UTILIZATION OF SUGARCANE FILTER PRESS MUD COMPOST AS ORGANIC FERTILIZER FOR IMPROVING CHEMICAL PROPERTIES OF ULTISOLS AND OIL PALM SEEDLINGS[†]

[UTILIZACIÓN DE COMPOSTAS DEL LODO DEL FILTRO DE LA PRENSA DE AZÚCAR COMO FERTILIZANTE ORGÁNICO PARA MEJORAR LAS PROPIEDADES QUÍMICAS DE ULTISOLES Y LAS SEMILLAS DE PALMA DE ACEITE]

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SUMMARY

Ultisols is suboptimal soil that have many problems those are low pH, nutrient deficiency and micronutrient toxicity and inhibit for crop growth and need ameliorant for improving the soil fertility. The aim of this research were to investigate the utilization of filter press mud compost for improving chemical properties of Ultisols and growth of oil palm seedling. This research consisted of five levels of compost (A=without compost, B= 4.25 t.ha^{-1},C=8.5 t.ha^{-1}, D=12.75 t.ha^{-1} and E=17 t.ha^{-1}) with three replications. The treatment units were allocated based on Randomized Block Design. The addition of filter press mud compost improving chemical properties of Ultisols especially pH value, decreasing Aluminum, total N 0.45%, organic C 2.19%, available P 37.14 ppm, CEC 22.04 cmol.kg$^{-1.}$ Filter press mud compost increased growth of oil palm seedling. Application of 12.75 t.ha^{-1} gave the optimum growth of oil palm seedlings. It showed that the crop height increased by 51.56%, leaves by 47.63%, N content by 2.26 %, P content by 0.18 % and K content by 1.44 %.

Keywords: Filter press mud; organic fertilizer; oil palm; ultisol.

RESUMEN

Ultisols es un suelo subóptimo que tiene muchos problemas, como pH bajo, deficiencia de nutrientes y toxicidad de micronutrientes e inhibe el crecimiento de los cultivos y necesita mejorar para mejorar la fertilidad del suelo. El objetivo de esta investigación fue investigar la utilización de composta del lodo del filtro de la prensa de azúcar para mejorar las propiedades químicas de los Ultisoles y el crecimiento de las plántulas de palma aceitera. Esta investigación consistió en cinco niveles de composta (A = sin composta, B = 4.25 t.ha^{-1}, C = 8.5 t.ha^{-1}, D = 12.75 t.ha^{-1} y E=17 t.ha^{-1}) con tres repeticiones Las unidades de tratamiento se asignaron según el diseño de bloques aleatorizados. La adición de composta de lodo de filtro prensa mejora las propiedades químicas de los Ultisoles, especialmente el valor de pH, disminuye el aluminio, total N 0.45%, orgánico C 2.19%, disponible P 37.14 ppm, CEC 22.04 cmol.kg^{-1}. La composta de lodo de filtro prensa aumentó el crecimiento de las plántulas de palma aceitera. La aplicación de 12,75 t.ha^{-1} dio el crecimiento óptimo de las plántulas de palma aceitera. Mostró que la altura del cultivo aumentó en un 51.56%, las hojas en un 47.63%, el contenido de N en un 2.26%, el contenido de P en un 0.18% y el contenido de K en un 1.44%.

Palabras Clave: Filtro prensa de lodo; fertilizante orgánico; aceite de palma; ultisol.

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INTRODUCTION

Plantation oil palm is the highest value in producing oil than the other comodities. Oil palm gives the highest oil yield per hectare of land compared to other major oilseed crops in the world such as sunflower and soybean (Foong *et al.,* 2018). To date, palm oil accounts for 65 Mt.yr^{-1} out of 215 Mt.yr^{-1} (30%) vegetable oil produced worldwide (R.E.A. Holdings PLC, 2018). According Directorate of General Plantation (2016) oil palm production increase from 29.3 t.yr^{-1} tons to 30 t.yr$^{-1.}$ Therefore, there is the discrepancy between needs and production. This problem can be solved with increased the population of oil palm in Indonesia, remember Indonesia is the largest producer around the globe (Muthusamy *et al.,* 2018) and Sumatra is the largest area to oil palm development. The addition of the population starts from oil palm seedling. The high quality of oil palm seedling required soil fertility by the chemical, physics and biology properties of soil, but fertil soil area in Indonesia is very limited because Indonesia have tropical climate with high humidity and temperature. From that climate Indonesia dominated by Ultisols. Indonesia have 41.9 Ha or approximately 25% Ultisols (Mulyani *et al.,* 2004). However Ultisols have problems with soil acidity presenting pH below 5.6 in addition, Al is the predominant cation, that problems make nutrient deficiency in Ultisols such as N, P, K because of intensive leaching proceess (Rheinheimer *et al.,* 2018). From that problem indicated that Ultisols have low soil fertility. Therefore it is important to slow down soil acidification and nutrient deficiency in Ultisols with soil amandement. Addition some ameliorant, lime and organic matter is an important source of cation exchanges sites in soil. Organic matter have weakly acidic carboxylic and pehnolic funtional groups absorb or provide protons as the soil pH decrease or rises, that material also can increases soil CEC (Shi *et al.,* 2018).

Besides animal waste, various materials like agroindustry waste such as sugarcane waste (filter press mud) can recycled as an organic fertilizer or soil amendement to agricultural land. Sugarcane filter press mud is the largest potential to environment pollution. According to PTPN III (2016) that 135.51 tons per seasons sugacane filter press mud produced by sugarcane factory. Satiro *et al* (2017) reported that sugarcane left in harvest is now considered one of the main raw material, that is potential to cellulosic. Therefore, is an important to composting of these waste together with cow manure and fertilizers to improve their chemical properties. Thus, the use of waste, both of animal and industrial origin, as nutrient sources in production is of paramount importance, because in addition to contributing to environmental sustainability by no longer having a status of polluters, they become an alternative in soil fertilization, decreasing the use of mineral fertilizers.

The objects of this study were to investigate the utilization of sugarcane filter press mud compost for improving chemical properties of Ultisols and this organic fertilizer improving growth of oil palm seedling.

MATERIALS AND METHODS

Soils and sugarcane filter press mud compost

Ultisols used in the experiment were collected from Agriculture Experiment Station of Andalas University, Limau Manis, Padang, West Sumatra Indonesia. Soil samples were taken from the surface layer (0-20 cm), air-dried, and ground so that they passed through a 2 mm sieve. A portion of the dried soil samples was taken of 8 kg.pot^{-1}. Sugarcane filter press mud compost were made by anaerobic system. This research mixture consisted of 75% of solid filter press mud and 25% of cow manure were expressed as wet weight. Each raw material weighed from the formula (7.5 kg sugarcane filter press mud and 2.5 kg cow manure). That material mixed until homogen Four open ventilated boxes were used in this study.

Experimental design

The experimental design was in randomized blocks with five treatments and three replications, totaling 15 experimental units. This research consisted of five level of organic fertilizer (without compost, B= 4.25 t.ha^{-1},C=8.5 t.ha^{-1}, D=12.75 t.ha^{-1}, and E=17 t.ha^{-1}). Each pot of Ultisols applied with dolomite 3.175 t.ha^{-1}. The observation such as growth of leaves and stem of oil palm seedling.

Soil sampling and analyzed parameters

The experiment was carried out for six months. The soil samples were air dried and sieved through a 2 mm mesh. The pH was determined in water at a soil:solution ratio of 1:2. P was determined with Bray II method (Soil Research Center, 2012), the levels of calcium (Ca), magnesium (Mg),and potassium (K) were extracted from Ammonium acetat 1N pH 7 (Soil Research Center, 2012). The sample also was ground to a fine powder and sieved with 0.5 mm, prior to the organic C with Walkley And Black method (Soil Research Center, 2012) and total N analyzed with Kjedhal method (Soil Research Center, 2012).

Statistical analysis

The statistical analyses were carried out using the software Statistix 8. To analyze the improved of chemical properties of Ultisols with sugarcane filter

press mud organic fertilizer submitted to an analysis of variance (ANOVA) and when significant (Ftest $p<0.05$), the means were compared using the Tukey test ($p<0.05$).

RESULTS AND DISCUSSION

Characteristic of sugarcane filter press mud organic fertilizer

The results of analysis chemical properties and content of sugarcane filter press mud organic fertilizer used for research showed in the Table 1.

Table 1 presents the results of analyses of chemical properties of filter press mud organic fertilizer. It should be noted that the moisture content and C/N ratio in sugarcane filter press mud compost were significantly lower than the raw material (pure filter press mud), reported by Fanny *et al* (2013) that filter press mud without composting proceess has C/N ratio by 50.1. The C/N ratio significantly affects the composting process. Sugarcane filter press mud compost is the efficient compost because has C/N ratio 50.1 from raw material. To ensure the efficiency of the composting process the C/N ratio of the input waste material should range between 20 and 40 with the moisture content (MC) maintained between 40% and 60% (Malinowski *et al.,* 2019).

Table 1 presents organic C of sugarcane filter press mud compost, from that table showed that organic C in compost significantly lower than without composting proceess. A low C/N ratio allows for a high temperature in the pile of composting materials, but also increases the loss of carbon (C) and nitrogen (N) causing undesirable emissions of CO_2 and ammonia into the atmosphere (Li *et al.,* 2016; Wang *et al.,* 2017). From Table 1 showed that Nitrogen in sugacane filter press mud compost higher than filter press mud without compost because sugarcane filter press mud compost have the other source of Nitrogen that is from cow manure. Based on Table 1 showed that filter press mud compost agree with National Standar of Indonesia's compost that is SNI-19-7030-2004 (National Standard Agency, 2004) therefore this compost have the high value of nutrient especially macro nutrient such as N 2.17%, P 0.29% and K 0.85% so that could support plant growth.

Soil characteristics

The soil used is an Ultisols Limau Manis as revealed by its low percentage base saturation or less than 35% (19.16%). The low base saturation indicated taht Ultisols have low bases such as Ca, Mg, K, Na this problem made nutrient deficiency in Ultisols. Ultisols formed in high humidity and temperature, this climate made intensive leaching process, therefore, Ultisols dominated by Hidrogen and Alumunium (Rheinheimer *et al.,* 2018). The initial Ultisols Limau Manis characteristics are presented in Table 2.

The soil in Limau Manis showed a high active acidity (pH H_2O) and Al saturation (50.17%). It has relatively made low pH and the particle size analyses showed that the soil is clay. This result agrees with the report of Tiecher *et al* (2016) that clay predominance could improving soil acidity until 5.5 units . High aicidity in Ultisols because of Indonesia especially in West Sumatra Climate is humid tropical climate with average annual rainfall of more than 5000 mm and average annual temperature 27ºC (BPSDA, 2018). Some of the chemical components before organic matter application showed that N, P, K, and organic carbon were of low value, which revealed that the soil is low in fertility. Soil acidity was corrected through the addition of lime and organic matter. This result used dolomite 3.175 $t.ha^{-1}$. This result agrees with the report of Tiecher *et al* (2018) that soil acidity was corrected through the addition of $CaCO_3$ and the othe lime.

Table 1.Chemical Characteristics of Sugarcane Filter press mud Organic Fertilizer

Parameters	Unit	Sugarcane Filter press mud Compost
pH value		7.05
Moisture content	%	54.77
C	%	36.84
N	%	2.17
C/N Ratio		16.98
P	%	0.29
K	%	0.85
Ca	%	0.94
Mg	%	8.93
Na	%	0.56
CEC	$cmol.kg^{-1}$	54.48

Table 2. Initial characterization of the of Ultisols Limau Manis in 0-20 cm depth.

Soil characteristics	Mean	Criteria
pH value	5.19	Acid
Exchangable Al (cmol.kg^{-1})	2.37	High
Exchangable H (cmol.kg^{-1})	1.27	High
Total N (%)	0.09	Very low
Organic C (%)	1.80	Very low
P Bray (ppm)	3.65	Very low
Exchangable K (cmol.kg^{-1})	0.26	Low
Exchangable Ca (cmol.kg^{-1})	0.36	Very low
Exchangable Mg (cmol.kg^{-1})	0.31	Very low
Exchangable Na (cmol.kg^{-1})	0.26	Low
CEC (cmol.kg^{-1})	6.59	Low
Base saturation (%)	19.16	Very low
Aluminum saturation (%)	50.17	High

Chemical properties of Ultisols applied with sugarcane filter press mud compost and dolomite with principal component analysis

The influence of sugarcane filter press mud compost and dolomite for imroving chemical properties of Ultisols showed at Table 3.Table 3 presented that addition of lime and sugarcane filter press mud compsot influential to improving soil chemical properties of Ultisols. From that table showed organic matter and lime could rises pH value until 6.65 unit, the optimum value of pH is 6.54 unit in 17 t.ha^{-1} compost.

From Table 3 showed that addition of compost and dolomite could increase available P because of compost could decrease soil aicidity. According to Shi *et al* (2018) it is important to slow down soil acidification when practicing suistanable agriculture in tropical climate like addition soil organic matter because organic matter have functional groups. When soil acidity slow down by them, make the better soil nutrient and uptake to the plant. This statement agrees with data from Table 3.

Base on Table 3 that showed that application 4.25 t.ha^{-1} of filter press mud compost can increasing pH value 0.35 unit and significantly different compared with control. 8.5 t.ha^{-1}, 12.75 t.ha^{-1} and 17 t.ha^{-1} also significantly different compared to control with increase till 0.84, 1.03 and 1.14 unit.

Additon of filter press mud compost could increasing persentage of organic C and total N. Application of filter press mud compost significantly different tcompared to control This is because of compost gave organic carbon till 36.84% from Table 1 and nitrogen 2.17%. increased of organic C and N value because increased soil pH can support the growth of microorganisms in the soil especially bacteria, Sabrina and Utomo (2016) reported that The bacteria consume carbon in soil as a source of energy, and the bacteria die so that the organic carbon in the soil to donate. Sabrina and Utomo (2016) stated that the short-lived soil organisms especially microorganisms the land eventually became the source of organic material and will be consumed and decomposed by other soil organisms.

Additon of filter press mud compost could increasing available P. Application of filter press mud compost significantly different compared to control. This is because of increasing pH value and through decomposition process that generates CO_2 and acid-organic acids. From that phenomenon inferred that the resulting CO_2 gas dissolves in water to form carbonic acid which is capable of increasing the availability of P in the soil.

Application of filter press mud also could improving CEC value and cations base in soil. Application of filter press mud in Ultisols significantly different compared to control. That is because of organic matter have weakly acidic carboxylic and phenolic funtional groups absorb or provide protons as the soil pH decrease or rises, that material also can increases soil CEC (Shi *et al.*, 2018). Incresed of cations base becuase of decomposition of organic matter gave some nutrient such as Ca, Mg, K, Na (Sabrina and Utomo, 2016).

Oil palm seedling growth

Growth of oil palm seedling growth after addition of sugarcane filter press mud compost represented in Figure 1. Figure 1 represented that sugacane filter press mud compost and dolomite could improving oil palm seddling growth compared to control. This is because of sugarcane filter press mud compost could release nutrient to soil and absorbed by plant. This research agree with Ramos *et al* (2017) that addition of sugarcane waste could increase soil phosphopus, Ca, Mg, K and Na, and addition of organic matter was higher compared to mineral fertilizers.

Table 3. Soil chemical properties of Ultisols applied with sugarcane filter press mud compost and dolomite

Compost	Items								
	pH	Organic C	Total N	P Bray	CEC	Ca	Mg	K	Na
		.....(%).....		(ppm)		.....(cmol.kg^{-1}).....			
0 t.ha^{-1}	5.51^{d}	1.84^{e}	0.18^{e}	5.17^{e}	6.31^{e}	2.16^{a}	1.49^{a}	0.28^{a}	0.24^{a}
4.25 t.ha^{-1}	5.86^{c}	2.18^{d}	0.42^{d}	12.79^{d}	10.74^{d}	2.10^{a}	1.55^{a}	0.36^{a}	0.29^{a}
8.50 t.ha^{-1}	6.35^{b}	2.73^{c}	0.49^{c}	21.02^{c}	17.17^{c}	0.94^{b}	1.60^{a}	0.34^{a}	0.29^{a}
12.75 t.ha^{-1}	6.54^{a}	3.65^{b}	0.57^{b}	32.89^{d}	21.19^{b}	0.92^{b}	1.67^{a}	0.34^{a}	0.25^{a}
17.00 t.ha^{-1}	6.65^{a}	4.04^{a}	0.63^{a}	42.95^{a}	28.36^{a}	1.01^{b}	1.68^{a}	0.39^{a}	0.32^{a}

a-c Means followed by the same letter within a column are not significantly different from each other

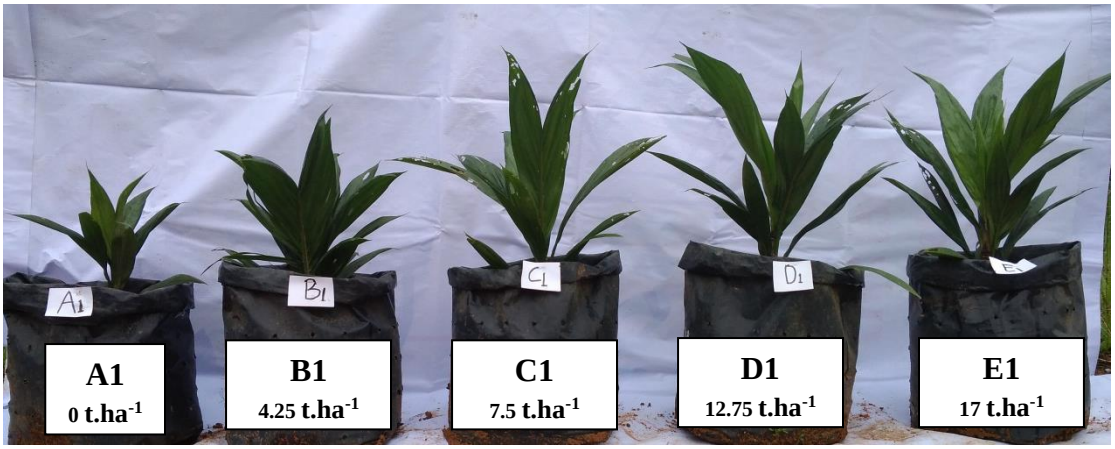

Figure 1. The growth of oil palm seedling (for months after pre nursery) with addition sugarcane filter press mud compost

Table 4. Influence of Sugacane Filter press mud Compost and Dolomite to high of Stem, Leaves in Oil Palm Seedling

Compost	Stem (cm)	Diameter (mm)	Leaves
0 t.ha^{-1}	32.33^{c}	20.20^{c}	8.67^{c}
4.25 t.ha^{-1}	40.67^{b}	28.60^{b}	10.00^{b}
8.50 t.ha^{-1}	45.67^{a}	30.30^{a}	12.67^{a}
12.75 t.ha^{-1}	49.00^{a}	31.00^{a}	12.80^{a}
17.00 t.ha^{-1}	45.33^{a}	30.30^{a}	11.67^{a}
SEM	1.18	0.15	0.58

Averages followed by the same letter in the line statistically by the Tukey test at 5% of probability. ns= non significant by the F test at 5%. SEM = Standard Error or Mean

Table 5. Influence of Sugacane Filter press mud Compost and Dolomite to Nutrients Absorb N,P,K in Oil Palm Seedling

Compost	Nitrogen (%)	Phosphorus (%)	Potassium (%)
0 t.ha^{-1}	3.39^{c}	0.13^{c}	2.37^{c}
4.25 t.ha^{-1}	4.79^{b}	0.20^{b}	2.80^{b}
8.50 t.ha^{-1}	6.67^{a}	0.24^{b}	3.11^{a}
12.75 t.ha^{-1}	5.65^{a}	0.31^{a}	3.81^{a}
17.00 t.ha^{-1}	5.55^{a}	0.27^{a}	3.31^{a}
SEM	0.28	0.007	0.15

Averages followed by the same letter in the line statistically by the Tukey test at 5% of probability. ns= non significant by the F test at 5%. SEM = Standard Error or Mean

Based on Table 4 and Table 5 showed that addition of sugarcane filter press mud compost and dolomite could increasing growth of oil palm seedling and nutrient absorbs. Table 4 and Table 5 presented that addition of sugarcane filter press mud compost significantly different to increasing growth and nutrients absrobed of oil palm seedling compared to control. The optimum growth showed 12.75 t.ha^{-1} compared to control (16.67 cm) by stem, 10.8 mm diameter of stem, and 4.67 by leaves. This research agrees with soil analysis that soil addition with orgnic matter and dolomite could increase soil fertility

especially N,P,K (Nasution *et al.*, 2014). Increasing organic metter level could increase soil fertility because of organic matter have acid organic which increase nutrient uptake to the plant such as N, P, K.

CONCLUSION

The addition of sugarcane filter press mud compost and dolomite can improving chemical properties of Ultisols especially pH value (1.1 unit) decreasing Aluminum, total N 0.45%, organic C 2.19%, available P 37.14 ppm, CEC 22.04 $cmol.kg^{-1}$. Addition sugarcane filter press mud and dolomite increased growth of oil palm seedling. Application of 12.75 $t.pot^{-1}$ gave the optimum growth of oil palm seedlings. It showed that the crop height increased by 51.56%, leaves by 47.63%, N content by 2.26 %, P content by 0.18 %, and K content by 1.44 % compared to control.

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