ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Growth of Seedlings of Three Perennial Crops on Gold Mine Soil Amended with Organic Waste in Bombana, Southeast Sulawesi.

Darwis[a], Asrul Sani*[b], Suaib[a], Dirvamena Boer[a], Syamsu Alam[a], and Yuni Trihewindati[c].

[a]Department of Agrotechnology, Faculty of Agriculture, Universitas Halu Oleo, Kendari 93232, South-east Sulawesi, Indonesia.
[b]Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Halu Oleo, Kendari 93232, South-east Sulawesi, Indonesia.
[c]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Terbuka, Jakarta, Indonesia.

ABSTRACT

Gold mining activity in Bombana district plays an important role in providing employment. However, it significantly influenced physical and chemical soil properties. This study investigates the effect of organic waste amendment on the growth of seedlings of three perennial crops; *Anthocepalus cadamba*, *Tectona grandis*L.*f*, and *Gmelina arborea*, on gold mine soil. Five soil samples were taken from different locations, air-dried, sieved and uniformly mixed to form a composite sample. A split-plot design with three replications was applied in this experiment. The main plot was seedlings of the crops. Subplot was organic waste amendment; biogas manure, layer manure and rice straw. Each organic amendment (with 50 g, 100 g, and 150 g ploybag^{-1}) was added with 25 g of *Trichoderma, sp*. to all treatments. The result shows that the application of organic waste amendment up to 50 g has significantly affected on the growth of all crops compared to the control. *G.arborea* has a good performance on plant height, length of leaf and number of leaves for severely degraded soil. Biogas manure was effective for *G.arborea* growth, while layer manure and rice straw were effective for *T.grandis*L.*f*. and *A.cadamba*. *A.cadamba* seems more sensitive to water stress than *G.arborea* and *T.grandis*L.*f*.

Keywords: Gold mining, organic waste, seedlings growth, trichoderma sp.

Corresponding author

INTRODUCTION

In September 2008, the local communities discovered gold deposits in several locations in Bombana District, such as Tahi Ite and Wumbubangka river, and transmigration sites (SP8 and SP9). Because gold has a high economic value, this mining activity was instantly create a new jobs for a thousand of Bombana's and surrounding communities, even the miners from outside of Southeast Sulawesi were coming to Bombana. Gold mining activities in Bombana were done in a very traditional ways, for instance, excavation and tunneling regardless the severity and so many workers were buried.

The separation process of gold ore with other materials was carried out in the river or another place with the amalgamation method using liquid metal, namely mercury (Hg). So that mining activities trigger the soil physical damage due to loss of top-soil, periodic sheet erosion, lack of vegetation, loss of biodiversity [1], absence of soil-forming fine materials, and shortage of essential nutrients [17-18] and more dangerous is the spread of mercury to the further areas through the river an drain water [10].

Therefore, the restoration of the severely degraded soil due to gold mining activities is urgently needed. One of the applicable method and more familiar in term of communities is revegetation that can protect soil erosion and stabilize the heavy metal in the soil.

The plant species used of course should be non-edible and which can be grown abundantly in a large scale on gold mine soil. Regarding all the plants available among non-edible trees, *Anthocepalus cadamba* (burflower-tree), *Tectonagrandis*L.*f* (Teak) and *Gmelina arborea* (beechwood) have selected for this experiment. These perennial crops well known grown in Bombana District and used as a rehabilitation plant. Currently it was lack information concerning the effectiveness of these species to protect hazard erosion on severely degraded soil.

Organic materials have been long known could be improved physical, chemical and biological properties of soil [20]. Some studies found that the addition of organic amendment, such as pig manure, layer manure, and sewage sludge was very effective in lowering the toxicity of metals in the soil and provide nutrients such as N, P, and K for plant growth [7, 19]. In the present experiment, we applied three organic amendments, i.e. biogas manure, layer manure and rice straw. Hence, the main objective of the present study was to investigate the growth of seedlings of perennial crop on the severely degraded soil amended with different organic waste in polybag experiment. It was hoped that this research would aid establishing suitable trees and organic amendment for rehabilitation of gold mine soil.

MATERIAL AND METHOD

Study site and design

The experiment was performed in a green house using gold mine soil from Bombana District, Southeast Sulawesi. Mining activity at this location employs very simple technologies, for instance, excavation and tunneling, and the separation of gold ore using amalgamation method. Split-plot design with three replications was applied in this experiment. Main plots consisted of three species of perennial crops, namely *A.cadamba, T.grandis* L.*f*, and *G.arborea* and the subplots consisted of three type of organic amendment; biogas manure, layer manure, and rice straw chopped at 3 cm long. Organic waste amendment applied at the rate of 50 g, 100 g, and 150 g polybag^{-1}.

Soil sampling and analysis

The soil used in the experiment was collected from gold mine area in Tahi Ite Village, sub district of East Poleang, the District of Bombana. Five soil samples from different area were taken at 0 – 30 cm soil depth. These soil samples were air-dried, sieved through a 2 mm mesh sieve and uniformly mixed to form a composite sample. Soil texture, bulk density and porosity were determined according to the procedures in [9]. The soil pH was measured using glass electrode pH meter in a 1:2 soil-water ratio. Soil organic C was determined by the procedure of Walkley and Black by wet oxidation using chromic acid digestion [12]. Total N content was determined by the Kjeldhal method [5], total P by Bray I method [4], total K by atomic absorption spectrophotometer (AAS) after digestion with Na_2CO_3. The cation exchange capasity (CEC) was extracted with 1M NH_4Oac (buffered at pH 7.0), and exchangeable base concentrations were measured using AAS.

Experimental procedures

This experiment used polybag sized 20 cmx 20 cm. Before transplanted, in each polybag was filled 2 kg of soil mixed with organic amendment and added to 25 g of *Trichoderma* sp. and incubated for one month in laboratory conditions. Two months old healthy seedlings of *A.cadamba, T.grandis*L.*f*. and *G.arborea*were were transplanted to the experimental polybags with three replications. During the experiment, the plants were watered daily avoiding plant water stress. The growth of plants (plant height, length of leaf, and number of leaves) in each polybag was recorded at 14, 28, 42, and 56 days after transplanted.

Statistical Analysis

The data were subjected to two-way factorial analysis of variance and contrasts test was used to detect possible differences among group of the different treatments [15].

RESULT AND DISCUSSION

Soil characteristic

The result of study revealed that gold mine soil has a relatively high bulk density, which ranged from 1.42 to1.80 g cm^3, soil water content of about 31.91 to46.45%, the porosity of the soil around 28.97 to 31.57%. The soil tended to be compacted due to gold mining activities. The soil texture tended to be sandy clay loam with high level of sand fraction ranging from 41.58 to 60.93% (Table 1), whereas it has a low clay content. This condition was different from the nature of Vertisols that have a clay content of at least 30%. In alluvial soil, clay content can reach 83%. This might be due to that mining activities has raised the subsoil to soil surface.

Table 1. Physical characteristics of gold mine soil in Bombana

Sample Code	Soil physical parameter						
	Bulk density (g/cm^3)	Water content (%)	Soil porosity (%)	Distribution of soil particle			
				Sand (%)	Silt (%)	Clay (%)	Texture class
L1A	1.74	34.23	28.97	59.95	20.34	19.71	Sandy clay loam
L2A	1.60	39.53	31.57	60.69	19.87	19.44	Sandy clay loam
L1B	1.80	31.91	26.97	60.93	19.64	19.43	Sandy clay loam
L2B	1.42	46.45	20.49	41.58	38.86	19.56	Silt loam

Table 2. Chemical characteristics of gold mine soil in Bombana

Sample code	Soil chemical characteristics							
	pH H_2O	pH KCl	C-org (%)	Total-N (%)	Potential-P mg/100g	Potential-K mg/100g	CEC me/100g	Base saturation (%)
L1A	7.40	3.87	3.91	0.25	9.89	19.89	27.33	49.50
L2A	7.53	5.81	1.70	0.21	8.96	13.98	21.37	52.78
L1B	7.60	5.07	1.32	0.28	7.87	18.18	19.89	57.48
L2B	7.56	5.93	4.46	0.32	14.99	28.45	28.74	60.24

The range of the soil pH was 7.4–7.60 (Table 2) which indicated that the soil was neutral. Soil organic carbon varied at four sampling point, ranging from 1.32 to 4.46% (Table 2). The highest level of organic carbon was obtained at the sampling point L2B with a value of 4.46%. This difference may be caused by differences in land cover and soil sample form post mining site. Potential P content (P_2O_5 in HCl 25% 1 N) is low, while the level of total-N and potential K (extraction HCl 25%) were moderate, except potential K at sampling point L2B is high. Low level of P content in all sampling points might be due to poor soil parent material. Caption exchange capacity of the soil is low with ranging from 20 to 30 meq$100g^{-1}$. The similar indication was reported in Southern region of Costa Rica by [6] that from the four sites of their experiment, the soil pH range and soil acidity saturation, bulk density, and CEC, varied according to the sites. Percentage of base saturation is moderate, with a value from 49.5 to 60.24% as shown in Table 2.

Plant height

The results revealed that no interaction between the species of seedlings of perennial crop with the type of organic amendment at various levels on plant height (Figure 1). Plant height is significantly affected by the species of seedlings (Pr>F: 0.0008). The growth of *G.arborea* is faster than *A.cadamba,* and *T.grandis*L.*f*, but not between *A.cadamba* and *T.grandis* L.*f*. The plant height of *G.arborea*, *T.grandis* L.*f.* and *A.cadamba* over 56 days of the experiment was 36.56 cm, 12.29 cm, and 10.87 cm, respectively. This suggested that the best adaptation to the severly degraded soil of the three tree seedlings was *G. arborea.* Compared to the field experiment of Onefeli and Adesoye (2014) in Nigeria showed that after a month of assessment, *G. arborea* increased in height for 7.03 cm and was the highest of all the species. It was followed by *K. grandifolia* (2.76 cm), *A. africana* (1.49 cm), *K. Senegalensis* (1.23 cm) and *T. grandis* (0.7 cm), which had the least height growth. This was indicated that growth of several trees spesies in manipulated environments showed the increasing of plant heights around two to seven times than that of in natural growth of seedling experiment.

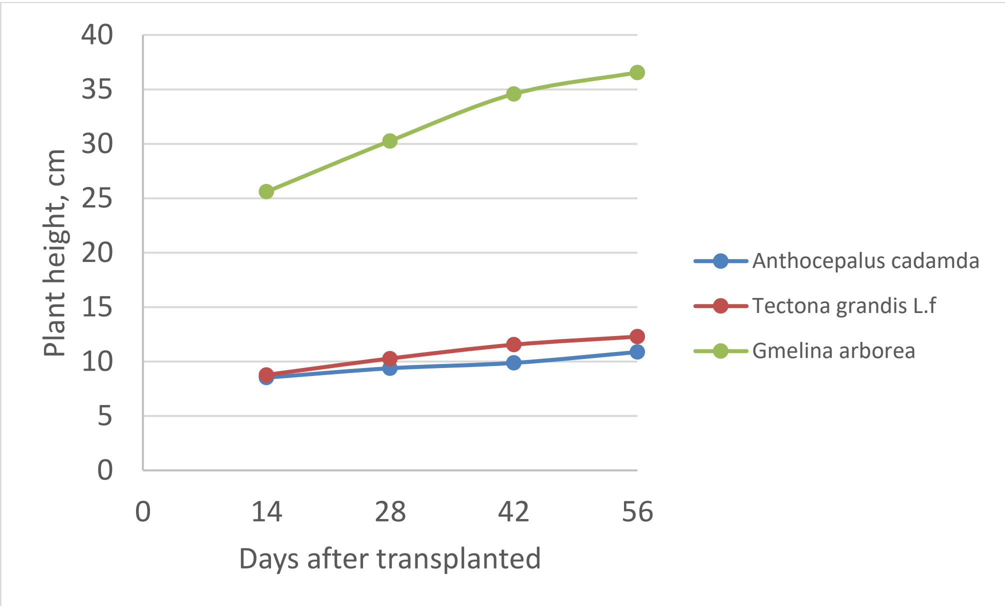

Figure 1. Plant height of seedlings of perennial crop after 56 days experiment

It was observed that the type of organic amendment did not affect significantly the growth of seedlings of perennial crops, but the combination of all organic amendment (biogas manure, layer manure and rice straw) influenced significantly the growth of *G.arborea* compared with check, while no significant difference observed in *A.cadamba* and *T.grandis* L.*f*. This important finding indicated that *G.arborea* was the best response to the severly degraded soil. As reported by Wasis and Fathia (2010), the combination between NPK and compost in the respective dosage of 10 and 30 grams was the highest growth as indicated the plant height of tested seedlings were affected significantly in response to the control (without NPK and compost either in singly or in combination). According to [1] even the *G. arborea* and *T. grandis* have exposed to the 1,0 and 5,0% levels of contaminated soils the plant height, number of leaves, and leaf area were not significantly different from the seedlings planted to the uncontaminated soils. The species is moderately adaptable and survives well on a wide range of soil types: acid soils, calcareous loams, and lateritic soils.

Length of leaf

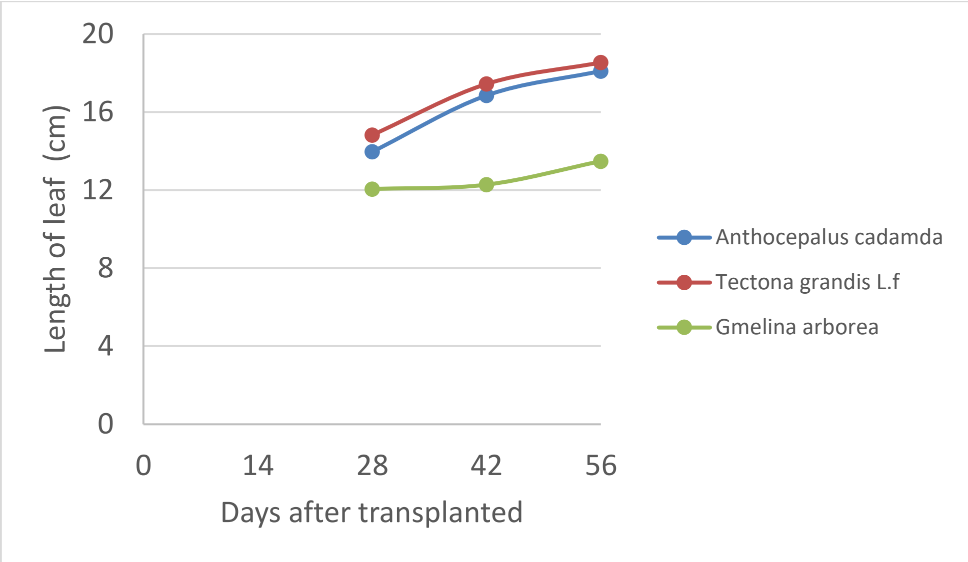

Figure 2. Length of leaf of perennial crop after 56 days experiment

It was observed that no interaction between species of seedlings of perennial crop with the type of organic amendment at various levels on length of leaf tested on severely degraded soil. We did not found also the difference effect between the type and the rate of organic amendment on length of leaf. The species of seedlings of perennial crop, however, affected significantly the width of leaf (P>F: 0.0404). Morphologycally, in particular in the length of the leaf, the difference of the three kinds of tree seedlings was due to the diferencies of their genetical factors encoding this character. According to [2, 8, 11, 14], the differencies between individual plant either in the same or in the different species were due to the differencet of genetical arrays that constituting the plant.

Contrast test showed the significant difference between *A.cadamba* with *G.arborea*(P>F: 0.0207), and *T.grandis* L*.f* .with *G.arborea* (P>F: 0.0353), but not in *A.cadamba* and *T.grandis* L*.f.* The length of leaves of *G.arborea* relatively shorter than *T.grandis* L*.f.* and *A.cadamba*, while no significant difference observed in *A.cadamba* and *T.grandis* L*.f*. The length of leaf of *A.cadamba*, *T.grandis L.f.*and *G.arborea* was 18.10 cm, 18.54 cm, and 13.48 cm, respectively.

Number of leaves

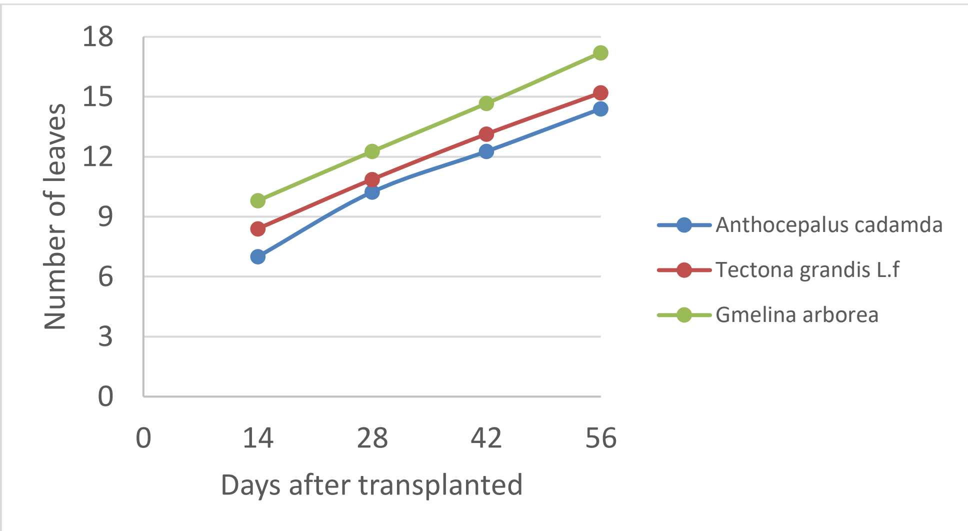

Figure 3. Number of leaves of seedlings of perennial crop after 56 days experiment

The seedlings number of leaves of perennial crop growing in different type and rate of organic amendments are presented in Figure 3. It was observed that no interaction between species of seedlings of perennial crop with the type of organic amendment at various levels on the number of leaves, while the species of perennial crop seedlings was affecting significantly the number of leaves obtained. The number of leaves of *G.arborea*, *T.grandis* L.*f.* and *A.cadamba* was 18.10, 18.54, and 13.48, respectively. These results suggested that *G.arborea* was the best response to the severely degraded soil. The similar results were reported by [13] that *G. arborea*, *Khaya senegalensis*, and *Afzelia africana* have showed that these three species statistically have the equal number of leafs after treatment for five months experiment.

Contrast analysis showed that the combination of all organic amendments significantly enhanced the growth of three species of perennial crop (P>F:0.0500). It was also observed the difference effect of biogas manure with layer manure, and layer manure with rice straw was in burflower-tree.This means that the differences between the three kinds of organic manure on growth of seedlings was caused by the different nutrient content in between them.

CONCLUSIONS

Polybag experiments have demonstrated that different organic amendment such as biogas manure, layer manure, and rice straw are effective on growth of three species of perennial crops in gold mine soil. The results also showed that biogas manure was effective to enhance the growth of *Gmelina arborea*, while layer manure and rice straw have any great influence on growth of *Tectona grandis* L.*f.* and *Anthocepalus cadamba*. The present study demonstrated that gold mine soil can be restored with concomitant use of organic amendment and suitable perennial crops.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Halu Oleo University for their financial assistance over the experiment. Special thanks are addressed to Wildan for technical assistance throughout the study.

REFERENCES

[1] Agbogidi OM, ED, Dolor, and EM Okechukwu, 2007. Evaluation of *Tectona grandis* (Linn.) and *Gmelina arborea* (Roxb.) for phytoremediation in crude oil contaminated soils. Agriculturae Conspectus Scientificus, 72(2): 149-152.

[2] Allard, R.W., 1960. Principles of plant breeding. John Wiley and Sons, New York.

[3] Bradshaw, AA. 1993. Understanding the fundamentals of succession. In: Miles, J., Walton, D.H. (Eds.). Primary Succession on Land. Blackwell, Oxford.

[4] Bray RH and Kurtz LT. 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Sci. 59. 39 – 45.

[5] Bremner JM and CS Mulvaney. 1982. Nitrogen Total p. 595 – 624. In: A.L. Page (Ed) Methods of soil analysis. Part 2. 2nd Eds. Agron. Monogr. 9. ASA and SSSA. Madison. WI.

[6] Calvo-Alvarado JC., D. Arias and DD Richter, 2007. Early growth performance of native and introduced fast growing tree species in wet to sub-humid climates of the Southerh region of Costa Rica. Forest Ecology and Management, 242: 227-235.

[7] Chiu KK, ZH Ye, MH Wong. 2006. Growth of Vetiveriazizanioides and Phragmitiesaustralis on Pb/Zn and Cu mine tailing amended with manure compost and sewage sludge. A greenhouse Study. Bioresource. Technol. 97. 158 – 170.

[8] Fehr WR., 1993. Principles of cultivar development. Volume 1 Theory and Technique. Macmilllian Publishing Company, New York, Ames Iowa, USA.

[9] Klute A. 1986. Methodes of soil analysis-Part 1. Physical and Mineralogical Methods. 2nd. American Society of Agronomy and Soil Science Society of America. Agronomy Series 9. Madison, WI, 1188p.

[10] Kumar GP, SK. Yadav, PR. Thawale, SK. Singh, and AA. Juwarkar. 2008. Growth of Jatropha curcas on heavy metal contaminated soil amended with industrial wastes and Azotobacter – A greenhouse study. Short Communication. Bioresour. Technol. 99. 2078 – 2082.

ISSN: 0975-8585

[11] Lauridzen EB and ED Kjaer, 2002. Provenance research in *Gmelina arborea* Linn., Roxb. A summary of results from three decades of research and a discussion of how to use them. International Forestry Review, 4(1): 1-15.

[12] Nelson DW and LE. Sommers. 1982. Total carbon, organic carbon and organic matter. p. 539-579. In: A.L. Page (Ed) Methods of soil analysis. 2ndEds. ASA Monograph. 9 (2). Amer. Soc. Agron. Madison. WI.

[13] Onefeli AO and PO Adesoye, 2014. Early growth assessment of selected exotic and indigenous tree species in Nigeria. South-East European Forestry, 5(1): 45-51.

[14] Poehlman JM and DA Sleper, 2006. Breeding filed crops. John Wiley and Sons, New York.

[15] Steel RGD, and JH. Torrie. 1980. Principles and Procedures of Statistic. 2nd Eds. McGraw-Hill, New York.

[16] Wasis, B and N. Fathia, 2010. Pengaruh pupuk NPK dan kompos terhadap pertumbuhan semai *Gmelina* (*Gmelina arborea* Roxb.) pada media tanah bekas tambang emas (tailing). Jurnal Ilmu Pertanian Indonesia, 16(2): 123-129. In Indonesian.

[17] Wong J.W.C., Q. Chen, FS. Zhang, MH. Wong, AJM. Baker. 1999. Phytostabilization of mimicked cadmium contaminated soil with lime amendment. In: Proc. 5thInt. Conf. Biogeochem. Trace Elements. Vienna, July. 1999.

[18] Wong MH.,CY Lan, L Gao, HM Chen. 1999. Current approaches to managing and remediating metal contaminated soils in China. In: Proc. 5th Int. Conf. Biogeochem. Trace Elements. Vienna, July. 1999.

[19] Wong MH. 2003. Ecological restoration of mine degraded soils, with emphasis on metal contaminated soils. Chemosphere. 50. 775 – 780.

[20] Ye ZH, JWC Wong, MH Wong, CY Lan, and AJM Baker. 1999. Lime and pig manure as ameliorants for revegetating lead/zinc mine tailings: a greenhouse study. Bioresour. Technol. 69, 35 – 43.