



THE EFFECT OF COAL WASTE BOTTOM ASH SURALAYA STEAM POWER PLANT AS A GROWING MEDIUM FOR OIL PALM SEEDLINGS

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Abstract

The purpose of this study was to compare the combination of planting media, including soil and solid organic fertilizer type, and bottom ash. The experiment used the Randomized Complete Block Design method. The design was achieved through a combination of organic fertilizer types A, B, C, D, E, F, G, H, I, J, K, L, and M, along with soil media. The number of treatments consisted of thirteen, repeated three times. The ratio of planting media 67% soil and 33% Solid organic fertilizer bottom ash D type (organic material derived from legumes and *Tithonia diversifolia* can provide a height of oil palm seedlings 28.57 cm at the age of twelve weeks after planting (WAP). At the same age and the same combination ratio, ion uptake and absorption of the best of potassium (K) by oil palm seedlings. The good Shoot Root ratio was given by a combination of media, 67% soil and 33% solid organic fertilizers, and bottom ash. Similarly, in the oil palm rhizosphere, the balance of media 67% soil and 33% solid organic fertilizer bottom ash was found to contain microorganisms *Lactobacillus sp*, *Streptomyces sp*, and *Bacillus sp*

Keywords: Bottom ash, planting media composition, oil palm seeds.

INTRODUCTION

Bottom ash coal ash from the Suralaya Steam Power Plant (PLTU), located in Banten Province. A Steam Power Plant (PLTU) is a power plant that uses steam to rotate turbines and generate electricity. Bottom ash is a solid waste product generated from the combustion of coal to produce steam. Bottom ash is a coarser, heavier fraction and has a darker color compared to fly ash. Bottom ash, along with fly ash, is a byproduct of the coal combustion process and has the potential to be used in agriculture and plantation crops. Solid organic fertilizer has been applied to several plant commodities in the UBP PLTU Suralaya Merak Greenhouse Experimental Garden and field applications. The author has conducted a lot of research with a long road map in the utilization of coal ash waste for agriculture. In 2011 the author conducted a study on the application of Bokashi Bottom ash for vetiver plants (Effect Of Bokashi Bottom Ash Dosages On The Growth Of Vetiver Grass (*Vetiveria Zizanioides*) And Its Lead Content and previous application in 2009



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the author published Application of bokashi bottom ash for increasing upland rice yield and decreasing grain Pb content in vitric hapludans The application of solid organic fertilizer Bottom ash has been tested with Ultisol soil media from the Suralaya Merak PLTU area, Pulo Merak District, Banten Province which is dominated by Kaolinite clay minerals. Solid organic fertilizer bottom ash has been applied to oil palm seedling seedlings . President Joko Widodo has removed coal waste from the hazardous and toxic waste (B3) category for coal-fired power plants (PLTU). This provision is stipulated in Government Regulation (PP) Number 22 of 2021 concerning the Implementation of Environmental Protection and Management. Reinforced by Jekki Irawan and Dewi Andriani (2025), other FABA (fly ash and bottom ash) contains silica (SiO_2), iron oxide (Fe_2O_3), aluminum oxide (Al_2O_3), potassium oxide (K_2O), magnesium oxide (MgO), and sulfate (SO_4), which play an important role in supporting the growth of onion plants.

President Joko Widodo has removed coal waste from the hazardous and toxic waste (B3) category for coal-fired power plants (PLTU). This provision is stipulated in Government Regulation (PP) Number 22 of 2021 concerning the Implementation of Environmental Protection and Management.

ROAD MAP STUDY ON COAL ASH WASTE UTILIZATION AS FERTILIZER IN COLLABORATION WITH THE EDUCATION AND WELFARE FOUNDATION PT. INDONESIA POWER AND PT. EPN (ENERGI PRIMA NUSANTARA) YPK PT. IP CHAIRPERSON: Prof. Dr. Ir. Nunung Sondari, MP.	
PERIOD	ACTIVITIES
1998-2000 	RESEARCH ON THE UTILIZATION OF COAL FLY ASH WASTE FOR FOOD CROPS ON ANDISOL SOIL AT THE UNWIM EXPERIMENTAL FARM IN TANJUNGSARI AND ON ULTISOL SOIL IN PURWAKARTA
2001-2005 	STUDY ON THE UTILIZATION OF COAL COMBUSTION RESIDUES: FLY ASH AND BOTTOM ASH SOME PHYSICAL AND CHEMICAL PROPERTIES OF SOIL, NUTRIENT CONCENTRATIONS, AND YIELD OF SORGHUM (<i>Sorghum bicolor</i> L. Moench) AS AFFECTED BY THE APPLICATION OF COAL COMBUSTION ASH (CCA) AND GREEN MANURE ON TYPIC KANHAPLUDULTS
2006-2010 	1. STUDY ON THE FORMULATION OF COAL ASH WASTE INTO FERTILIZER USING 8 RK KB FORMULATIONS AT THE UNWIM EXPERIMENTAL STATION 2. TESTED ON RADISH TUBER CROPS AT THE UNWIM EXPERIMENTAL FARM WITH HEAVY METAL CONTENT ANALYSIS 3. FIELD TESTS ON VETIVER GRASS (<i>Vetiveria zizanioides</i>) AND UPLAND RICE
2011-2012 	STUDY ON THE UTILIZATION OF SOLID ORGANIC FERTILIZER FROM BOTTOM ASH YPK-IP FOR VARIOUS FORESTRY/TIMBER SEEDLINGS, PLANTATION AND FRUIT CROP SEEDLINGS, AND FOOD CROPS IN GREENHOUSE AND SCREENHOUSE CONDITIONS AT THE UBP PLTU SURALAYA EXPERIMENTAL GARDEN, MERAK, BANTEN PROVINCE
2013 	FIELD TRIAL OF SOLID ORGANIC FERTILIZER FROM BOTTOM ASH ON VARIOUS FRUIT AND TIMBER PLANTS AT FIELD G, UBP PLTU SURALAYA EXPERIMENTAL FARM, MERAK, BANTEN PROVINCE
2014 	VISIT OF MR. ISSEI IKENO FROM JAPAN, MANAGER OF HOKURIKU THERMAL POWER PLANT (HOKURIKU ELECTRIC POWER COMPANY) FOR A COMPARATIVE STUDY ON THE UTILIZATION OF FLY ASH IN AGRICULTURE

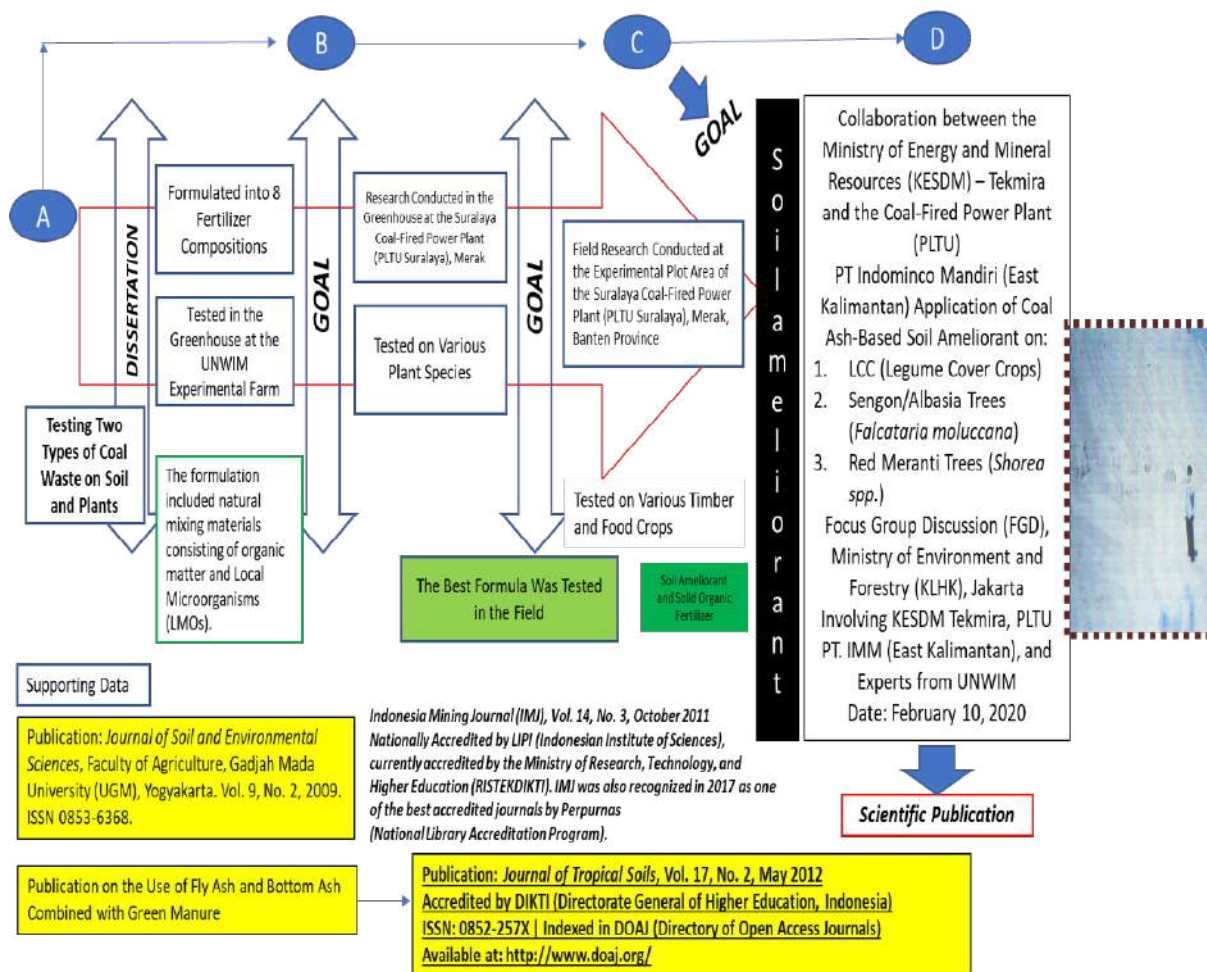


Figure 1. Road Map of Study The Effect of Coal Waste Bottom Ash

Table 1. Quality Test Results of Bottom Ash Solid Organic Fertilizer

No	Parameter	Unit	Quality Standards	Hasil Analisis Sampel
A	Mikroba			
1	Rhizobium sp (N-anchor)	CFU/g	$>10^3$	4.56×10^4
2	Azotobacter sp (N-anchor)	CFU/g	$>10^3$	1.25×10^6
3	P Solvent Bacteria	CFU/g	$>10^3$	7.73×10^5
4	Aspergillus sp	Propragul/g	-	2.10×10^3
B	Functional Tests			
1	Solvent Activity P	-	Positive	Positive
C	Hormone content			
1	Giberelin	Ppm	-	174.19
2	Kinetin	Ppm	-	51.48
3	Zeatin	Ppm	-	70.31

Analyzed at the Soil Training Center, IPB Cimanggu. Bogor

PT PLN Sawah Lunto (2022) helped farmers around the Ombilin Steam Power Plant (PLTU) increase the productivity of agricultural land, such as rice, corn, and shallots, by utilizing fertilizer derived from coal combustion ash, or Fly Ash and Bottom Ash (FABA). PLN also collaborated with the Research and Development Agency of the Ministry of Agriculture of West Sumatra Province to analyze the use of FABA from the Ombilin PLTU to increase the productivity of agricultural land, such as rice, corn, and shallots. Ismon Lenin (2022) an Associate Researcher in Soil Science at the Ministry of Agriculture's Research and Development Agency, stated that through a study on the use of coal ash from the Ombilin PLTU, the provision of 5 tons of FABA per hectare can increase corn productivity by 15.15 percent and paddy productivity by 15.16 percent.

MATERIALS AND METHODS

Bottom ash from Suralaya Steam Power Plant (PLTU), Banten Province. The manufacture of Solid Organic Fertilizer Bottom ash was carried out in the Greenhouse of the Faculty of Agriculture, Universitas Winaya Muktiin Tanjungsari, Sumedang Regency, and the Greenhouse of Suralaya PLTU. Certified palm oil seeds PPKS IOPRI Marihat Medan. Ultisol soil media (Podzolic Yellowish red) from the Suralaya Merak PLTU area, Pulo Merak District, Banten Province, which is dominated by Kaolinite clay minerals, analyzed through XR-D, is listed below. In each horizon (soil layer) up to a depth of > 80 cm, the clay mineral kaolinite dominates, which is a characteristic of Ultisol (strongly acid clays) acid silicate and Fe, Al oxides, wet tropical and subtropical forests. The soil was taken from a processing tillage depth of 0 to 20 cm. Soil physics information data is shown in the X-ray Diffractogram results.

The results of the analysis of clay mineral fractions using the X-ray diffraction (XRD) method with four types of treatments, namely saturation, Mg^{++} glycerol, K^{+} saturation, and Mg^{++} heating to 550 °C, found the dominant clay mineral, namely kaolinite (clay type 1:1). it appears that the peak value of the saturation results of Mg^{++} , Mg^{++} glycerol, and K^{+} is 7.1 Ao to 7.2 Ao. The peak collapsed with a heating treatment of 550 °C. These characteristics indicate the presence of type 1:1 minerals, namely kaolinite (Dixon and Weed, 1989). According to Sanchez's (1976) opinion, Ultisols are characterized by a high content of type 1:1 clay minerals, oxides, or hydroxides of aluminum (Al) and iron (Fe).

Table 2. The analysis of clay mineral fractions

No	Code	Soil Depth	Semektit	Vermikulit	Kaolinit	Ilit	Kuarsa	Gibsit
1	N1/I	0-12 c,		(+)	+++			
2	N1/II	12-37 cm			++++			
3	N1/III	37-83 cm			++++			
4	N1/IV	83-120 cm			++++			

Information: ++++ = predomnan, +++ = dominan, ++ = enough, + = a little (+) = very few

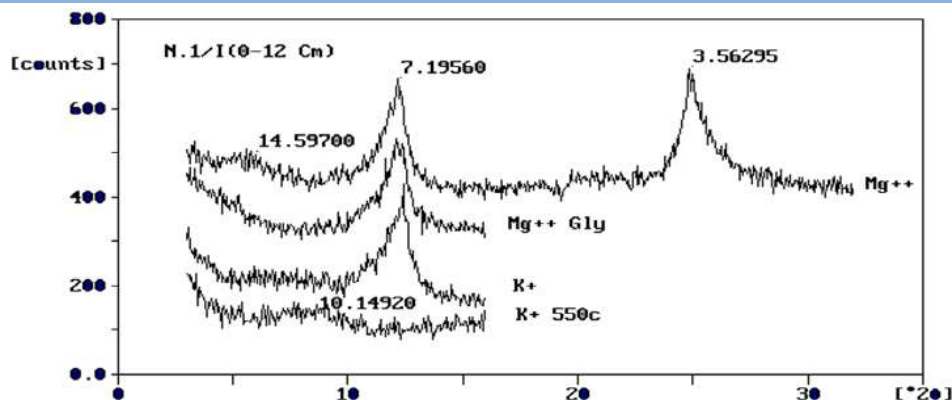


Figure 2. Several peaks for determining clay minerals and Mg⁺; Mg⁺⁺Glycerol; K⁺ and K⁺ 550 °C. at a soil depth of 12 cm – 37 cm

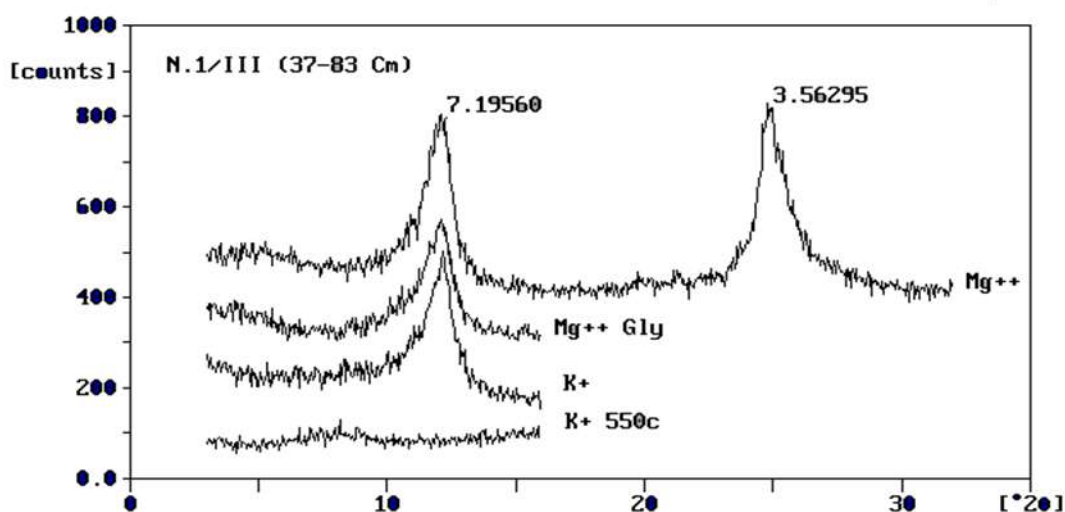


Figure 3. Several peaks for determining clay minerals and Mg⁺; Mg⁺⁺Glycerol; K⁺ and K⁺ 550 °C. at a soil depth of 37 cm – 83 cm

The tools used include small buckets, PVC pipes, scales, rulers, soil sieves, hoes, thermometers and electric hygrometers, measuring cups, sprayers, large buckets, measuring cups, calipers, ovens, desiccators, electrode pH, Kjeldahl devices, spectrophotometers, Atomic Absorption Spectrophotometers (AAS), XR-D, and stationery. The experimental method used was a Randomized Complete Block Design (RCB) that combined the types of bottom ash organic fertilizer with soil media composition. There were 13 treatments, each with three replications. The purpose of replication was to estimate experimental error and increase the accuracy of measuring the effects of the treatments. Three replications resulted in a total of 39 experimental units. This experimental treatment studied the combination of bottom ash solid organic fertilizer with the planting media composition for palm oil (*Elaies guenensis*) trees planted on Ultisol (Typic Kanhapludults).

The ratio used in this planting media was a volume ratio. The types of treatments in this study are as follow :

A=1 : 0 (100% soil media: Without solid organic fertilizer bottom ash)
 B=1 : 1 (50% soil : 50% Solid organic fertilizer bottom ash type A)
 C=1 : 1 (50% soil : 50% Solid organic fertilizer bottom ash type B)
 D=1 : 1 (50% soil : 50% Solid organic fertilizer bottom ash type C)
 E=1 : 1 (50% soil : 50% Solid organic fertilizer bottom ash type D)
 F=1 : 2 (33% soil : 67% Solid organic fertilizer bottom ash type A)
 G=1 : 2 (33% soil : 67% Solid organic fertilizer bottom ash type B)
 H=1 : 2 (33% soil : 67% Solid organic fertilizer bottom ash type C)
 I = 1 : 2 (33% soil : 67% Solid organic fertilizer bottom ash type D)
 J= 2 : 1 (67% soil : 33% Solid organic fertilizer bottom ash type A)
 K=2 : 1 (67% soil : 33% Solid organic fertilizer bottom ash type B)
 L= 2 : 1 (67% soil : 33% Solid organic fertilizer bottom ash type C)
 M=2 : 1 (67% soil : 33% Solid organic fertilizer bottom ash type D)

Information: type A= organic rice straw; type B= organic banana stem ; type C= organic market waste; Type D = organic Leguminosae + *Tithonia diversifolia*

Based on the results of the analysis of variance that has been calculated, the difference in the average values of the treatments must be known. To determine this difference in the average values of the treatments, a further Scott-Knott test is used at a 95% significance level.

RESULTS AND DISCUSSION

Height of oil palm seed plants

The average height growth of oil palm plants aged 2 weeks after planting (WAP) has begun to show a significant difference between treatments. However, there is no significant difference between the treatments of 33% and 50% organic bottom ash fertilizer compared to unfertilized oil palm plants. In fact, some of the plants given 67% fertilizer showed somewhat slower growth compared to other treatments.

This is because the application of up to 67% fertilizer is an excessive fertilizer volume ratio for oil palm plants. At the ages of 6, 8, 10, and 12 weeks after planting, there is a very significant difference between the growth of oil palms fertilized with 33%, 50%, and 67% organic bottom ash fertilizer and those without. This indicates that there has been an increase in the decomposition and mineralization process of the organic bottom ash fertilizer, resulting in an increase in the availability of macro- and micro-nutrients contributed by the fertilizer. An increase in the number of oil palm leaves accompanies the rapid increase in plant height. The CaO and MgO oxides contained in the bottom ash can function like agricultural lime, improving soil acidity. The micronutrients contained in the bottom ash include Zn (0.028%), Mn (0.03%), and B (0.08%).

The bottom ash contains 2.68% CaO, 3.10% MgO, and a pH of 8.5. Ash bottom ash, growing media, and cow manure on plant height, leaf width, leaf length, number of leaves, and dry weight of mustard plants. Supported by the opinion of (Barajuang et al, 2023) based on the growth standards of oil palm seedlings in the pre-nursery at the age of 3 months, the seedling height shows 20.0 cm, stem diameter 1.3 cm, and the number of fronds is 3-4 fronds.

Table 3. Average Height of Oil Palm Plants Aged 2, 4, 6, 8, 10, and 12 Weeks After Planting (WAP) Due to the Ratio of Soil Media Volume to Bottom Ash Solid Organic Fertilizer.

Treatment	Average plant height (cm)					
	2 WAP	4 WAP	6 WAP	8 WAP	10 WAP	12 WAP
A	3.35 b	9.28 b	13.92 b	17.68 b	20.33 b	24.32 b
B	2.80 a	7.90 b	12.93 b	17.10 b	20.45 b	23.12 b
C	2.67 a	8.23 b	12.07 b	16.62 b	20.07 b	22.63 b
D	2.95 a	8.27 b	13.37 b	17.65 b	20.73 b	24.47 b
E	2.68 a	8.27 b	12.50 b	17.63 b	20.80 b	24.40 b
F	2.65 a	6.55 a	9.42 a	12.62 a	14.33 a	15.42 a
G	2.62 a	5.60 a	7.32 a	11.10 a	12.58 a	13.12 a
H	2.53 a	5.10 a	7.10 a	10.90 a	13.25 a	14.70 a
I	2.82 a	6.17 a	9.92 a	12.30 a	15.37 a	16.08 a
J	3.15 b	8.92 b	16.15 c	20.12 c	23.43 c	27.32 c
K	3.35 b	9.72 b	16.65 c	21.27 c	27.20 c	29.12 c
L	3.40 b	9.00 b	16.32 c	20.23 c	23.57 c	27.30 c
M	3.20 b	8.98 b	16.40 c	20.17 c	23.62 c	28.57 c

Description: The average numbers followed by the same letter are not significantly different according to

The Scott Knott Test at a significance level of 5%.

Number of leaves

The average number of leaves increased every two weeks after planting. At twelve weeks after planting, the treatments on media J, K, L, and M showed the highest number of leaves.

Table 4. Average Number of Oil Palm Leaves Aged 6, 8, 10 and 12 Weeks After Planting (WAP) Due to the Ratio of Soil Media Volume to Bottom Ash Solid Organic Fertilizer.

Treatment	Average Number of Oil Palm Leaves			
	6 WAP	8 WAP	10 WAP	12 WAP
A	1.35 a	2.53 a	2.78 a	3.25 a
B	2.00 b	2.00 b	3.00 b	3.83 b
C	1.83 b	2.00 b	2.83 b	3.50 b

D	2.17 b	2.19 b	3.00 b	3.83 b
E	2.00 b	2.00 b	3.00 b	3.67 b
F	1.50 a	1.33 a	2.33 a	2.50 a
G	0.83 a	1.50 a	1.83 a	1.67 a
H	1.00 a	1.17 a	2.17 a	2.83 a
I	1.33 a	1.66 a	2.50 a	3.00 a
J	2.17 b	2.50 c	3.33 b	4.17 b
K	2.33 b	2.67 c	3.50 b	4.50 b
L	2.33 b	2.50 c	3.33 b	4.00 b
M	2.17 b	2.67 c	3.33 b	4.16 b

Note: Means followed by the same letter are not significantly different according to the Scott-Knott test at the 5% significance level.

Potassium Uptake and Shoot Root Ratio

The average potassium content in oil palm seeds with a media ratio of 67% soil and 33% Solid organic fertilizer bottom ash type K, L, M shows sufficient potassium ion uptake levels with increased K absorption. The S/R ratio in the media balance of 67% soil and 33% solid organic fertilizers, with bottom ash increased, is very suitable for oil palm seeds, indicating that all photosynthate is translocated to the shoot part of the oil palm seeds.

Table 5. Average K (Potassium) uptake and Absorption and Root Destruction Ratio of Oil Palm Plants 12 Weeks After Planting (WAP) due to the Ratio of Soil Media Volume to Bottom Ash Solid Organic Fertilizer.

Treatment	Average		
	Potassium up take (%)	Potassium Absorp g/plant	Shoot/Root Ratio (S/R Ratio)
A	1.66 a	7.66 b	4.54 b
B	2.28 b	8.09 b	4.61 b
C	3.22 c	8.99 b	4.80 b
D	2.46 b	8.07 b	3.01 a
E	2.69 b	9.05 b	3.31 a
F	2.49 b	4.36 a	3.66 b
G	2.28 b	0.98 a	1.93 a
H	2.35 b	3.94 a	3.86 b
I	2.36 b	5.46 a	3.76 b
J	2.91 c	18.93 c	4.27 b
K	3.23 c	21.10 c	4.15 b
L	3.45 c	23.53 c	4.13 b
M	3.78 c	24.57 c	6.84 c

Description: The average numbers followed by the same letter are not significantly different according to the Scott-Knott Test at the 5% significance level.



Figure 4. Photo of The age of oil palm seeds 6 weeks after planting shows that growth in L media (67% soil: 33% solid organic fertilizers bottom ash type C), M (67% soil: 33% solid fertilizers bottom ash D type) is better compared to treatment G (33% soil: 67% solid organic fertilizers bottom ash).

The growth of oil palm seeds appears healthy, with an increase in growth compared to 100% soil media. The results of the analysis of organic bottom ash fertilizer in type A are the beneficial microorganism population, the total N-fixing bacteria population is 2.3×10^{10} CFU / g, the total fungi are 1.4×10^5 CFU / g; in type B the total N-fixing bacteria are 1.7×10^{10} CFU / g and the total fungi are 6.5×10^5 CFU / g; type C the total N-fixing bacteria are 2.3×10^{10} CFU / g total fungi are 6.2×10^5 CFU / g; type D the total N-fixing bacteria are 3.1×10^{10} CFU / g and the total fungi are 9.0×10^5 CFU / g and the results of the analysis show that the organic bottom ash fertilizer contains humic and fulvic acids.

There was an increase in K absorption by oil palm plants, and the highest K absorption was by oil palm plants given 33% solid organic fertilizer bottom ash media volume. The increase in K absorption caused the diameter of the oil palm seedling stem to increase as well. There was a 33% increase in stem diameter for oil palm plants given 50% fertilizer, 50% with 67% fertilizer, and even 60% with 67% fertilizer. The diameter of the oil palm seedling stem is critical to pay attention to, because it is the seedling of the strength of the oil palm seedling for TBM (Immature Plants) before being transferred to the TBM plantation nursery. Hal itu didukung oleh Muhammad Rifki Firmansya (2025) The best FABA composition is fly ash $\geq 60\%$ and bottom ash $\leq 20\%$. Plants require a longer time to raise the pH of AMD.



Figure 5. Photo of Oil palm seeds 8 weeks after planting



Figure 6. Image. Oil palm seeds 12 weeks after planting
(Doc. Greenhouse YPK IP. PLTU Suralaya Merak, Banten Province)

Beneficial microorganisms such as *Lactobacillus* sp, *Streptomyces* sp, and *Bacillus* sp were found in the rhizosphere of oil palm seeds treated with treatments J, K, L, and M, as shown in the figure below. This demonstrates that the growing medium, comprising 67% soil and 33% bottom ash solid organic fertilizer, is capable of supporting the life of functional microorganisms beneficial to the rhizosphere of oil palm seeds.

Chelo
<https://>





Figure 7. The architecture of the root zone of oil palm seedlings in Soil : Organic fertilizers bottom ash in the greenhouse of the Suralaya steam power plant, Banten province.

CONCLUSION

The ratio of planting media, comprising 67% soil and 33% Solid organic fertilizer, bottom ash type D (organic material derived from legumes and *Tithonia diversifolia*), can provide a height of oil palm seedlings of 28.57 cm at the age of 12 weeks after planting. At the same age and with the same combination ratio, the best potassium (K) ion uptake by oil palm plants occurred. The good Shoot Root ratio was given by a combination of media, 67% soil and 33% solid organic fertilizers, bottom ash. Similarly, in the oil palm rhizosphere, the balance of media 67% soil and 33% solid organic fertilizer bottom ash was found to contain microorganisms *Lactobacillus sp*, *Streptomyces sp*, and *Bacillus sp*.

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