch compost on production and metal uptake of eggplant in tailings of post-tin mining land

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Abstract: Tailings of post-tin mining land have the potential to be cultivation fields for eggplant, but the problem from post-tin-mining land is the low essential nutrient and high metal contents. The quality of land needs to be improved by providing ameliorant such as oil palm empty fruit bunch compost. This research aims to determine the best dosage of oil palm empty fruit bunch compost to production and metal uptake of eggplant in post-tin mining land. This research was conducted from January to May 2019 in post-tin mining land, Dwi Makmur Village, Bangka. This research used a randomized block design with six treatments and four replications. Treatments consisted of organic fertilizer (control) of 15 t/ha (K0), oil palm empty fruit bunch compost 20 t/ha (K1), 30 t/ha (K2), 40 t/ha (K3), 50 t/ha (K4), and 60 t/ha (K5). The results showed that the application of oil palm empty fruit bunch compost of 60 t/ha was the best dose to increase eggplant production in the tailing of post-tin mining land. Application of oil palm empty fruit bunch compost reduced metal absorption of eggplant fruit in tailing of post-tin mining land.

Keywords: *ameliorant, post-tin mining, Solanum melongena, soil chemical characteristics, tailings*

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Introduction

Post-tin mining land caused by tin mining activity in Bangka Belitung provided tailing overlays in that area. Post-tin mining land in Bangka Belitung reached 124.838 ha in total (Sukarman and Gani, 2017). Most of the post-tin mining land was dominated by sand tailing, which has low water absorption and high sand fraction content that can reach 92 % (Inonu et al., 2011). Low nutrients and high metal content in tailing make it hard to utilize for plant cultivation. Metals that are mostly found in post-tin mining land are mercury (Hg), cadmium (Cd), lead (Pb), copper (Cu) and aluminium (Al) (Purwantari, 2007). Nowadays, communities are trying to utilize the post-tin

mining land into cultivation area. Many kinds of crop cultivar were planted in the post-tin mining area; one of them is eggplant. The challenge from plant cultivation, especially eggplant in post-tin mining land is a high requirement of organic material, fertilizer and possibility for the crops to become metal accumulator. General effort to increase growth and production of eggplant in post-tin mining land is the application of ameliorant to improve soil physical and chemical characteristics (Asmarhansyah and Subardja, 2012). Amelioration of sand tailing in post-tin mining land by using topsoil and organic material improved the quality of sand tailing characteristic and increased plant growth (Inonu et al., 2011).

Application of ameliorant, such as organic material can decrease metal content in contaminated soils (Gul et al., 2015). One kind of ameliorant that useful for cultivation in post-tin mining land is oil palm empty fruit bunch compost. Oil palm empty fruit bunch compost had essential nutrient for plant such as organic-C 35%, N 2.34%, C/N 15, P 0.31%, K 5.53%, Ca 1.46%, Mg 0.96%, and water 52% (Widiastuti and Panji, 2007). Bangka Belitung has vast oil palm plantation, so it possible to produce a high amount of oil palm empty fruit bunch that can be converted to compost and applied to post-tin mining land. Utilization of post-tin mining land for eggplant cultivation is an excellent way to improve the productivity of post-tin mining land. Ameliorant application is one solution to increase growth and production of eggplant in post-tin mining land. Identification of metal absorption in a plant is an important issue to get information about the ability of oil palm empty fruit bunch compost to decrease metal absorption in eggplant. Proper utilization of post-tin mining land can provide alternative cultivation land for community especially farmer and addition of organic material can increase eggplant growth and production and hopefully can decrease metal absorption in eggplant to provide food safety for the community.

This study aimed to know the effect of application various doses of oil palm empty fruit bunch compost on production and metal absorption of eggplant in tailings of post-tin mining land.

Materials and Methods

The study was conducted from January to May 2019 in the post-tin mining land of PT. Timah Tbk, Dwi Makmur Village, Bangka Regency, Bangka Belitung Province, Indonesia. Farming tools, digital scales, cameras, ovens, fabric meters, label paper, scissors, digital callipers, sprinklers, buckets, measuring cups and stationery were used in this research. The materials used were eggplant seeds mustang cultivar, polybag, oil palm empty fruit bunch compost, NPK 16:16:16 fertilizer, cow manure, topsoil, and pesticides. This study used a randomized block design (RBD). Treatment was application of ameliorant consisting of 6 levels i.e. K0 (control 15 t/ha cow manure), K1 (20 t/ha of oil palm empty fruit bunch compost), K2 (30 t/ha of oil palm empty fruit bunch compost), K3 (40 t/ha of oil palm empty fruit bunch compost), K4 (50 t/ha of oil palm empty fruit bunch compost), and K5 (60 t/ha of oil palm empty fruit bunch compost). Each treatment was repeated four times resulting in 24 experimental units. Each

experimental unit contained nine plants consisting of 5 plant samples from each experimental unit. The first step of this study was soil sampling in the experimental area. The method of soil sampling used was composite disturbed soil sampling techniques. A soil sample was taken by using a soil auger. Soil samples then analyzed in the laboratory to obtain soil nutrient and metal contents. Land preparation was done by clearing the land from weeds and rocks. Planting beds were made with size 2.6 m x 0.8 m and the distance between planting beds was 50 cm. Plant distance of eggplant was 60 cm x 60 cm. Planting holes with 30 cm deep and 30 cm high were made on planting beds. Compost and topsoil were mixed and applied into the planting holes according to treatment then let it stood for 1 week. Eggplant seedling of the age of 14 days after seedling was then transferred into the planting hole according to treatments. The eggplant maintenance included watering, fertilization, replanting, pruning, weeding, and eradicating plant pests and diseases. Harvesting was done when the fruit meet harvest physical characteristics such as fruit are healthy with a shiny purple colour (Bukhari, 2013).

Harvesting was conducted until the 3rd harvest. The parameters observed consisted of plant height (cm), number of leaves (sheet), stem diameter (mm), weight of fruit (g/ plant), diameter of fruit (mm), length of fruit (cm), number of fruits (fruit/plot), yield (g/plot), dry root weight (g), root volume (cm³), production (t/ha¹) and metals uptake that consisted of Al (mg/kg), Cu (mg/kg), and Pb (mg/kg) by eggplant fruit. Eggplant production data were analyzed using the F test at 95% of a significant level. If there were significant effects in treatments, further tests were conducted using the Least Significant Difference test (LSD) at 95% significant level. Soil nutrients and metals contents in the soil and eggplant fruit that consisted of Al, Cu and Pb were analyzed in the laboratory of PT. Global Quality Analytical. Soil nutrient analysis results were then adjusted to the soil chemical characteristics based on the Indonesia Soil Research Center (Balittan 2009). The results of metals analysis in eggplant fruit were adjusted to the standards of food metal contamination based on the Indonesian national standard (SNI) 7387:2009 (BSN 2009). Results of soil characteristic analysis in tailing showed that the experiment area has sand fraction content of 70.10% and it is categorized into sandy loam texture. Criteria of soil chemical characteristics were dominated from very low to moderate criteria, except for the K-potential parameter, which has very high criteria. Metal content criteria in tailing are below average (Table 1).

Table 1. Characteristic of tailing of post-tin mining land.

Analysis Parameter	Value	Criteria
Organic-C (%)	0.31	Very low
Total-N (%)	0.14	Low
C/N ratio	2.23	Very low
Available-P (ppm)	7.28	Very low
Total -P (ppm)	32.23	
Potential-P (ppm)	21.92	Moderate
Potential -K (ppm)	67.56	Very high
Ca (cmol/kg)	0.87	Very low
Mg (cmol/kg)	0.19	Very low
K (cmol/kg)	0.08	Very low
Na (cmol/kg)	0.06	Very low
Cation exchange capacity (cmol/kg)	2.80	Very low
Base Saturation (%)	42.86	Moderate
Al (mg/kg)	<1.00	-
Pb (mg/kg)	0.01	Below average
Cu (mg/kg)	0.01	Below average
Texture		
- Sand (%)	70.10	Sandy loam
- Silt (%)	27.04	
- Clay (%)	2.86	

Notes: Determination of soil characteristic criteria based on the Soil Research Center (Balittan 2009). Determination of soil metal criteria based on Alloway and Ayres (1995).

Results and Discussion

The results from an analysis of variance showed that the treatment of various doses of oil palm empty fruit bunch compost significantly affected plant height, number of leaves, stem diameter, fruit weight, fruit diameter, fruit length, a total of fruit, yield and root dry weight. The root volume parameter did not show a significant effect (Table 2). Oil palm empty fruit bunch compost is a

suitable soil ameliorant to be used in sandy tailing of post-tin mining land. According to Onggo et al. (2017), compost can improve soil physical characteristic, so it is easier for plant roots to grow and increase their ability to absorb nutrients optimally. Astralya (2009) reported that the use of compost as a growth medium is very suitable for improving the quality of soil physical, chemical, and biological properties and increasing available nutrients in the soil due to soil organisms activities. Oil palm empty fruit bunch compost contained high potassium nutrient (LKKT 2013). The present of fibre in texture and structure of oil palm empty fruit bunch compost makes compost not easily washed and has a higher capacity to store water in soil especially in sandy tailing such as post-tin mining land. Sembiring et al. (2015) reported that compost can improve soil structure, water-holding capacity, and soil chemical properties. Application of oil palm empty fruit bunch compost in post-mining land improves soil physical properties (Asmarhansyah and Subardja, 2012) and contains essential nutrients (macro and micro) (Amri et al., 2018) that can help plant growth and increase eggplant production. Plant height, stem diameter, and root dry weight of eggplant with treatment of 60 t/ha of oil palm empty fruit bunch compost has higher and significantly different than control treatment, 40 t/ha, 30 t/ha, and 20 t/ha of oil palm empty fruit bunch compost, but not significantly different from the 50 t/ha of oil palm empty fruit bunch compost. Number of leaves of eggplant in the treatment 60 t/ha of oil palm empty fruit bunch compost was significantly higher than that in the control, 30 t/ha and 20 t/ha of oil palm empty fruit bunch compost treatment but it was not significantly different from the treatments of 50 t/ha and 40 t/ha of oil palm empty fruit bunch compost (Table 3).

Table 2. Analysis of variance of application various doses of oil palm empty fruit bunches compost to growth and production of eggplant.

Variable	F-value	Pr > F	KK (%)
Plant height (cm)	19.15	<0.0001*	10.15
Number of leaves (sheet)	14.46	<0.0001*	18.77
Stem diameter (mm)	23.48	<0.0001*	9.27
Fruit weight (g/plant)	6.33	0.0011*	28.71
Fruit diameter (mm)	6.84	0.0051*	12.41
Fruit length (cm)	9.93	0.0011*	8.75
Total of fruit (fruit/plant)	37.62	<0.0001*	7.76
Yield (g/plot)	13.51	0.0002*	18.79
Root dry weight (g)	4.62	0.0099*	34.02
Root volume (cm ³)	2.62	0.1082 ^{tn}	42.29

Note: Pr > F (probability), * (significant effect), tn (no significant effect), KK (coefficient of diversity).

Oil palm empty fruit bunch compost can improve the characteristic of physical, chemical and biological of soil. Compost can improve soil physical characteristic, so it is easier for plant roots to grow and increase their ability to absorb nutrients optimally (Onggo et al., 2017). Oil palm empty fruit bunch compost contains macro and micronutrients that are essential for eggplant so that it can help the growth of eggplant cultivated in post-mining land. Research from Abbasi et al. (2012) showed that the combination of soil and compost increased the mineralization of soil N-organic and release high amounts of available N so it can stimulate plant growth. According to Hidayat et al. (2013), the availability of N in sufficient quantities will help plant metabolism and improve the growth of plant organs such as stems, leaves, and roots.

Fruit weight, fruit diameter and fruit length of eggplant with treatment 60 t/ha of oil palm empty fruit bunch compost were significantly higher than those in the control, 30 t/ha and 20 t/ha of oil palm empty fruit bunch compost treatment but they were not significantly different from treatments of 50 t/ha and 40 t/ha of oil palm empty fruit bunch compost. The yield of eggplant with treatment of 60 t/ha of oil palm empty fruit bunch compost was significantly higher than that in the control 40 t/ha, 30 t/ha and 20 t/ha of oil palm empty fruit bunch compost but it was not significantly different from treatment of 50 t/ha of oil palm empty fruit bunch compost. Total of fruits with treatment of 50 t/ha of oil palm empty fruit bunch compost was significantly higher than that in the control, 30 t/ha and 20 t/ha of oil palm empty fruit bunch compost treatments but it was

not significantly different from the treatments of 60 t/ha and 40 t/ha of oil palm empty fruit bunch compost (Table 3). Application 60 t oil palm empty fruit bunch compost/ha has a better result than that of 20, 30, 40 and 50 t/ha. This was probably due to a higher supply of essential nutrient from 60 t/ha of oil palm empty fruit bunch compost than other treatments. The tailing soil is dominated by a sand fraction that causes low fertility so it requires a high amount of compost as organic material. Application of a high dose of oil palm empty fruit bunch compost can improve the quality of soil structure and help plants to uptake more essential nutrients (Hidayat et al., 2013).

In general, 60 t oil palm empty fruit bunch compost /ha gave higher result than a lower dose of oil palm empty fruit bunch compost treatment. There was a tendency that a higher dose of oil palm empty fruit bunch compost made growth and production of eggplant higher. Based on the yield parameter, the highest calculated production of eggplant (6.87 t/ha) was obtained by treatment 60 t/ha of oil palm empty fruit bunch compost. The lowest calculated production (2 t/ha) was obtained by the treatment of cow manure (control) (Table 3). Production of eggplant that was cultivated in post-tin mining land with application of oil palm empty fruit bunch compost reached 6.87 t/ha at a dose 60 t/ha. Even though the dose of 60 t/ha gave the highest production, the production was still lower than the potential yield of eggplant in agricultural land that can reach 50 – 60 t/ha. Production of eggplant cultivated in tailing post-tin mining land still below the production of eggplant planted on agricultural land.

Table 3. Growth and production parameters of eggplant with various doses of oil palm empty fruit bunch compost in post-tin mining land.

Parameters	Treatments											
	K0		K1		K2		K3		K4		K5	
Plant height (cm)	9.4	d	15.0	c	15.1	c	16.5	bc	18.7	ab	18.9	a
Number of leaves (sheet)	9.2	d	23.6	c	26.2	bc	30.5	ab	32.2	ab	35.5	a
Stem diameter (mm)	4.7	d	7.9	c	8.5	bc	8.5	bc	9.5	ab	9.9	a
Root dry weight (g)	5.1	b	7.1	b	7.1	bc	9.5	ab	13.8	a	12.2	a
Total of fruit (fruit/plant)	1.0	d	1.9	c	2.0	c	2.1	abc	2.2	a	2.2	ab
Fruit weight (g/plant)	139.9	c	530.9	b	602.4	bc	684.9	ab	876.5	a	900.6	a
Fruit diameter (mm)	26.3	c	33.2	b	32.9	bc	37.1	ab	41.6	a	40.8	a
Fruit length (mm)	15.0	d	17.6	c	18.1	c	20.3	ab	21.5	a	21.8	a
Yield (g/plot)	417.3	d	996.5	c	1004.8	c	1110.5	bc	1388.8	ab	1428.5	a
Root volume (cm ³)	23.5		32.0		33.0		41.8		56.0		58.3	
Production (t/ha)	2.01		4.79		4.83		5.34		6.68		6.87	

Notes: Numbers followed with same letters on the same line show no significant difference based on the LSD test with 95% significant level. K0 (control), K1 (20 t/ha), K2 (30 t/ha), K3 (40 t/ha), K4 (t/ha), K5 (60 t/ ha).

Differences in eggplant growth and production between sandy tailing and agricultural land might be influenced by environmental factors. Lakitan (2010) reported that higher or lower crop production caused by the ability of plant adaptation to adapt to the environment. Application of oil palm empty fruit bunch compost reduced metal content, especially lead (Pb) in eggplant fruit (Table 4). The highest Pb metal content 0.4 mg/kg was found in the control treatment. Application of oil palm empty fruit bunch compost decreased Pb content in eggplant fruit became less than 0.002 mg/kg. Oil palm empty fruit bunch compost has not yet affected in the reduction of Al and Cu in eggplant fruit cultivated in post-tin mining land (Table 4). The application of oil palm empty fruit bunch compost has proven to reduce the metal uptake by plants, especially Pb metal. Gul et al. (2015) state that compost as an organic material can reduce the potential for metal absorption by plant tissue. According to Tan (2011), compost consists of organic material containing lignin, amino acids, and carbohydrates that can react in the soil through the humification process to form humic compounds. Humic compounds can reduce metal content in soil by binding the excess free metal in soil with metal chelation process so that it can reduce metal content in the soil.

Table 4. Metal (Al, Pb and Cu) concentration in eggplant fruit.

Treatments	Metal Concentration (mg/kg)		
	Al	Pb	Cu
K0	<0.05	0.40 (-)	0.47 (-)
K1	<0.05	<0.002 (-)	2.12 (-)
K2	<0.05	<0.002 (-)	1.53 (-)
K3	<0.05	<0.002 (-)	2.64 (-)
K4	<0.05	<0.002 (-)	0.20 (-)
K5	<0.05	<0.002 (-)	1.03 (-)

Notes: The sign (-) means that metals contained in fruit organs have levels below the standard. The maximum of Pb for food based on SNI 7387: 2009 is 0.5 mg/kg. Cu standard for food based on WHO (1976) is a maximum of 20 mg/kg. K0 (control), K1 (20 t/ha), K2 (30 t/ha), K3 (40 t/ha), K4 (t/ha), K5 (60 t/ha).

Conclusion

Application of 60 t oil palm empty fruit bunch compost/ha yielded the highest eggplant production compared to other treatments in post-tin mining land. Application of oil palm empty fruit bunch compost reduced the metal uptake, especially Pb in eggplant fruit cultivated on post-tin mining land.

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