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The benefit of top soil and fertilizer mixture to improve the ex-coal mining land

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Abstract. *Sopialena, Rosfiansyah, Sila S. 2017. The benefit of top soil and fertilizer mixture to improve the ex-coal mining land. Nusantara Bioscience 9: 36-43.* The mining activities have led severe impacts on some environmental issues including a decrease in soil fertility, which affects the ability of soil to supply soil nutrients to growing plants, a destruction in soil structure, and the loss of microorganisms, which are important for reforming process to treat organic materials. In this regards, reclamation of mined degraded land has been continually used to improve soil structure and its microorganisms. In practice, for large scale reclamation, fertilizer use can primarily enhance soil qualities in improving plant's growth and yield. It is suggested that healthy soil should contain millions of microorganisms at the aggregation which leads to the improvement of soil nutrients and its structure, as the medium for plant growth. For this purpose, therefore, this study aimed to determine the impact of organic fertilizer (Ostindo) and top soil mixture on microbial diversity, soil fertility and the growth of sengon (*Paraserianthes falcataria* L. Nielsen). This study made use of a randomized block design, using four treatments and five replications including P0: without top soil and fertilizer, P1: with top soil but without fertilizer, P2: without top soil but with fertilizer, P3: mixture of top soil and fertilizer. The results showed that a mixture of top soil and fertilizer has successfully increased in the number of fungal genus, starting from two genus *(Phytium* and *Penicillium)* turning into five genus *(Phytium, Fusarium, Penicillium, Aspergillus,* and *Rhizoctonia),* as well as in the number of nematode genus, from two (*Dorylaimus* and *Rhabditis*) turning into five genus (*Dorylaimus, Steinernema, Dorylaimus, Hoplolaimus,* and *Mononchus*). This study indicated that the mixture has significantly improved soil health in ex-coal mining land, which was viable through the pH level (almost neutral), the significant increase of C, N and P_2O_5 , and also the growth of Sengon. In conclusion, this study succeeds in demonstrating that the mixture of top soil and fertilizer has enhanced the microbial diversity, soil fertility, and sengon growth.

Keywords: Bacteria, coal mining, fungal, Ostindo soil microorganisms, nematode

INTRODUCTION

East Kalimantan has had a long reliant on fossil fuels for decades. For East Kalimantan solely, fossil fuels such as coal have provided economic benefits and played a significant role to Indonesian national income. However, the coal industry also imposes some costs, such as public infrastructure expenses, and in particular, to environmental impacts mostly because of its operation. In general, an opening mine process involves forest logging, eroding soil layers (which may cause erosion), the formation of sinkholes (dredging), and backfilling. This process can severely create environmental damages, which ultimately harm the fertility of the soil as the natural medium for plant growth. In the cause of stripping and stockpiling, soil fertility decreases as a result of the removal of cover plants, which add litter and protect the soil. In addition, such mining activities might also produce the destruction of the ability of soils to be infiltrated by water and to resist erosion. These initial environmental problems will lead to wider aspects, such as the decrease of soil productivity, soil compaction, sedimentation, the movement of soil or avalanche, disturbance to the security and health of the population, disruption of flora and fauna, as well as the microclimate change.

It is common practice in Indonesia including East Kalimantan to use open-pit-mining in the coal industry, as one of the forms of mining to extract strategic minerals from the Earth. It often involves the scalping of the vegetation through land clearing, topsoil removal, stripping/overburden removal, coal cleaning and its mining process. Each phase in this process is believed to be associated with different sets of environmental damage covering physical, chemical and biological effects to mining land. As mentioned by Sudiana (2002), the ex-mining area could be classified as degraded land, referring to the land that loses its natural productivity due to a decrease in land quality, from the point of view of agriculture land usage.

The degraded land of the ex-mining area comprises the deterioration of the physical and chemical properties of the soil, a drastic species reduction in some flora, fauna and soil microorganisms. The poor land quality causes the decline in soil fertility and leads to a more compacted structure, which physically affects its capability of performing penetration, a condition which is unfavorable for the plant to grow. For this purpose, it is critical in restoring mined lands to repair the soil quality through a reclamation process, or even to improve the land productivity after surface mining. As an important part to

remediate the land degradation, there are many methods of reclamation, such as revegetation, and improving land quality by using fertilizer to increase essential nutrients and reach the optimum of pH levels by adding an appropriate amount of lime based on the soil type and intended pH, as well as the use of microbes for soil rejuvenation. The objective of the treatments is to enhance soil health and quality.

Soil quality is defined as the *'continued capacity of soil to function as a vital living system, within an ecosystem and land used boundaries, sustain biological productivity, to promote the quality of air and water environments, and to maintain plant, animal, and human health'* (Doran and Safley 1997). Quantifying soil health is important to identify the ecosystem services provided by soil, as a living space for the biota, which brings the benefits for humans. In this regards, though it may be difficult to quantify, however, there are necessity and possibility to measure soil function directly through the relevant indicators. At last, the ecosystem services can be regarded as a considerable value (Costanza et al. 1997), which include soil functions to store and release water, decomposing plant and animal residues, transforming and recycling nutrients, sequestering and detoxifying organic toxicants, and promoting plant health by suppressing plant-pathogenic microbes and phytophagous fauna. Further, Jenkinson and Powlson (1976), and also supported by Doran and Parkin (1996) mentioned that the criteria of indicators needed to measure soil quality and health were mainly related to their utility in defining ecosystem processes and integrating physical, chemical, and biological properties, their sensitivity to management and climatic variations, and their accessibility and utility to agricultural specialists, producers, conservationists, and policy makers.

Regarding microbes for soil rejuvenation, it is suggested that soil microbes in Ostindo fertilizer mixture can stimulate the vast array of soil microorganisms to rejuvenate the poor quality of ex-mining land into a fertile state. The microbes work by stimulating microbial activity and providing immediate nutrients to help in revamping and fragmenting the host rocks into soil form. In the end, this activity will lead to the improvement of soil structure and its fertility by enhancing aeration conditions, which are needed for root respiration. In addition, soil microbes can also enhance the plant growth by making nutrients and minerals in the soil to be available for plants. It is clear that microbes can serve as an indicator of soil health and quality. As the total number of microbes has a peculiar relation to soil quality, thus, the more microbes are available in the soil, the better the soil is. This idea has been grounded by Elsas and Trevors (1997); Doran and Safley (1997) who stated that soil microbial diversity could be used as an indicator to determine the health of the environment on land re-vegetation coal mines. The existence of microbes in the soil has naturally had a role in maintaining the function of soil and the control of its productivity, a key in various life processes of land, such as the formation of soil structure, organic matter decomposition, transforming toxic substances, and cycles of C, N, P and S.

Taking into account the degraded ex-mining land, and the benefits of the fertilizer use to increase soil fertility, this study considered that there is a need to identify the effect of the mixture of fertilizer and top soil in enhancing the recovery of coal mined lands. This study was aimed to (i) determine the effect of a mixture of organic fertilizer Ostindo to the development of soil microorganism, soil fertility and plant growth of sengon (*Paraserianthes falcataria* L. Nielsen), and (ii) determine the diversity and population of soil microorganisms and their role in the land after coal mining.

MATERIALS AND METHODS

Materials

The material used in this research were Ostindo fertilizer, lime, chicken manure, husks, sugar, 70% alcohol, distilled water, cotton, media of NA, media of PDA, aluminum foil and sengon plant (*Paraserianthes falcataria* L. Nielsen). Ostindo (PT. Anugerah Mustika Ostindo, Jakarta, Indonesia) is a biotechnology fertilizer, as part of the green process, which is intended to enhance land productivity through the development of soil microbiology. As it contains organic materials only, and comes with soil microbes, humus concentrate, enzymes, proteins and starch fossils and macronutrients, it is suggested that Ostindo will naturally reduce the dependency to chemical fertilizers up to 25%. Masliyani (2016) revealed that Ostindo consists different type of microbes such as *Azotobacter, Azospirillum, Aspergillus, Bacillus, Lactobacillus, Pseudomonas, Penicillium, Saccharomyces, Rhizobium, Rhizoctonia,* and *Pythium*. It also contains various macro and micronutrients such as N, P, K, Ca, Mg, S, and Zn, Cu, Mo, Co, B, Mn, Fe respectively.

Chicken manure

This study used chicken manure, because it contains a high level of N nutrient, it can dry the moisture within, and it is easy to collect. Pinus Lingga and Marsono (2006) mentioned that chicken manure is often used as basal application fertilizer before starting the planting. It usually is placed in the planting holes, or dispersed all over the land before the cultivation.

The husk

Husk is an organic material that is commonly used in media to bind Nitrogen, phosphorus, and potassium, and also all elements which are leached out by water, and absorbed by plants. The husk applied in this study is the outermost layer of the rice grain-cover which protects the inside embryo and starchy endosperm. During the rice milling, it becomes by product of the grain and is unable to be eaten, so it is considered as inexpensive materials. According to Houston (1972) husk has a bulk density of 0.100 g/ml, a calorific value of 3300-3600 kkal/kg with a thermal conductivity of 0.271 BTU.

The methods

The soil samples were collected from four different locations in the coal mining area of PT. CEM (Cahaya Energi Mandiri) Tanah Datar, Samarinda, East Kalimantan, Indonesia. They were the areas which were not mined, and the reclaimed areas with the age of 1, 3 or 6 years (depending on the locations). These samples then were analyzed in the Laboratory of Plant Pests and Diseases Science and Soil Science Laboratory of the Faculty of Agriculture, Universitas Mulawarman, Samarinda, East Kalimantan, Indonesia.

The research was used a randomized block design (RBD) consisting of 4 treatments and five replications. The treatments were carried out as follow: (i) P0: Without fertilizer and top soil; (ii) P1: Without fertilizer but with topsoil; (iii) P2: With fertilizer but without topsoil; (iv) P3: mixture of fertilizer and top soil.

Soil sampling

The sampling is aimed to identify chemical and physical characteristics, as well as for biological analysis. As aforementioned, the samples collected were based on the reclamation age, the slope (upper, middle and bottom), and the depth of the soil including unspoiled land from native forest, which has never been mined. The samples were taken from the predetermined areas, in three different spots.

Soil chemical properties

The soil pH level was usually measured in water suspension. If the measurement was conducted in 0.01 M CaCl2 or 1 M KCl solution, the data would have been converted to pH in water by multiplying the value with 1.1 (Mao et al. 1992; Joergensen and Castillo 2001; Cerri et al. 2006). The majority of soil organic C values were obtained by the Walkley- Black method (Srivastava and Singh 1991; Mazzarino et al. 1993; Motavalli et al. 2000), using potassium dichromate sulphuric acid oxidation as described, for example, by Nelson and Sommers (1982). Loss of ignition was sometimes used to determine soil organic C (Northup et al. 1999; Michelsen et al. 2004). Total N was measured in the majority of cases by the Kjeldahl procedure (Srivastava and Singh 1991; Northup et al. 1999; Motavalli et al. 2000). On the other hand, gas chromatographic determination of total C and total N were often used by different authors (Joergensen and Castillo 2001; Ndiaye et al. 2004; Li et al. 2006a, b). A variety of other methods were also applied for determining organic C and total N in soil.

For microbial analysis, from the profile which was made, the sample was taken at a depth of 0-20 cm and 20-40 cm to identify the total population of bacteria, fungi, and nematodes (Holt 1994). Furthermore, the samples are packed in a plastic bag and labeled corresponding to its depth. Then, the sample was picked up to the laboratory in a cool box, to maintain the existing microbes well preserved. Others samples were also collected from the rhizosphere area of the sample plants. The soil attached to this part was analyzed to identify the associated microorganisms around them. This process then will be followed by the determination of the total population of microbes; before and after planting based on the standard procedure for microbial analysis. 1 kg of each soil sample was taken from the depth of 0-20 cm and mixed into one, then from that mixture, 1 kg was taken to represent sample. The next step is to randomly make three holes (7,5 cm length and 15 cm depth) from each plot using a soil auger. Following Barker and Campbell (1981), in order to form a composite from the samples, and lessen the variance associated with aggregated spatial patterns of nematodes in the soil, this study thus mixed the collected samples. Large plant parts or stones were separated from soil samples by passing them through a soil sieve (6 mm mesh). All soil samples were stored overnight in the dark at 5°C and the existing field moisture levels were maintained to minimize changes in microbial populations and biochemical reactions (Barker et al. 1969). In relation to the method used to calculate the microbes population, this study applied plate count method with a colony counter. A total of 10 g of soil was added by 90 ml of normal saline (8.5 g NaCl / 1 liter of distilled water) and made serial dilution to 10-6. Dilution is used to define the population of each of the different parameters. The total population of bacteria was calculated using the dilution with a ratio of 10-5 and 10-6 under the media of nutrient agar (NA), within 2-days incubation period. While for the total fungi, this study used a ratio of dilution at 10-3 and 10-4 and using the media of Potato Dextrose Agar (PDA) within three days period of incubation. On the other hand, to determine the total population of nematodes, using a stereo microscope, a direct counting from a total of 50 grams of soil were taken and extracted according to Baermann funnel method within 2-3 days period of incubation.

Soil analysis

The soil analysis comprises a process to identify the soil bulk density, organic matter, particulate organic matter (0.05-2 mm), and mineral-associated organic matter (<0.05 mm). Mineral -N (NH_4 +-N, NO_3_N) is potentially a mineralized -N and C. In this regards, this study considered to determine the characteristics of the soil from a non-reclaimed areas, in the form of physical, chemical and biological perspective, by taking into account the variable of the duration these areas were abandoned. The physical analysis was focused on the soil texture such as sand, silt, and clay. The biological analysis covered microbial aspects. On the other hand, the chemical analysis comprises more aspects such as pH, organic C, total-N, P-available, K, Ca, Mg, Na-available, Al, Fe, Mn and CEC. The analysis was conducted in laboratory. In addition, to identify the difference aspects of physical and chemical properties, the T-test was applied. From this process, this study can calculate the reserve of microorganisms availability in rhizosphere, before and after the treatment; as well as the weight of wet and dry plants, and the growth of the plant (in cm). The data then were analyzed using Analysis of Variance. If the result has a significant difference, then it was continued to The Least Significant Difference test (LSD) on the level of 5%.

RESULTS AND DISCUSSION

Regarding the total population of microorganisms before and after treatment, this study showed that the mixture of top soil and fertilizer has significantly improved the genus of microorganisms.

Top of form: Microbial biomass

This study indicated that based on the results of microbial reserves, the mixture of top soil and Ostindo had affected the microbial growth, compared to the state before treatment, as seen on the plot P0, P1, P2, and P3 (Table 1). Meanwhile, as shown in Table 2, after the treatments, as can be seen in plot P0 and P1, the amount of microbial genus and its population was slightly higher. On the other hand, for P2 and P3, the number of microbial genera increased. This finding suggested that the plots which received the treatment with the mixture of top soil and Ostindo such as P2 and P3 showed better results, compared to those which did not get the treatment. This study revealed that on the after-mining land before receiving with no treatment, there were only two fungi genus (Penicillium and Phytium), three genera of nematode (Dorylaimus, Rhabditis and Steinernema), and two families of bacteria (Azotobacteriaceae and Corynebacteriaceae). On the other hand, after treatment on that land, it can be seen that there was an increase on the genus of fungi and nematode, from 2 to 5 types, while for bacteria, the number of genus remained the same. In addition, P3 showed a more promising result. It indicated the increase in fungi, nematode, and bacteria at the same time. Therefore, it can be concluded that addition of Ostindo and top soil mixture has proven to improve the condition of microbial growth. The C organic criteria rose from 2.9% (before treatment) to 5.2% (after treatment). This finding was along with the Soil Survey Staff (1988) which mentioned the correlation between the microbes and organic materials in soil.

The soil microbial biomass can be defined as organisms living in soil that are generally smaller than approximately 10 µ. Most people gave more attention to fungi and bacteria, as they are considered to be more important, in terms of energy flow and nutrient transfer in terrestrial ecosystems (Richards 1987). Though, fungi and bacteria are mainly dominated by biomass, protozoa sometimes exist also. The microbial biomass may consist of dormant and metabolically active organisms. However, the existing methods to estimate the content within biomass, either direct or indirect (biochemical) techniques, are not valid enough to differentiate this fraction. It is suggested that the microbial biomass content can be regarded as an integrative signal of the microbial significance in soils, as it is one of the few fragment of soil organic matter which is biologically meaningful, sensitive to management or pollution and measurable (Powlson 1994).

Table 1. The inventory of microbial diversity before treatments

Sample	Fungi		Nematode		Bacteria	
	cfu/ g	Genus	Population /kg soil	Genus	cfu/ g	Caracters/family
P_0	6.0×10^3	*Phytium* sp.	2.2×10^2	*Dorylaimus* sp.	1.4×10^3	Colony is white, coccus-oval, gram (-)
			1.0×10^1	*Rhabditis* sp.		Azotobacteriaceae
P_1	5.0×10^3	*Penicillium* sp.	3.0×10^2	*Rhabditis* sp.	2.4×10^2	Colony is white, bacil, gram (+)
			1.0×10^1	*Steinernema* sp.		Corynebacteriacee
P_2	3.0×10^3	*Penicillium* sp	2.6×10^2	*Dorylaimus* sp.	1.0×10^6	Colony is white, coccus-oval, gram(-)
		Phytium sp.	2.0×10^1	*Rhabditis* sp.		Azotobacteriacee
P_3	5.0×10^3	*Penicillium* sp.	2.3×10^2	*Dorylaimus* sp.	1.5×10^3	Colony is white, coccus-oval, gram (-)
			1.0×10^1	*Steinernema* sp.		Azotobacteriaceae

Table 2. The inventory of microbial diversity after treatment

Sample	Fungi		Nematode		Bacteria	
	cfu/ g	Genus	Population /kg soil	Genus	cfu/ g	Caracters/family
P_0	$5{,}6 \times 10^2$	*Phytium* sp.	$2{,}0 \times 10^2$	*Dorylaimus* sp.	$2{,}0 \times 10^3$	Colony is white, coccus-oval, gram (-)
		Fusarium sp.	$2{,}0 \times 10^1$	*Rhabditis* sp.		Azotobacteriaceae
P_1	$5{,}0 \times 10^3$	*Penicillium* sp.	$4{,}0 \times 10^2$	*Rhabditis* sp.	$4{,}0 \times 10^2$	Colony is white, bacil, gram (+)
		Aspergillus sp.	$2{,}0 \times 10^2$	*Steinernema* sp.		Corynebacteriacee
P_2	$4{,}0 \times 10^3$	*Penicillium* sp.	$6{,}0 \times 10^2$	*Dorylaimus* sp.	$2{,}3 \times 10^6$	Colony is white, coccus-oval, gram (-)
		Phytium sp.	$4{,}0 \times 10^1$	*Steinernema* sp.		Azotobacteriaceae
		Aspergillus sp.	$2{,}8 \times 10^2$	*Rhabditis* sp.		
		Fusarium sp.				
P_3		*Penicillium* sp.	$2{,}0 \times 10^2$	*Dorylaimus* sp.	$1{,}6 \times 10^3$	Colony is white, coccus-oval, gram (-)
	$3{,}8 \times 10^3$	*Phytium* sp.	$2{,}0 \times 10^1$	*Steinernema* sp.	$2{,}8 \times 10^3$	Azotobacteriaceae
		Aspergillus sp.	$2{,}3 \times 10^3$	*Rhabditis* sp.		Colony is white, bacil, gram (+)
		Fusarium sp.	$1{,}0 \times 10^2$	*Hoplolaimus* sp.		Corynebacteriacee
		Rhizoctonia sp.	$3{,}0 \times 10^2$	*Mononchus* sp.		
			$1{,}0 \times 10^3$			

Soil microbial biomass indicates the fraction of the soil and it is responsible for the energy and nutrient cycling, as well as the transformation of organic matter (Gregorich et al. 1994; Turco et al. 1994). In regards to this issue, there has been a great attention on the discussion about the relationship among soil microbial biomass, decomposition rate and N-mineralization (Jenkinson 1988; Smith et al. 1990; Carter et al. 1999). Microbial biomass has also shown to correlate positively with grain yield in organic farming, but not in conventional farming (Mäder et al. 2001). Finally, soil microbial biomass contributes to soil structure and soil stabilization (Fließbach et al. 2000; Smith et al. 1990). Soil microbial biomass is also recommended as indicators of soil organic carbon (Carter et al. 1999).

Neher (2001) stated that biologically, the soil ecosystems appear to support the growth and diversity of microbes (fungi, bacteria, and algae), microfauna (protozoa), and mesofauna (arthropods and nematodes). Microbes have known for its critical roles in ecological processes, such as nutrient cycling, and also to respond the environmental disturbances of soil, such as contamination by heavy metals (Duxbury 1985; Nannipieri et al. 1990). As microbes have narrow niches, therefore they are in a vulnerable position to environmental changes. Yuste et al (2010) indicated that this vulnerability issue which stimulates microbes to transform themselves in order to survive in new environmental conditions. Martinez-Salgado et al. (2010) states that soil contains a large variety of microbes with a wide diversity of metabolic activities. Compared to superior organisms, Soil microbial biomass is a more sensitive indicator and is influenced by different ecological factors such as plant diversity, soil organic matter content, moisture, and climate changes. Besides having an important role in nutrient cycling and energy flow, microbes also take effects in providing information on the impact of intercropping, incorporation of organic matter, management practices, and tillage activities which related to soil structure and stabilization. Microbial communities respond to the environmental stress or ecosystem disturbance, thus affecting the availability of energetic compounds that support microbial population. In addition, Neher (2001) also emphasized that most of the soil nematode species have beneficial roles in ecosystem processes, not only as parasites or pests. For instance, microbial grazing mesofauna (as nematodes) has proven to stimulate the growth of microbes metabolic activities and could alter the microbial community. Thus, it can be deduced that nematodes and microorganisms could be used as sensitive bioindicators for soil recovery in metal-contaminated habitats; however, how this process happened is still poorly understood (Shao et.al 2008; Shao, et.al. 2012).

In relation to this study, as seen in Table 2, the treatment of mixture of top soil and Ostindo fertilizer has successfully made the genus of fungi grow. They were of *Penicillium*, *Phytium*, *Aspergillus*, *Fusarium* and *Rhizoctonia*. It has also made nematodes genus increase. It comprises of *Dorylaimus*, *Rhabditis*, *Steinernema*, *Hoplolaimus* and *Mononchus*. But it has made no additional bacteria family.

The increase in fungi and nematode genus is believed to be caused by Ostindo containing microorganism, such as *Azotobacter*, *Azospirillum*, *Aspergillus*, *Bacillus*, *Lactobacillus*, *Pseudomonas*, *Penicillium*, *Saccaromyces*, *Rhizobium*, *Rhizoctonia*, and *Phytium*. Even so, the entire microorganisms cannot be found directly after the treatment using a biological method. This is due to the incubation period of isolation and the media used, and it depends on the dominance of the microorganisms which happens after treatment.

Yuste et al. (2011) stated that, compared to bacterial diversity, fungal diversity was less sensitive to season changes due to the moisture, temperature and plant activities. Therefore, fungal communities showed the ability to adapt to the changing environments dynamically without a loss of diversity. Thus, this study deduced that the capacity of fungi to overcome the disturbances is essential particularly in developing the microbial community and in exerting a strong influence on the temporal and spatial variability of soil organic matter decomposition, and soil C dynamics. It is suggested that fungal biomass and diversity should be extensively and intensively explored to understand and to correctly estimate the soil CO2 emissions from different types of ecosystems, especially in the frame of current human-driven alterations in the C cycle and the resulting climate change.

The addition of organic matter and microbes in the soil is believed to enhance the development of nematodes, as it serves as a source of nutrients. Additions of organic matter to soil are expected to increase the number of bacterivorous and fungivorous nematodes and to decrease the number of plant-parasitic nematodes (Bohlen and Edwards 1994; Freckman 1988; Griffiths et al. 1994). The added fertilizer comprises organic matter and microbes, and serves as a source of food for the nematodes (Andren and Lagerlof 1983; Weiss and Larink 1991.

The effect of treatments to wet weight and dry weight of plants

It can be seen from Table 3 that the treatment gave different effects on the average weight of the wet plant of sengon at 77 days after planting. It showed that P0 is significantly different from P1, P2, and P3. Similarly, in P1, there was also an indication that P1 was different from P2, and P3, whereas the treatment made no significant difference of P2 from P3. The complete result can be seen in Table 3.

This research showed that the mixture of fertilizers and topsoil gives higher impact on total dry weight and total wet weight of sengon when it was compared to the plant without being given by fertilizer and as control. It is suggested that the nutrients which exist in the media for planting has an important effect. Table 4 showed the various effect of fertilizer to the average plant height growth of sengon after 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77 days of planting (dap). It is also revealed that the treatment of using fertilizer without top soil and the treatment coming with the mixture of top soil and fertilizer indicated no significant differences.

Tabel 3. Effect of fertilizer to the average wet weight and dry weight of sengon (*Paraserianthes falcataria* L. Nielsen) at the age of 77 DAP

Treatment	Wet Weight	Dry Weight
P0	100.40 d	48.60 d
P1	137.80 c	63.00 c
P2	320.60 ab	87.40 ab
P3	350.80 a	96.20 a

Dense soil conditions resulted in the poor water system (water infiltration and percolation) and aeration or air circulation which can directly have a negative impact on the functioning and development of roots. Roots cannot be developed properly, thus they cannot function properly as tool for nutrients absorption, and this plant cannot grow normally (Soepardi 1983). This will indirectly affect plant growth; that's why soil microorganisms may play a critical role in the development and survival of plants. Activities are not just limited to the supply of nutrients, but also the activity in improving soil structure since the growth of sengon is better in the soil with treatments.

Araujo et al. (2009); Joergensen, R.G. (2010), also mentioned, by using soil respiration, and organic carbon in organic farming practices, it can result in the lower soil bulk densities and higher soil microbial activity. This was caused by the higher inputs of organic matter and energetic substrate for the present microbial communities that were activated to assure the turnover of applied nutrients.

The effect of treatments on soil fertility

This study found out that the pH of soil before the treatment was 4.1 and raised to 5.9 to neutral for after treatment. Similarly, the organic C prior the treatment was 2.9% and reached 5.2% after the treatment. Likewise, the N of soil before treatment showed 0.10 and after treatment it increased to 0.25. The detail results of chemical analysis of the soil before treatments and after treatments can be seen in Table 5.

Ostindo organic fertilizer contains N which fastens microbes and bacteria t will form nodules. N fixation process occurs through the nitrification to tether the N-free, and convert the nitrogen into NH_4 or NO_3 ions. The stability of soil aggregates could increase the capacity to restrain the water flow and amend the soil structure to intensify the development of plant roots. Ostindo bacteria in the group promote the activity of mucus mycelial and produce the aggregates.

The microbes' metabolic processes in the soil might lead to the organic material change, as it produces organic acids and dissolution of soil particle nutrients. This process eventually could improve the availability of the important nutrients which needed by the plants. Thus, besides decomposing the organic raw materials, the microbial groups can produce humic acid which dissolve P in the soil. This decomposition process formalizes humus and increases the CEC (cation exchange capacity) of the soil. Moreover, this process also triggers the production of hormones, antibiotics, and vitamins, which were created naturally by their biological activity in the soil. All in all, it will increase the root ability to resist the attack of pests and diseases.

Chirinda (2008) stated that the increase of microbial activity depends on the increase of annual C and N in a cropping system. Soil microbial activity is not only able to release the nutrients for a plant, but it is also able to stimulate the process of mineralization and mobilization of pollutants and xenobiotics. Thus microbial activity is crucial in biogeochemical cycling. It is quite certain that microbial activities depend on nutritional conditions, temperature and water availability. In this regards, Schloter et al. (2003) also added other important factors which affect the microbial activities, such as proton concentrations and oxygen supply. Moreover, bacterivorous and predatory nematodes are estimated to contribute (directly and indirectly) about 8% to 19% of nitrogen mineralization in conventional and integrated farming systems, respectively (Beare 1997 in Neher 2001). Nematodes contribute indirectly to nitrogen mineralization by grazing on decomposer microbes, excreting ammonium, and immobilizing nitrogen in live biomass (Beare 1997; Ferris et al. 1998; Ingham et al. 1985).

In summary, the mixture of top soil and fertilizer has successfully increased the number of fungal genus from 2 genera (*Phytium* and *Penicillium*) into 5 genera (*Phytium*, *Fusarium*, *Penicillium*, *Aspergillus*, *Rhizoctonia*), and the number of nematode genus from 2 genera (*Dorylaimus* and *Rhabditis*) into 5 genera (*Rhabditis, Steinernema*, *Dorylaimus*, *Hoplolaimus*, and *Mononchus*). Besides, the mixture of top soil and Ostindo can improve the soil fertility in post-mining areas, can increase C, N and P2O5, as well as the growth of sengon, regarding the pH soil (which is closed to neutral). This study also indicated the different result on the use of fertilizer solely (without top soil) to the plant height, fresh/wet weight, and dry weight at 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77 days after planting.

Table 4. Effect of treatments to the plant height growth of sengon (*Paraserianthes falcataria* L. Nielsen)

Treatment	Days after planting (cm)										
	7	14	21	28	35	42	49	56	63	70	77
P_0	17.58c	17.61c	17.83c	18.17c	18.62c	19.09c	19.53c	20.17c	21.48c	22.62c	23.66c
P_1	16.62d	16.68d	16.91d	17.27d	17.70d	18.16d	18.66d	19.55d	20.45d	21.66d	22.97d
P_2	18.29ab	18.52ab	18.97ab	19.43ab	19.89ab	20.63ab	21.62ab	22.52ab	24.12ab	26.18ab	27.93ab
P_3	18.62a	18.89a	19.33a	19.83a	20.31a	21.04a	22.12a	22.68a	24.54a	26.49a	28.30a

Table 5. Results of chemical analyses and texture of the soil before and after treatment

Treatments	pH	C Organic	N Total	C/N Ratio	P_2O_5 Bray 1	K_2O Morgan	Acid cation		Base cation				CTC	Al	Base	Pyrite	Clay	Particle distribution				Texture
		%			ppm P	ppm K	Al^{3+}	H^+	Ca^{++}	Mg^{++}	K^+	Na^+	meg/100 g		%			Silt	Sand Fine	Sand Medium	Sand Coarse	
																		%				
Without Ostindo	4.1	2.9	0.10	30	4.8	75	2.6	1.6	4.4	5.4	0.18	0.51	16	20	64	0.017	39	46	13	1	1	SiCL
Ostindo	5.9	5.2	0.25	21	17.5	52	0.0	0.0	7.9	6.8	0.11	0.26	26	0	59	0.05	44	48	6	1	1	SiC

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