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# The Effect of Organic Fertilizer and Liquid Complementary Fertilizer on The Seed Growing Medium from Topsoil

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## ABSTRACT

In coal mine reclamation activities, topsoil is generally used as the top layer on the reclamation land surface and the primary material in the growing medium for reclamation plant seeds due to its abundant availability. Topsoil generally has a low fertility rate because the soil layers between horizons have been mixed. Improvement of topsoil quality can be performed by adding organic fertilizers. This study aimed to identify the effect of organic fertilizers, liquid complementary fertilizers (LCF), and their interactions on selected soil's chemical properties from the topsoil used as a seed growing medium. This study used a factorial completely randomized design (CRD) with two factors, consisting of organic fertilizer factors and LCF factors. The results showed that the independent treatment of organic fertilizers and LCF had a very significant effect on pH. The independent treatment of organic fertilizers had a very significant effect on organic C and Total K. Meanwhile, the interaction between the two treatments had a very significant effect on the Total N and Total P of the growing medium. The addition of organic fertilizers and LCF can improve topsoil quality to be used as a medium for growing medium.

**Keywords:** coal mine reclamation, liquid complementary fertilizer, topsoil, organic fertilizer.

## 1. Introduction

In open-pit coal mining, activities carried out before mining include clearing the top layer (vegetation) and stripping the soil layer consisting of overburden and topsoil. According to the definition of coal mining, Topsoil is the upper soil layer of the O, A, B, and with or without C horizon (Ghose, 2001; BSN, 2016). Generally, the topsoil has been mixed between the horizon layers. As a result, there is a quality degradation, characterized by damage soil structure, decreased pH, decreased nutrients, depletion of organic matter, and decreased microbial activity. In reclamation activities, topsoil is used to cover the overburden layer. Although the quality is low, it is more beneficial than using overburden for plant growth in reclamation programs. Topsoil also serves as the main ingredient in the growing medium's composition for plant seeds in reclamation. Improvement of topsoil quality for reclamation activities can be performed by adding organic matter (Darmody et al., 2009 ; Iskandar et al., 2012 ; Erfandy, 2017 ; Mushia, 2018). Mixing topsoil with organic fertilizers has been shown to increase soil pH, soil chemical quality (C, N, and P), and topsoil macro and microorganisms (Sopialena et al., 2017).

Organic fertilizers are fertilizers derived from dead plants, animal manure and or animal parts, or other organic wastes that have been engineered, in solid or liquid form, enriched with mineral and or microbial materials, useful for increasing nutrient content and organic matter in soil and improve soil physical and biological properties (Kementerian Pertanian, 2011). The nutrient content and advantages of organic fertilizers depend on the raw material source and the production process. Therefore, each organic fertilizer has its advantages and respective dominant characters (Sentana, 2010 ; Hartatik et al., 2015). Some organic fertilizers are guano phosphate, vermicompost, and commercial organic fertilizers such as Subur Ijo.

Another material that can be used to improve topsoil quality is liquid complementary fertilizer (LCF). LCF is a liquid organic fertilizer that can be applied through soil or leaves. LCF sourced from extracts of plant parts, animal waste (Martínez-Alcántara et al., 2016 ; Pangaribuan et al., 2019), liquid extract from solid organic fertilizers, leachate products of an organic fertilizer production (Zarei et al., 2018), fermentation product, gasification and carbonization of biomass or organic matter (Grewal et al., 2018), and materials that contain microbes that break down organic matter and are rich in growth hormones and plant protection (Suhastyo and Setiawan, 2017 ; Zulputra and Hidayat, 2018). Some examples of LCF are indigenous microorganisms (IMO), liquid smoke, and Vermiwash.

Combining several organic fertilizers and LCF on topsoil as a medium for growing plant seeds for reclamation is still not widely studied. Therefore, this study aimed to determine the effect of organic fertilizers (guano phosphate, vermicompost, Subur Ijo) combined with LCF (IMO, liquid smoke, Vermiwash) on the chemical properties of topsoil used as a growing medium.

## 2. Materials and Methods

### *Materials*

Topsoil

Topsoil was taken from topsoil stock of PT Adaro Indonesia reclamation activities. The topsoil was air-dried and sieved to a uniform size (1.5 mm) and then heated in a furnace until it reached at least $80^0$C for at least 30 minutes. Stirring was carried out during heating so that it was evenly heated. Some of the chemical properties of the topsoil are presented in Table 1.

Guano phosphate

Guano phosphate was an organic fertilizer derived from bat droppings that accumulate at the bottom of limestone caves.

Subur Ijo

Subur Ijo was a granular commercial organic fertilizer produced by PT Green Planet Indonesia (GPI), one of the contractors for PT Adaro Indonesia's reclamation activities.

Vermicompost

Vermicompost was collected from worm farms at PT Adaro Indonesia's research workshop during January to April 2019. The worms that were raised were *Lumbricus* sp. The feed given was the mixture of fresh cow dung plus tofu dregs, with a ratio of 1: 3, and given every two days. Vermicompost was collected every week and air-dried at the PT Adaro Indonesia research workshop room. The analysis of the nutrient content of the organic fertilizers used is presented in Appendix 1.

Indigenous Microorganism (IMO)

IMO was produced following Park and DuPonte (2010). The stages are:

1. IMO 1 was produced by placing 500 g of rice in a wooden box. The wooden box was placed around the bamboo roots that grow in the reclamation area for 2-3 days. The rice was covered with tissue paper and then covered again with bamboo leaf litter and the soil from around the bamboo roots. After 2-3 days, the rice in the box will full of white hyphae indicates IMO has grown and developed in the medium.
2. IMO 2. IMO 1 was taken and mixed with 500 g of brown sugar, then stirred evenly.
3. IMO 3. IMO 2 was incubated in a dark room at room temperature for seven days.

Liquid Smoke

In husk charcoal production, the smoke produced was captured through a funnel and flowed through a simple distillation process (cooling with water). The liquefied smoke was collected in a container. After that, the middle section of the solution, clear yellowish color, was sucked in to obtain liquid smoke/charcoal vinegar.

Vermiwash

In the cultivation of *Lumbricus* sp. worms at the PT Adaro Indonesia research workshop, the remaining waste generated at each feeding was leaching from the worm cultivation tub. The leaching fluid was collected and used as a treatment in this study. The Vermiwash was produced from January to April 2019.

Growing Medium

The growing medium for the seeds were tested using the composition of topsoil : husk charcoal : organic fertilizer with a ratio of 50% : 45% : 5%, respectively. All materials were sieved to obtain uniform grain (1.5 mm). Vermiwash and liquid smoke were each diluted 30 times, and for IMO, the dose used was 10 g/liter.

All of the LCF were incubated into mixed medium of topsoil, husk charcoal, and organic fertilizer. The incubation conditions were adjusted so that the final moisture content in each medium was 80%. Incubation was carried out on the same day for all treatments for two weeks (14 days) in the room at room temperature.

*Methods*

Experimental design

This research used experimental methods, factorial Completely Randomized Design (CRD) with two factors. The first factor was the organic fertilizer (P), three types, namely guano phosphate (p1), Subur Ijo (p2), and vermicompost (p3). The second factor was LCF (C), three types, namely IMO (c1), liquid smoke (c2), and Vermiwash (c3). All treatment combinations from the two factors (9 combinations) were repeated three times. Therefore, 27 experimental units were obtained.

Observation

Observations made on the treated medium were soil pH, organic C content, total N, total P, and total K. Soil pH was calculated by mixing 10 g of medium with 50 ml of distilled water, then stirred for 30 minutes and measured with a pH meter. Organic C content was measured following the Walkley and Black (1965) method. Total N was measured by the Kjeldahl Micro method. Total N and total K were measured by extracting 25% HCL. Total P was measured using a spectrophotometer at a wavelength of 889 nm and K total using AAS.

Data Analysis

The data's homogeneity was tested using the Barlett test (1937) at the significance level of 5% before continuing with the analysis of variance (ANOVA). If the data analysis shows non homogeneous data, then data transformation will be carried out to obtain a homogeneous distribution data. The effect of each treatment (types of organic fertilizers and liquid complementary fertilizers) and their interactions with the observation components were determined using the F test on analysis of variance with the significance level of 1% and 5%. Suppose the analysis of variance has a significant effect. In that case, it will be continued with Tukey's Honestly Significant Difference Test at $\alpha$ 5% to determine the mean value of the variables between the experimental factors. Data analysis in this study was carried out using the Minitab 18 program.

## 3. Results and Discussion

*Chemical Content of Topsoil*

Table 1. Chemical properties of topsoil

| Parameter | Unit | Result | Criteria[1] |
|---|---|---|---|
| pH $H_2O$ | | 4.11 ± 0.006 | Very Acidic |
| Electrical Conductivity (EC) | dS/m | 0.15 ± 0.002 | Very Low |
| Redox Potential (Eh) | mV | 171.43 ± 0.321 | nr |
| Organic C | % | 1.08 ± 0.005 | Low |
| Total N | % | 0.13 ± 0.006 | Low |
| C/N Ratio | | 8.63 ± 0.413 | Low |
| KTK | me/100 g | 17.02 ± 2.642 | Medium |
| $P_2O_5$ HCl 25 % | mg/100 g | 6.26 ± 1.218 | Very Low |
| $K_2O$ HCl 25 % | mg/100 g | 4.65 ± 0.226 | Very Low |
| Exchangeable Na | me/100 g | 0.02 ± 0.004 | Very Low |
| Exchangeable K | me/100 g | 0.05 ± 0.001 | Very Low |
| Exchangeable Ca | me/100 g | 3.82 ± 1,137 | Low |
| Exchangeable Mg | me/100 g | 0.03 ± 0.005 | Very Low |

Note [1]) The criteria refer to the Technical Guidelines for Chemical Analysis of Soil, Plants, Water and Fertilizers, 2nd Edition, Soil Research Institute (BPT, 2009); nr = not required; Values are mean of 3 replicates ± standard deviation.

The chemical analysis of topsoil in Table 1 shows that the growing medium's quality level is classified as very low to low criteria. The low chemical quality of the topsoil is probably due to the mixed soil horizon when stripping the cover and storing topsoil as stock before it is used in reclamation activities. The low quality of topsoil in this study is in accordance with several previous studies (Rai et al., 2014 ; Makdoh K and Kayang H, 2015 ; Sofyan et al., 2017a).

*Treatment effect on pH, Organic c, total N, Total P, and Total K of the seed growing medium*

Table 2. ANOVA of the treatment effect on pH, organic C, total N, total P, total K in the seed growing medium

| SK | db | Middle-Square | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | pH | | Organic C | | Total N | | Total P | | Total K | |
| Organic Fertilizer (p) | 2 | 0.568 | ** | 2.049 | ** | 0.081 | ** | 1,278,956.996 | ** | 18,172.139 | ** |
| LCF (c) | 2 | 0.043 | ** | 0.056 | ns | 0.001 | * | 47.216 | ns | 200.938 | ns |
| p x c | 4 | 0.001 | ns | 0.047 | ns | 0.001 | ** | 1,313.271 | ** | 217.632 | ns |
| Error | 18 | 0.001 | | 0.029 | | 0.000 | | 289.146 | | 115.687 | |
| KK | % | 0.57 | | 5.22 | | 3.11 | | 3.34 | | 11.51 | |

Note:
- ns = Non significant ($P \geq 0.05$)
- * = Significant ($P \leq 0.05 \geq 0.01$)
- ** = Very significant ($P \leq 0.01$)

Analysis of variance (Table 2) indicates that the independent treatment of organic fertilizers (p) and LCF (c) has a very significant effect on pH. The independent treatment of organic fertilizers had a very significant effect on Organic C and Total K. The interaction between the two treatments had a very significant effect on total N and total P of the seed growing medium.

Table 3. The effect of organic fertilizers and LCF on the pH of the seedling growing medium

| pH $H_2O$ | | | |
|---|---|---|---|
| Organic Fertilizer | | LCF | |
| Guano Phosphate | 6.88 ± 0.070b | IMO | 6.833 ± 0.255a |
| Subur Ijo | 6.96 ± 0.072a | Liquid Smoke | 6.700 ± 0.253b |
| Vermicompost | 6.49 ± 0.070c | Vermiwash | 6.797 ± 0.249a |

Note: The numbers followed by the same letter in the same column are not significantly different at the 5% level based on Tukey's Honestly Significant Difference Test, ** = very significant effect at 1% ; Values are mean of 3 replicates ± standard deviation.

Table 3 shows that the average pH in the seedling medium with Subur Ijo treatment was 6.96 ± 0.072, higher than guano phosphate 6.88 ± 0.070 and vermicompost 6.49 ± 0.070, respectively. Organic fertilizers are known to increase soil pH by releasing organic acids during the decomposition process, which can bind $H^+$ ions and chelate $Al^{3+}$ and $Fe^{2+}$ as soil acidity sources. It mostly occurred in medium incubated with organic fertilizers for some time, as reported by Siregar et al., 2017.

Treatment with LCF on the initial medium also affected the average soil pH. The IMO 6.83 ± 0.255 and Vermiwash 6.79 ± 0.249 treatments were not significantly different and showed a higher effect on pH than the liquid smoke treatment of 6.70 ± 0.253. IMO and Vermiwash, which are rich in microorganisms, could increase the decomposition process higher. There may be more organic acids capable of binding $H^+$ ions than in the liquid smoke treatment. This increase in pH with IMO and Vermiwash was also reported by SomaSekhar et al., 2013.

The topsoil pH of 4.11 ± 0. 006 is in the very acid category (Table 1). The addition of organic fertilizers and PPC showed an effect on increasing the pH of the planting medium. These two treatments could increase the pH to the optimal range to support nutrient availability for plant seeds.

Table 4. Effect of organic fertilizers on Organic C on seed growing medium

| Organic C (%) | |
|---|---|
| Guano Phosphate | 2.733 ± 0.058c |
| Subur Ijo | 3.667 ± 0.195a |
| Vermicompost | 3.367 ± 0.090b |
| p-value | ** |

Note: The numbers followed by the same letter in the same column are not significantly different at the 5% level based on Tukey's Honestly Significant Difference Test, ** = very significant effect at 1%; Values are mean of 3 replicates ± standard deviation.

Table 4 shows that the independent treatment of organic fertilizers significantly affected the average organic C content of the seed growing medium. The highest average value of organic C was found in the Subur Ijo treatment at 3,667± 0.195 %, followed by vermicompost 3,367 ± 0.090 %, and guano phosphate 2,733 ± 0.058 %.

The difference in organic C content in each organic fertilizer treatment was caused by differences in the type of fertilizer and the organic C content in each type. Vermicompost and Subur Ijo have relatively higher organic C content than guano phosphate.

The addition of organic fertilizers was proven to increase organic C. According to its characteristics, each type of fertilizer could increase organic C differently (Nurida and Jubaedah, 2012; Surya and Suyono, 2013; Adviany and Maulana, 2019). Organic C as a parameter indicating the status and the amount of organic matter is an essential indicator in soil health or planting medium to support plant seeds' growth. Soil organic matter has a function to improve soil physics, chemistry, and biology (Önemli, 2004; Bot and Benites, 2005). The high organic C content in this study, especially in the Subur Ijo and vermicompost, indicates that the growing medium for seedlings treated with organic fertilizer is ideal for supporting the growth of plant seeds. The value of Organic C in this treatment was higher than the organic C content in topsoil, which was only 1.08 ± 0.005 %. It indicates that the addition of organic fertilizers could increase the organic C content in topsoil.

Table 5. Effect of treatment interactions on Total N in seed growing medium

| Total N (%) | |
|---|---|
| Guano – IMO | 0.43 ± 0.010d |
| Guano – Liquid Smke | 0.45 ± 0.006d |
| Guano – Vermiwash | 0.46 ± 0.018d |
| Subur Ijo – IMO | 0.66 ± 0.012a |
| Subur Ijo – Liquid Smoke | 0.62 ± 0.001ab |
| Subur Ijo – Vermiwash | 0.62 ± 0.017ab |
| Vermicompost – IMO | 0.60 ± 0.018abc |
| Vermicompost – Liquid Smoke | 0.56 ± 0.014c |
| Vermicompost – Vermiwash | 0.57 ± 0.033bc |
| p – value | ** |

Note: The numbers followed by the same letter in the same column are not significantly different at the 5% level based on Tukey's Honestly Significant Difference Test, ** = very significant effect at 1%; Values are mean of 3 replicates ± standard deviation.

Table 5 shows that the interaction of the two treatments had a very significant effect on the medium's total N content. N is one of the macro and essential nutrients, which crucial for plant growth and is needed in large quantities compared to other nutrients (Wiraatmaja, 2016). The combination of Subur Ijo and IMO revealed that it had the highest average N content than all treatments (0.66 ± 0.012%). However, it was not significantly different from the combination of Subur Ijo and other LCF. The combination treatment of vermicompost with all LCF was not significantly different and showed a lower N content than the combination of Subur Ijo and LCF. The combination treatment of guano phosphate with all LCFs was not significantly different and showed the lowest N content than other treatments.

The availability of nutrients, including N, in the growing medium comes mainly from fertilizers, which are given as a mixture for the planting medium. Subur Ijo, as commercial organic fertilizer, has controlled standards in the supply of nutrients, including N (1-3%), where the quality standard is certified in the quality of goods (PT Green Planet Indonesia, 2018). As a quality organic fertilizer, vermicompost is known to have high N content and is readily available to plants (Sinha. et al., 2009). Changes in organic N so that it can be absorbed by plants (mineralization) require the role of microorganisms. It supports the initial medium analysis results, where the IMO combination treatment had higher N than other treatments. Other studies have also found that IMO administration can increase nutrient content, including N (Zuraihah et al., 2012).

The N content in all combination treatments of guano phosphate and LCF was lower than the other treatments. It is most likely due to the lower initial N content in these fertilizers than other organic fertilizers (Subur Ijo and Vermicompost). Meanwhile, the N content with organic fertilizer and PPC treatment was higher than the N content in topsoil, which was 0.13 ± 0.006 %. It indicates that the addition of organic fertilizers can increase the N content in topsoil.

Table 6. The effect of the treatment interaction on the total P of the seed growing medium

| Total P (mg/100 g) | |
|---|---|
| Guano – IMO | 274.52 ± 6,504de |
| Guano – Liquid Smoke | 259.63 ± 4.947e |
| Guano – Vermiwash | 248.86 ± 19.998e |
| Subur Ijo – IMO | 920.19 ± 3.930b |
| Subur Ijo – Liquid Smoke | 938.52 ± 22.501ab |
| Subur Ijo – Vermiwash | 969.35 ± 36.493a |
| Vermicompost – IMO | 323.97 ± 7.568c |
| Vermicompost - Liquid Smoke | 332.74 ± 7.568c |
| Vermicompost – Vermiwash | 312.04 ± 9.736cd |
| p – value | ** |

Note: The numbers followed by the same letter in the same column are not significantly different at the 5% level based on Tukey's Honestly Significant Difference Test, ** = very significant effect at 1%; Values are mean of 3 replicates ± standard deviation.

The highest P content was found in the Subur Ijo-Vermiwash treatment of 969.35 ± 36.493 mg/100 g, followed by the Subur Ijo treatment with other LCF. The combination treatment of Vermicompost with LCF showed lower P content and was followed by all the combination treatments of guano phosphate with LCF. The high P content in the combination treatment of Subur Ijo with LCF compared to other treatments was caused by the higher P content in Subur Ijo, followed by vermicompost and guano phosphate. Moreover, the P availability in the soil is influenced by factors such as soil pH, the amount of P in the soil solution, the amount and degree of decomposition of organic matter, and microorganisms' activity. P will be available optimally in the soil pH range between 6-7 (Putra and Nuraini, 2017). It can be seen in the pH analysis of all treatments, where the soil pH range is suitable and ideal for P's availability.

The high P in the Subur Ijo-Vermiwash treatment was also caused by Vermiwash, rich in nutrients, including P. The addition of substrate from Vermiwash to the soil, which was incubated over time, was proven to increase soil P content (Putra and Nuraini, 2017). The P content in the planting medium treated with organic fertilizers and PPC was higher than the P content in the topsoil.

Table 7. The effect of organic fertilizers on the total K of the seed growing medium

| Total K (mg/100 g) | |
|---|---|
| Guano Phosphate | 57.087 ± 6.949c |
| Subur Ijo | 143.697 ± 10.933a |
| Vermicompost | 79.627 ± 6.643b |
| p-value | ** |

Note: The numbers followed by the same letter in the same column are not significantly different at the 5% level based on the Tukey's Honestly Significant Difference Test, ** = very significant effect at α 1%; Values are mean of 3 replicates ± standard deviation.

Table 7 shows that the independent treatment of organic fertilizers has a very significant effect on total K in the seed growing medium. The K content level in the growing medium is influenced by the K content in the fertilizer or material and soil pH. The addition of organic fertilizers to the medium will increase the K. Acidic pH content will increase the K fixation, thereby reducing the availability of K in the soil (Gunawan et al., 2018). Analysis of variance on the seed growing medium showed that the total K content was significantly affected by organic fertilizers' independent treatment. The highest average K content was found in the Subur Ijo treatment, followed by vermicompost and guano phosphate, respectively. The K content in each of these organic fertilizers, follows the analysis of organic fertilizer treatment effect on seed growing medium, which is supported by the ideal medium pH range for the availability of K. This analysis indicated that the given organic fertilizer increased the K content in the topsoil.

## 4. Conclusions

The organic fertilizers and LCF treatment in this study affected the growing medium's chemical properties, whose main composition was topsoil. The independent treatment of organic fertilizers and LCF had a very significant effect on pH. The independent treatment of organic fertilizers had a very significant effect on organic C and Total K. Meanwhile, the interaction between the two treatments had a very significant effect on total N N and the total P of the seed growing medium. This study indicates that the application of organic fertilizers and LCF could improve topsoil quality for utilization as seeds growing medium.

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