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Research Article

Utilization of oil palm empty bunches waste as biochar-microbes for improving availability of soil nutrients

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Abstract : There are about 23% waste oil palm empty fruit bunches (OPEFB) of total waste generated from the production of crude palm oil in oil palm plantations. Pyrolysis technology can be used to convert waste into biochar and further can be utilized for the improvement of soil. Biochar-microbes of OPEFB are biochar from OPEFB biomass that enriched with soil microbes. Biochar-microbes is expected to be used for the improvement of the soil and plants. Therefore the purpose of this research was to study the ability of biochar-microbes OPEFB to increase availability of the nutrients in sandy soils. The process of making biochar done by using slow pyrolysis technology by heating 300^{o}C and 400^{o}C for 2 and 3 hours, and with sizes 40 and 80 mesh, as well as indigenous microbial *Bulkhorderia nodosa* G.52.Rif1 and *Trichoderma* sp.) added. The biochar production and research were conducted in the Department of Forestry Laboratory and in the Department of Agronomy Laboratory, Faculty of Agriculture, Palangka Raya University. In general, the study showed that biochar-microbes could maintain the soil pH value and tends to increase the soil pH, increasing the holding capacity of sandy soil to the elements of P and K as well as increasing the availability of nutrients N, P and K. Furthermore, this study showed that the biochar process by 400^{o}C heating for 3 hours and 40 mesh with microbes or without microbes were the best effect on the improvement of the quality of holding capacity and the nutrients supply in sandy soils.

Keywords *: biochar-microbes, biochar, oil palm empty fruit bunches*

Introduction

Indonesia is currently the producer of CPO (crude petroleum oil) in the world. Every year, an increase in plantation area, production and productivity. Increased production of CPO clearly led to an increase in waste generated. Solid waste is the most widely discarded waste which is about 23% of the total waste (Indriyati, 2008). Pyrolysis is one of technology to convert oil palm empty fruit bunches (OPEFB) into biofuels, gas and biochar. Malaysia is a country that has been using the technology.

Pyrolysis technology to convert oil palm empty fruit bunches (OPEFB) into biofuels, gas and biochar is not a new thing because it was done by the state CPO producer in the world as Malaysia (Sukiran et al., 2011; Vanderbosth et al., 2007; Yang et al., 2006). Oil palm empty fruit bunches biomass processed into biochar is a strategy to undertake sustainable oil palm plantations. Harsono et al. (2011) mentions that the results of a Life Cycle Analysis (LCA) of OPEFB biochar showed a positive energy balance of about 25%. The biochar analysis showed that the low emissions of CO_2, N_2O and CH_4. Some research on agricultural land that has been given biochar provides benefits such as maintaining the nutritional and cations, decreasing soil acidity, decreasing absorption of toxic soil, improving soil structure, using of nutrients efficiently, maintaining water holding capacity and decreasing the compounds of non-CO_2 and greenhouse gases (CH_4, N_2O) (Krull, 2011). Research on the best temperature and retention time of making biochar from OPEFB has not been done, further, there is still limited knowledge about biochar from oil palm empty fruit bunches combined with microbes to the improvement of soil fertility and plant growth and efficiency and reduce the use of chemical fertilizers. Therefore the purpose of this research was to study the ability of microbe-enriched biochar oil palm empty bunches to increase holding capacity and availability of the nutrients in sandy soils.

Materials and Methods

In this study, materials used are follows the OPEFB, biochar of OPEFB, microbes *Bulkhorderia nodosa* G.52.Rif1 *and Trichoderma sp*.), sandy soil, and fertilizers. The OPEFB biomass derived from PT. Sawit Bina Abadi (Sinar Mas Group) oil palm plantations, Seruyan Regency, Central Kalimantan Province. Biochar of OPEFB production conducted in the Department of Forestry Laboratory, Faculty of Agriculture, University of Palangka Raya. Microbes used is indigenous peatland microbial. These microbes are results study collection of Nion and Toyota (2008). Sandy soil taken from cultivation of land in the village of Bukit Tunggal, Palangka Raya.

Biochar was made by using a temperature 300^{o}C and 400^{o}C, withtime of biochar manufacturing for 2 and 3 hours (Kong et al., 2011; Sukiran et al., 2011). Biochar is filtered with a sieve size of 40 and 80 mesh and added microbes such as *Bulkhorderia nodosa* G.52.Rif1 *and Trichoderma sp*. Biochar from OPEFB that have been added microbes to the next in this paper is called the *biochar-microbes.* The biochar-microbes that are ready to be applied to sandy soil was given at a dose of 7.5 ton/ha. Fertilization was done with a dose of N in the form of (300 kg Urea/ha), K (200 kg KCl/ha) and P (SP-36 200 kg/ha). One kg soil dry-air that has been mixed with biochar-microbes and fertilizer was placed in the leaching tube and incubated for 1 month.

At an incubation period of soil, soil moisture content was maintained at 100% field capacity conditions. After 1 month of incubation, leaching of nutrients from the soil carried out by means of the work done by Salampak (2002). Leaching carried out after the incubation period was completed by providing water according to the calculations of rainfall. Observation have done to the pH of leached water, nutrient content of N, P, and K in water leached, soil pH and nutrient content of N, P and K soil. Soil pH in 1 : 2.5 ratio solution (with water deionized) and water pH were measured with a pH meter.Water leached was filtered by filter paper to get the filtrate. It will used for total N, P-dissolved and K-dissolved. Phosphorus dissolved determined using filtrate treated with bluemolidenumphosphate and measured by spectrofotometer 693 nm. Filtrate added with $LaCl_3.7H_2O$ and determined with flamefotometer for K-dissolved measurement. Total N content of soil was determined by the Kjedhal methods with added H_2SO_4-selenium extract and destillated. Avalibility of P soil was extracted by P-Bray I method and determined using the bluemolibdenumphosphate procedure with spectrofotometer 693 nm. Exchangable of K was percolated by NH_4OAc pH 7 and determined with flamefotometer.

Results and Discussions

Existing soil properties before applying of biochar-microbes

Results of initial soil analysis (Table 1) shows that soil have the pH (acid soil), soil CEC, the arrangement of cations and base saturation are low. However, the soil have very high P-available because of the content of the Al-dd quite low. Soil C / N ratio is very low so that the risk of having a low organic matter.

pH and nutrient conditions on water leached and leached soil after application biochar-microbes

In Table 2 shows that the pH value of the leachate on soil with biochar-microbes is lower than the pH value of water leached the soil without biochar-microbes. Nonetheless, the pH value is able to survive at a neutral pH range is about pH 7. The biochar-microbes treatment given on sandy soil microbes indicated that aplication microbes to the biochar OPEFB can provide soil pH values higher than a given soil biochar without microbes. Differences in temperature, time of manufacture and the mesh size of biochar does not give a significant difference in the pH value of the soil sand.

The existence of microbes on biochar OPEFB showed that there is a trend of the effect of biochar in reducing the loss of P and K from the sandy soil. It can be seen from the analysis of P and K in water leached in Table 2 which shows the tendency of decreasing in the concentration of P-dissolved and K-dissolved in water leached from the soil given the biochar-microbes. The effect of the application of biochar-microbes on total N content in soil showed that the presence of microbes can improve the N total soil in the sandy soil.

Table 1. the Initial chemical of soils and after fertilizing of N, P, and K fertilizers

pH H_2O (1:2.5)	CEC (cmol/kg)	Exchangeable cations (cmol/kg)					P-Bray I (mg/kg)	Total-N (%)	Organik C (%)
		K^+	Ca^{2+}	Mg^{2+}	Na^+	Al^{3+}			
Initial soils condition									
5.00	10.99	0.13	0.60	0.09	0.06	2.83	52.77	0.91	0.72
Soil condition after fertilizing									
7.88	16.62	1.07	4.69	0.38	0.62	0.34	141.76	1.49	0.76

Table 2. Analysis results of pH value and nutrient content on water and soil leached after aplication of biochar-microbes treatment

Sample	Biochar wihout microbes				Biochar-microbes			
	pH	N-total (%)	P-dissolved (mg/kg)	K-dissolved (mg/kg)	pH	N-total (%)	P-dissolved (mg/kg)	K-dissolved (mg/kg)
Water leached								
$T_1W_1S_1$	8.73	0.74	28.49	75.01	9.04	0.55	24.00	30,12
$T_1W_1S_2$	8.69	0.11	124.22	34.15	8.59	0.58	108.98	31,84
$T_1W_2S_1$	8.82	0.74	92.69	75.01	8.95	0.47	51.46	29,68
$T_1W_2S_2$	8.58	0.31	90.08	124.30	8.93	0.53	67.95	77,87
$T_2W_1S_1$	8.94	0.10	92.75	124.30	8.72	0.48	95.98	34,58
$T_2W_1S_2$	8.71	0.13	125.06	31.23	8.58	0.51	46.86	74,40
$T_2W_2S_1$	8.81	0.51	50.31	30.92	8.98	0.67	59.18	76,37
$T_2W_2S_2$	8.81	0.59	106.68	25.74	8.91	0.62	37.88	77,37
	pH (1:2.5)	N-total (%)	P-Bray I (mg/kg)	K-exch (cmol/kg)	pH (1:2.5)	N-total (%)	P-Bray I (mg/kg)	K-exch (cmol/kg)
Soil leached								
$T_1W_1S_1$	7.35	2.52	146.82	2.38	7.36	0.06	138.73	1,24
$T_1W_1S_2$	7.46	2.56	149.16	1.88	7.24	17.59	153.08	1,98
$T_1W_2S_1$	7.57	0.06	141.71	1.13	7.52	5.82	142.40	3,85
$T_1W_2S_2$	7.56	2.79	122.91	1.35	7.65	4.32	149.66	3,10
$T_2W_1S_1$	7.24	2.16	142.52	1.25	7.41	8.20	156.77	3,82
$T_2W_1S_2$	7.18	0.44	147.50	1.48	7.57	2.77	144.71	3,49
$T_2W_2S_1$	7.45	0.47	120.39	1.25	7.72	0.12	147.51	2,55
$T_2W_2S_2$	7.29	0.59	146.52	0.89	7.30	6.97	162.14	2,51

T_1 = Temperature of biochar manufacturing at 300°C, W_1 = Time of biochar manufacturing for 2 hours, S_1 = Size of biochar = 40 mesh T_2 = Temperature of biochar manufacturing at 400°C, W_2 = Time of biochar manufacturing for 3 hours, S_2 = Size of biochar = 80 mesh

Although there is an increasing the total N contained in the leached water. Based on the analysis of the morphology of biochar OPEFB with Scanning Electron Microscopy (SEM) showed that biochar-microbes has a group of organic compounds that is more than biochar without microbess (Jemi et al., 2015). The existence of the group of organic compounds thought to give microbes-biochar's ability to reduce the leaching of nutrients in the soil. Biochar produced from a different temperature (300°C and 400 °C) do not give a significant difference to changes in pH and nutrient value of the water and soils leached. The length of time of making biochar longer that 3 hours gave the effect to sandy soil tends to accelerate the release of N and K, except of P decreased concentration P leached. Aplication of biochar with time manufacturing for 3 hours to sandy soil gave the effect the low availibity of nutrients P and K in soil more than 2 hours, except on the N-total. The size of biochar (80 mesh) can help increase N total and availibity of P in sandy soil. Despite the availability of P-dissolved concentrations is higher in water leached from the soil added by biochar 80 mesh size.

The sandy soil have porous characteristic that causes the nutrient of soil loss through leaching process dominantly. If the N-total of soil is high, it will be trigger the N-soil losses through leaching process will be higher. The availibility of soil P increased significantly after fertilization P. Based on assessment of nutritional status, content of P-available soil is very high. However, the P-available high is followed high P nutrients leached from the soil (nutrient leaching patterns of P follows the availability of P in the soil). When calculated, the percentage of P which is leached from the P-available nutrients in the soil have about 50% of P-available will be lost through leaching.

Based on the amount of nutrients leached and nutrients availability, then each nutrient is classified in available nutrients leached as high, medium, and low. In order to determine biochar plus applicable, then chosen biochar plus who are in the lead group and available nutrients being leached, because if you choose a low leached nutrients too strong then allegedly bound (immobilized) so that the low availability for plants or leached high if it can happen unsynchronized with the needs of plants against such elements.

Selection of biochar-microbes based on leached and nutrient availability. Biochar-microbes should lead to conditions available and leached nutrient in medium catagory. When the low leached nutrients, nutrients will be firmly attached (immobil) to the low availability to the plants. High leached nutrient lead to discrepancies with the nutrient needs of plants. Based on the above considerations, the manufacturing technology of biochar from oil palm empty fruit bunches using temperature to 400°C, 3 hours, the size of 40 mesh (T2W2S1) either with or without the microbess need to be done further research to study the effects on aspects of soil fertility, growth and yield as well as efforts to fertilizer efficiency.

Conclusion

The use of biomass OPEFB in the form of biochar-microbes can help maintain the pH value of the soil and tends to increase the pH of the soil. Biochar-Microbes biochar improve soil retention of the P and K with the downward trend in concentrations of P and K in water and soil leached and the availability of nutrients N, P and K. In consideration of synchronization with the nutrient needs of plants, the best manufacturing of biochar is done by using 400°C temperature, 3 hours and 40 mesh either with microbes or without microbes.

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