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The Effect of The Biochar Application of Oil Palm Shells and Municipal Waste Compost on Soil Water Content of Coal Mine Reclamation and Soybean Yield

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ABSTRACT

Characteristics of the most prominent former coal mining land are severe damaged land, causing decreased soil productivity, erosion and sedimentation, soil movement and resulting in land slides, and soil compaction so that it is difficult to process. Efforts to improve the physical properties of coal mining reclamation soils, namely by adding biochar and compost. Biochar and compost can improve the physical properties of the soil by increasing the content of organic matter, total pore space, water content and reducing the weight of soil volume. This study uses a complete random design with 6 treatments and 4 replications. The treatment used in this study is B0 without treatment (control); B1 15 tons/ha biochar oil palm shells; B2 10 tons/ha biochar oil palm shells and 5 tons/ha of city waste compost; B3 7.5 tons/ha biochar oil palm shells and 7.5 tons/ ha of city waste compost; B4 5 tons/ha Biochar palm oil shell and 10 tons/ha of city waste compost; B5 15 tons/ha of city waste compost. The observed variables are the content of organic matter, the weight of soil volume, total pore space, soil water content in several PF values, plant height, plant yields and the number of plant pods. The results obtained that the treatment combination of 7.5 tons/ha of biochar oil palm shells 7.5 tons/ha of city waste compost is the best composition to improve the groundwater content of coal mining reclamation. Furthermore, the provision of 15 tons/ha of city waste compost has effectively improved soybean yield.

INTRODUCTION

Soil in ex-mining areas is usually soil that is poor in nutrient content and the microorganisms in the soil are decreasing. The impact of mining also causes the top soil (top soil) which is fertile soil to be in the lower layer and to be replaced by soil from the lower layer which is less fertile, causing the soil to lose organic C in the soil, as well as the biological population in the soil which should be present. the top layer of soil then sinks inward so that it does not function as per its role and can also cause biological populations to disappear or die (Subowo, 2011).

According to Wiskandar (2017) Former coal mining land at PT. Nan Riang showed that the C-organic content was 0.57% which was relatively low, the pH was 4.21 (acid) and the soil volume on the land was relatively high, namely 1.3 g/cm^3. One way that can be done to improve the problem of ex-coal

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mining land is by adding organic material to the soil in the form of biochar and compost. Biochar has a function as a soil amendment by supplying several useful nutrients to the soil and improving the physical and biological properties of the soil and increasing plant growth (Sujana and Nyoman, 2015).

The addition of compost can also be useful as a complement and additional nutrition for the soil and additional nutrients that biochar does not have. The use of compost for critical land is expected to be able to improve the physical properties of the soil, such as improving the texture and structure of the soil by forming more stable and loose aggregates and improving soil drainage and aeration so that soil management becomes easier (Sandrawati *et al.,* 2007). One of the plant indicators to see the effect of the application of palm oil shell biochar and municipal waste compost on several physical properties of coal mine reclaimed land is soybeans. Soybean (*Glycine max* (L.) Merril) is a food crop that is widely used by people because it is a rich source of vegetable protein, vitamins and minerals.

MATERIALS AND METHOD

The research was carried out at the Teaching and Research Farm (Experimental Garden) of the Faculty of Agriculture, Jambi University. Soil sample analysis was carried out at the Soil Science Laboratory, Faculty of Agriculture, Jambi University. This research was carried out for ± 6 months, starting from July to December 2021. The materials used in this research were Anjasmoro variety soybean seeds, palm oil shell biochar, organic municipal waste compost (green vegetables), manure, sawdust, brown sugar, soil samples, Decis, Dithane M-45, Furadan, water and other materials needed for analysis of soil samples, biochar and compost in the laboratory. The tools used in this research are a hoe, polybag measuring 50 cm x 25 cm , sample ring, measuring tape, rope, rubber bands, plastic/zinc tarpaulin, machete, cutter/ knife, label paper, gembor, bucket, scales, oven, camera, hand sprayer, stakes, sacks and other equipment needed during the research. This research was in the form of an experiment using a Completely Randomized Design (CRD) with 6 treatments and 4 replications, so there were 24 experimental pots. Each experimental unit consisted of 1 plant so that the total number of plants was 24 plants. The research treatments used were: b0 = no treatment (control); b1 = 15 tons/ha palm oil shell biochar; b2 = 10 tons/ha palm shell biochar + 5 tons/ha municipal waste compost; b3 = 7.5 tonnes/ha palm shell biochar + 7.5 tonnes/ha municipal waste compost; b4 = 5 tonnes/ha palm shell biochar + 10 tonnes/ha municipal waste compost; b5 = 15 tons/ha of municipal waste compost. The variables observed were organic matter, soil volume weight, total pore space, soil water content at several pF values, plant height, plant yield and number of pods containing soybean plants. The data was analyzed using variance with a confidence level of 95% (α = 5%) then continued with the Least Significant Difference test (LSD). Meanwhile, the growth of soybean plants based on graphs was analyzed descriptively based on the results of observations.

RESULTS AND DISCUSSION

Physical Properties of Soil Before Treatment

The results of the initial soil analysis on the experimental land with several parameters of soil physical properties showed that the soil organic matter content was low with a value of 2.69%, apart from that the soil volume weight was classified as medium with a value of 1.33 g/cm3 and the total soil pore space value was also is classified as low with a value of 48.875% (Table 1), which makes it difficult for plant roots to penetrate the soil to obtain nutrients and oxygen which will inhibit plant growth. The organic material content has a high ability to absorb water so that soil with high organic material will also have a high water holding ability.

Low organic matter also affects the availability of water content, where the soil used in the research has an available water content with medium criteria, namely 12.95%

Table 1. Results of soil analysis of former coal mining PT. Nan Riang

Parameter	Resuts	Criteria
Bulk density (g/cm^3)	1.33	moderate*
Total Soil Pore Space (%)	47.78	low *
Soil Water content	25.94	low *
Organic Material (%)	2.69	low *
Water content Field Capacity (pF 2.54) (% vol)	33.45	high *
Permanent Wilting point moisture content (pF 4.2) (%vol)	20.50	high*
Available water content (pF 2,54-pF 4,2) (%vol)	12.95	moderate*

Note: *Bogor Soil Research Center (1994)

vol. The water content at the permanent wilting point is water that is strongly absorbed by the forces of the soil matrix so that it can no longer be absorbed by plant roots or is not available to plants. The water content at the permanent wilting point in the soil used before treatment is 20.5% with the criteria high, this is also related to soil pores, in line with Murtilaksono and Wahyuni (2004), that the higher the clay content, the higher the permanent wilting point water content, conversely the higher the soil macro pores, the lower the permanent wilting point water content because the surface area of the soil particles is smaller.

Results of Analysis of Palm Oil Shell Biochar and Municipal Waste Compost Fertilizer

This investigation explores the impact of palm oil shell biochar and municipal waste compost as treatments on soil properties. Utilizing the dry ashing method, the analysis of ash content revealed 7.6% for palm oil shell

Table 2. Results of analysis of palm oil shell biochar and municipal waste compost

Analysis	Analysis Results	
	Compost	Biochar
Ash content (%)	7.40	7.60
Organic material (%)	31.89	62.60
Water content (%)	20.96	9.48

Note: UPT Integrated Basic Laboratory and Soil Biology Fertility Laboratory, Faculty of Agriculture, Unja.

biochar and 7.4% for municipal waste compost. The organic material content of palm oil shell biochar and compost fertilizer was found to be 62.60% and 31.89%, respectively. Additionally, the water content in palm oil shell biochar was 9.48%, while municipal waste compost exhibited 20.96% water content (Table 2).

The analysis of soil volume weight, total soil pore space, and soil organic matter (Table 3) illustrates alterations between soil conditions before and after treatment. Pre-treatment, the volume weight was 1.33 g/cm^3, categorized as medium, decreasing to 1.08 g/cm3 post-treatment, maintaining its medium classification. The total pore space increased from 47.78% to 58.34%, reflecting improved soil structure. Organic matter content elevated from 2.69% (low category) to 4.03% (medium category) post-treatment.

Treatments B0, B1, B2, and B3 showed no significant impact on soil volume weight, while B4 and B5 exhibited a notable effect. Analysis of variance indicated that untreated soil and B1, B2, and B3 treatments had no significant influence. It is presumed that the dosage applied failed to maximize the reduction in soil volume weight due to the

Table 3. Analysis values of average soil physical characteristics due to the application of palm oil shell biochar and municipal waste compost fertilizer

Treatments	Bulk density (g/cm^3)	Particle density (g/cm^3)	Total porosity (%)	Organic matter (%)	Soil moisture (%)
B0	1.15 bc	2.46 a	53.18 a	1.3 a	20.68 a
B1	1.20 c	2.48 a	51.65 a	1.93 a	25.45 a
B2	1.16 bc	2.45 ab	52.73 a	2.93 b	23.90 a
B3	1.14 ab	2.44 abc	53.53 a	3.02 b	29.42 a
B4	1.08 a	2.35 bc	54.13 a	3.2 b	27.19 a
B5	1.08 a	2.34 c	53.73 a	4.03 c	24.48 a

Note: Numbers followed by the same letter in the same column are not significantly different according to the BNT test at the 5% level inherent challenge of biochar decomposition in the soil. Conversely, B4 and B5 treatments significantly improved soil volume weight, demonstrating that higher doses positively influenced this parameter. This underscores the capacity of treatments B4 to B5 to enhance soil volume weight.

Treatment B5 (15 tonnes/ha of compost fertilizer) contributed the highest organic matter at 4.03%. The B0 treatment had a tangible impact on treatments B2 to B5, influencing organic matter content positively. The observed increase in organic matter content, as presented in Table 3, correlates with the applied doses of compost and biochar. This aligns with previous research by Hasibuan (2015), emphasizing the role of various compost types in augmenting soil organic matter through C-Organic contributions.

The study revealed a reduction in soil solid particles and an augmentation in total pore space with increasing treatment doses (Table 3). This phenomenon is attributed to the role played by the supplied organic material. These findings resonate with the research of Endriani (2010), affirming that higher soil organic matter leads to reduced soil volume weight and an increase in total pore space. The inverse relationship between soil volume weight and total pore space was evident: higher volume weight corresponds to lower total pore space and vice versa.

Statistical analysis demonstrated the impact of applying palm oil shell biochar and municipal waste compost to ex-coal mining soil on field capacity water content (pF 2.54), permanent wilting point water content (pF 4.2), and available water content (pF 2.54 - pF 4.2), as outlined in Table 4.

Based on the results of statistical analysis, the effect of applying palm oil shell biochar and municipal waste compost to ex-coal mining soil shows its effect on field capacity water content (pF 2.54), permanent wilting point water content (pF 4.2), and available water content (pF 2.54 - pF 4.2) (Table 4). The field capacity water content (pF 2.4) showed that the B0 treatment was significantly different from the B3 treatment, but had no significant effect on the B1, B2, B4 and B5 treatments. This is thought to be related to the volume weight value in the treatment which shows a change between the soil before being treated and after being treated, namely the volume weight before being treated was only 1.33 g/cm^3, including the medium category, to 1.135 g/cm^3, which is also the medium category. Volume weight affects water absorption and water movement in the soil. This statement is supported by Intara *et al.,* (2011) that the amount of water obtained by the soil depends on the soil's ability to absorb and transmit the water received from the soil surface to the soil layers below.

Hardjowigeno (2010) states that permanent wilting point water content is a condition where the water content is very low in the planting medium where the roots at certain times cannot absorb water so that the plant experiences temporary wilting. The results of the permanent wilting point water content analysis (pF 4.2) showed data that B0 had no real effect on B1, B2 and B4 but had a significant effect on treatments B3 and B5. To

Table 4. Results of analysis of average water content at several pF values due to the application of palm oil shell biochar and municipal waste compost fertilizer

Treatment	Water content at field capacity（% vol.)	Water content at permanent wilting point（% vol.)	Available water content (%)
B0	31.05 a	20.15 cd	10.90 a
B1	32.68 ab	20.13 bcd	12.55 ab
B2	33.03 ab	21.88 d	11.15 a
B3	33.70 b	18.30 ab	15.40 c
B4	31.35 ab	18.38 abc	12.98 abc
B5	32.33 ab	17.85 a	14.48 bc

Note：Numbers followed by the same letter in the same column are not significantly different according to the BNT test at the 5% level take up water in the soil, plant roots have a maximum suction power of 15 atm. If there is water in the soil in pores with a diameter of <0.2 µm, the plant will wither and die.

Based on the data in Table 4, treatment B3, B4 and B5 shows a change in the available water content before being treated, where the initial available water content was only 12.95% then increased respectively to 15.40%, 12.98% and 14.475%. The high water content available in treatments B3, B4, B5 is due to the total pore space value being higher than the others so that they have fast drainage pores which are not much different from each other. This shows that the B3, B4, B5 treatments are still capable of storing good water.

Average Growth, Yield and Pods of Soybean Plants Due to Application of Palm Oil Shell Biochar and Municipal Waste Compost

Based on Table 5, it can be seen that the treatment of palm oil shell biochar and municipal waste compost has a significant effect on the average value of soybean yield. BO treatment had a significant effect on treatments B1, B2, B3, B4 and B5. The treatment with the highest value and the best potential to increase soybean yields was treatment B5 (15 tonnes/ha of municipal waste compost), namely 47.72 gr. Providing 15 tons/ ha of municipal waste compost succeeded in increasing soybean crop yields because municipal waste compost has sufficient nutrients to help the growth and yield of soybean plants. Apart from that, the root nodules of soybean plants also play a role in fixing nitrogen in the soil so that it can affect plant yields.

Table 5. Average value of soybean grain yield and pods due to Application of palm oil shell biochar and municipal waste compost

Treament	Soybean yield/ plant (gram)	Number of full pods /plant
B0	10.06 a	22.75 a
B1	19.47 b	58.50 b
B2	25.65 c	72.25 bc
B3	31.66 d	85.50 c
B4	38.71 e	110.25 d
B5	47.72 f	136.75 e

Note: Numbers followed by the same letter in the same column are not significantly different according to the BNT test at the 5% level.

Based on Table 5, it can be seen that the treatment of palm oil shell biochar and municipal waste compost had a significant effect on the average yield value of pods containing soybeans. The average yield value of pods containing the best soybean plants was found in B5 with treatment of 15 tonnes/ha of municipal waste compost with a value of 136.75 gr. Providing 15 tons/ha of municipal waste compost succeeded in increasing soybean crop yields because municipal waste compost has sufficient nutrients to help the growth and yield of soybean plants. Nurida and Undang (2009) stated that organic matter in the soil functions as a binding agent for soil particles to form aggregates. Organic matter as a stabilizer for soil aggregates can maintain and improve the physical properties of the soil with the help of soil organisms that use it as an energy source. Organic materials also act as binders in the formation of microaggregates, mesoaggregates and macroaggregates.

B5 treatment with 15 tonnes/ha of municipal waste compost provided the best production results and number of pods with a value of 47.72 g and 136.75 seeds. This is because compost fertilizer decomposes more quickly in the soil, thereby increasing the soil's holding capacity to store water. This is in accordance with the opinion of Intara *et al.*, (2011) which shows that the provision of organic material in the form of manure and compost can increase the available water content in the soil compared to without organic material. The more water content given to plants, the better their growth and production.

The treatment with the highest value and the best potential to increase soybean plant height is treatment B5 (15 tonnes/ha of municipal waste compost) which is 58 cm. Plant growth without treatment showed lower growth compared to treatment with palm oil shell biochar and municipal waste compost. Plant height measurements were carried out from the second week after planting (MST) until entering the generative period (60% of the plants had flowered) at intevals of once a week (Figure 1).

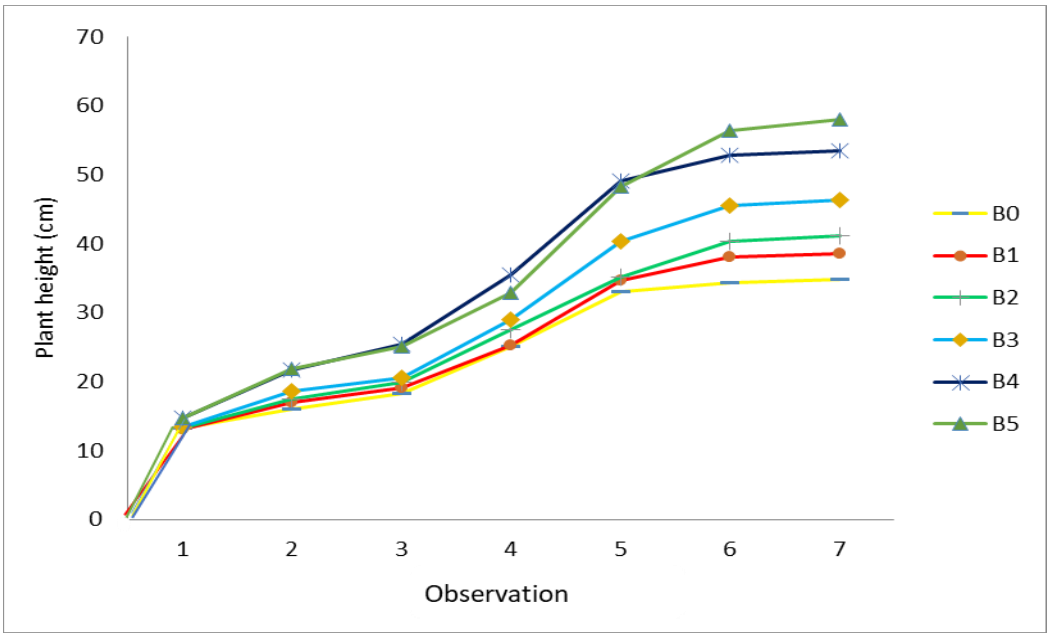

Figure 1. Graph of differences in soybean plant height between treatments B0-B5

The treatment of palm oil shell biochar and municipal waste compost had a significant effect on the average height value of soybeans. Plant growth without treatment showed lower plant growth compared to treatment with oil palm shell biochar and compost fertilizer. The height growth of soybean plants treated with palm oil shell biochar and municipal waste compost increases every week. In the 2nd and 3rd measurements after planting, plant height growth showed a response to the provision of palm oil shell biochar and municipal waste compost with normal growth. However, the 4th to 7th measurements showed significant growth even though the plant height did not meet the description of Anjasmoro soybeans because the oil palm shell biochar treatment and municipal waste compost given were not able to optimally contribute the nutrients needed by the soybean plants.

Plant growth is greatly influenced by soil water content. The water content in the soil greatly influences the consistency of the soil, the suitability of the land to be able to be cultivated and variations in soil water content affect the carrying capacity of the soil (Anwar *et al*., 2016). According to Soemarno (2004), one of the parameters for meeting plant water needs is the availability of plant water. The increasing availability of plant water due to the provision of compost causes the time span for using up the available water to become longer so that in analysis it gives the impression that plant water needs are low.

CONCLUSION

Application of a combined dosage of 7.5 tonnes/ha of palm oil shell biochar and 7.5 tonnes/ha of municipal waste compost represents the optimal composition for soybean production. This combination proves to be the most effective in influencing key aspects such as field capacity water content, permanent wilting point water content, and available soil water content. The dosage of 15 tons/ha of municipal waste compost stands out as the most beneficial treatment for enhancing the growth, increasing production yields, and augmenting the number of pods in soybean plants. These results underscore the significance of the specified doses in achieving optimal soil conditions and promoting robust soybean crop development.

REFERENCES

Anwar, S., D. Tjahyandari, K. Idris. 2016. Dasar-dasar Ilmu Tanah. Ed.2. Universitas Terbuka, Tanggerang . 334 hal.

Endriani. 2010. Sifat Fisika dan Kadar Air Tanah Akibat Penerapan Olah Tanah Konservasi. J. Hidrolitan. 1(1): 26-34.

Hardjowigeno S. 2010. Ilmu Tanah. CV

Akademika Pressindu, Jakarta. 97 Hal

Hasibuan A.S.Z. 2015. Pemanfaatan Bahan Organik dalam Perbaikan Beberapa Sifat Tanah Pasir Pantai Selatan Kulon Progo. Planta Tropika Journal of Agro Acience (3): 31-40.

Intara Y L, A. Sapei, N. Sembiring dan M.B. Djoefrie. 2011. Pemberian Bahan Organik pada Tanah Lempung dan Lempung Berliat Terhadap Kemampuan Mengikat Air. Jurnal Ilmu Pertanian Indonesia. 16 (2):130 -135

Murtilaksono, K dan E. D. Wahyuni. 2004. Hubungan Ketersediaan Air Tanah dan Sifat-Sifat Dasar Fisika Tanah. Jurnal Tanah dan Lingkungan 6(2): 46-50

Nurida NL dan Undang K. 2009. Perubahan Agregat Tanah pada Ultisol Jasinga Terdegradasi Akibat Pengolahan Tanah dan Pemberian Bahan Organik. Jurnal Tanah dan Iklim No. 30

Sandrawati, A., E.T. Sofyan, & O. Mulyani. 2007. Pengaruh kompos sampah kota dan pupuk kandang sapi terhadap sifat kimia tanah dan hasil tanaman jagung manis (*Zea mays saccharata*) pada Fluventic Eutrudepts asal Jatinagor Kabupaten Sumedang. Laporan Penelitian Dasar (LITSAR). Universitas Padjadjaran.

Soemarno, M.S. 2004. Manajemen Sumberdaya Air dan Pengelolaan Air Tanah Bagi Tanaman, Program Pascasarjana Universitas Brawijaya, Malang.

Subowo, G. 2011. Penambangan sistem terbuka ramah lingkungan dan upaya reklamasi pasca tambang untuk memperbaiki kualitas sumberdaya lahan dan hayati tanah. Jurnal Sumberdaya Lahan. 5(2):83–94. ISSN 1907-0799. Balai Penelitian Tanah Bogor.

Sujana P dan Nyoman L 2015. Pengelolaan Tanah Ultisol Dengan Pemberian Pembenah Organik *Biochar* Menuju Pertanian Berkelanjutan. Agrimeta : Jurnal Pertanian Berbasis Keseimbangan Ekosistem. 5(9): 01-09.

Wiskandar. 2017. Pengaruh Abu Terbang Batubara dan Pupuk Kandang Terhadap Produktivitas Lahan Bekas Tambang Batubara. Disertasi. Universitas Andalas.