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The effect of POME application on production and yield components of oil palm in Lampung, Indonesia

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Abstract. Oil palm plant is one of the plantation crops that become the largest foreign exchange income in the national economy. But the lack of information regarding Palm Oil Mill Effluent (POME) deserves serious attention since POME utilization could support plant growth and production and reduce the environmental pollution. This study aimed to evaluate the effectiveness of POME land application in increasing the production and yield components of oil palm crops. This study was conducted in PTPN VII, Bekri Unit, Lampung, Indonesia, from April to August 2019. The experiment was arranged in a Complete Randomized Group Design (CRGD) with three replicates while the difference in mean values between treatments was analysed using the Independent T-Test. This research results showed that the POME applied land could increase the total FFB number up to 40% significance with 38 harvested FFB per month. While, the total FFB weight increased up to 44% significance with 791,3 kg/38 FFB per month. The results of this study showed that POME applied land could be advantageous to be applied on oil palm plantation and could reduce environmental pollution.

1. Introduction

Oil palm (*Elaeis guineensis* Jacq.) is one of the plantation crops having good prospects in Indonesia. Oil palm is not native plant to Indonesia, but the suitability of agro-climate in this tropical country has made oil palm a major export commodity beside oil and gas sector and has become the largest foreign exchange contributor to the national economy [1]. Furthermore, refined palm oil or Indonesian CPO (*Crude Palm Oil*) was able to change the world vegetable oil market which was previously dominated by soybean oil for more than one hundred years [1]. Palm oil market share grew from 22% in 1965 to 40% in 2016, in contrast, soybean oil fell from 59% to 33% over the same period.

Data from the Center for Agricultural Data and Information Systems, Ministry of Agriculture of the Republic of Indonesia [2], noted that the area of oil palm land in Indonesia in 2017 had reached 12.3 million hectares with CPO production of around 46.98 million tons year^{-1} with a productivity of 3.82 tons ha^{-1} year^{-1}. From the total land area above, its ownership is spread consisting of 4.76 million hectares (38.70%) of smallholder plantations, 6.80 million hectares (55.28%) large private Plantations, and 0.75 million hectares (6.10%) of Large State Plantations [3].

In the process of growth and production, oil palm plants require a lot of nutrients and water. Oil palm requires nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and boron (B) during the growth cycle. The low availability of nutrients in the soil can cause nutrient deficiency that can reduce the growth and production of oil palm [3].

An alternative of fertilization other than using inorganic fertilizers is the use of organic fertilizers which are more environmentally friendly and could create the sustainability. For oil palm plantations, organic fertilizer POME (*Palm Oil Mill Effluent*) is the most profitable alternative because POME is made from liquid waste from palm oil processing mill. However, the high production of palm oil in the world creates a serious pollution problem caused by waste from palm oil processing factories [4]. POME is the most abundant waste produced from fresh oil palm fruit bunches. According to Budianta [5], about 60% of one fresh oil palm fruit bunch is POME.

The nutrients resulted by POME are needed by plants. According to Deublein and Steinhauster [6], POME is rich in organic compounds and carbon dioxide and contains large amounts of nitrogen, phosphate, calcium, magnesium, and potassium so it can be used as fertilizer. In general, this study aimed to evaluate the agronomic character of oil palm plants due to the application of POME while the specific objective was to evaluate the production and yield component of oil palm due to the application of POME.

2. Materials and methods

This study aimed to evaluate the effect of POME application to the production and yield components of oil palm and to analyze the agronomic criteria of healthy oil palm plants between the plants with POME land application and control.

2.1. Place and time of research

The research was conducted in plantation of Perkebunan Nusantara VII, Bekri Unit, Central Lampung, Lampung, Indonesia, start from April until August 2019.

2.2. Tools and materials

The materials used in this study consisted of POME (Palm Oil Mill Effluent) which has been applied to oil palm plantations and oil palm trees of the Tenera variety resulting from a cross between Dura and Pisifera (DxP). The tools used to measure the agronomic character of oil palm plants consisted of excavators, hoes, crowbars, axes, machetes, FFB picking poles, paints, meters, calipers, scales, ovens, counters, cameras, and other stationery needs.

2.3. Research methods

This research is an experiment with one-way treatment, namely land application POME which will be compared with control (without POME application). The experiment was arranged in a Complete Randomized Group Design (CRGD) with three replications. The agronomic character data were analysed with variance at 5% significance level; while the difference in mean values between treatments was analysed with Independent T-Test for the production and yield component variables.

2.4. Research implementation

2.4.1. Block designation and crop samples. The first step taken in this research was to determine block, namely POME land application block and POME non-application block as a control, each with an area of 15 hectares. The next step is to define crop rows as a group, which is 3 rows per block for POME land applications, and 3 lines per block for POME non-application (control), with 6 sample plants per row.

After doing the above steps, the next step is to mark the blocks, rows and sample plants. On the blocks and rows, the sign used is a nameplate plank made of plywood supported by bamboo with the writing of paint, while in the sample plants, the sign used is a dot (large dot) of bright yellow paint applied to the palm oil trunk with a height of ± 2 meters above ground level.

2.5. Observation

After completion all of the above steps, the next step is the observations on each sample plant according to the specified variables. The agronomic character variables observed included production and yield components of oil palm.

2.5.1. Total weight and number of fresh fruit bunches (kg 18 trees^{-1} 1 months^{-1}). The weight and total amount of fresh fruit bunch production were measured during one month of the research period. The observation and implementation were carried out four times in each research sample block.

2.5.2. Average weight of fresh fruit bunches (kg). The average weight of 3 samples of fresh fruit bunches taken from each research block was weighed using a digital scale.

2.5.3. Loose fruits weight per bunch (kg). The weight of the oil palm fruit that has been removed from the spikelet attached to the bunch stalk. Three samples of fresh fruit bunches (FFB) were taken from each block and then the loose fruit were weighed.

2.5.4. Weight and number of fertile fruits (g). Weight and total number of parthenocarpy fruits in one fresh fruit bunch (FFB). Three samples of FFB were taken from each block to be weighed and calculated the weight and number of fertile fruits.

2.5.6. Weight and number of spikelet (kg). Weight and total number of spikelets in one fresh fruit bunch. The weight and number of spikelets were obtained by counting 3 chopped fresh fruit bunches from each research block.

2.5.7. Bunch stalk weight (kg). Stalk weight taken per fresh fruit bunch. Three samples of fresh fruit bunches (FFB) were taken from each research block and then weighed the bunch stalks.

2.5.8. Crude palm oil level (% of CPO). Comparison of CPO to weight of fruit processed at processing plants. Three samples of fresh fruit bunches (FFB) were taken from each block and then processed in the laboratory.

3. Results and discussion

3.1. Characteristics of pome at PTPN VII, Bekri Unit, Lampung

POME is a liquid waste or by product of palm oil mills derived from condensate, clarification stations and hidrocyclon. This product is a waste product that does not have toxins but has a high pollutant. Based on research by Irvan et al. [7], in general, the pH value of POME in the inlet (raw waste) ponds ranges from 4 to 5, TSS 15,000–40,000 mg L^{-1}, BOD (*Biochemical Oxygen Demand*) 20,000 to 30,000 mg L^{-1}, COD (*Chemical Oxygen Demand*) 40,000 to 60,000 mg L^{-1}, Oil and grease 5,000 to 7,000 mg L^{-1}. The liquid waste result should be managed properly so that it will not cause environmental pollution. To overcome this problem, steps to control liquid waste are carried out through ponding systems which can then be applied to the soil [8].

POME processing in Indonesia mostly uses an open pond system, with the consideration of low cost input and ease of operation. In general, open pond system consists of four ponds, called a fat pit, a cooling pond, an anaerobic pond and a maturity pond. Several companies often increase the number of ponds in order to reduce pollutant content so that could meet the waste quality standards. After completing all the stages, this waste is allowed to use for land application or distribute to other place and river [8].

Liquid waste treatment at PTPN VII, Bekri Unit, Lampung uses an open pond system consisting of 14 ponds, namely, pool 1 (fat pit), pool 2 (cooling pond), pool 3 (anaerobic pond), pool 4 (maturity pond) and pool 5 to 14 (application pool). POME analysis results of PTPN VII, Bekri Unit, Lampung in the inlet (raw waste) and outlet (final processed waste) ponds can be seen in table 1.

Table 1. The analysis results of the final processed waste at PTPN VII, Bekri Unit Lampung.

Parameter	Unit	Quality Standards	Raw Waste	Final Processed Waste
pH	-	6-9	3.3-4.6	8
TSS	mg L^{-1}	300	19,000	96
BOD	mg L^{-1}	250	25,000	189
COD	mg L^{-1}	500	53,600	402

Source: Research and Development Center of PTPN VII, Bekri Unit, Lampung [9], Quality standards: South Sumatra Governor Regulation No. 08/2012 [10].

The analysis results of the inlet and outlet ponds of PTPN VII, Bekri Unit, Lampung, is lower than the results of Budianta [5] study which examined POME from PT. Leidong West Indonesia Plantation Airlines. The analysis results from Budianta's research [5] are pH (4.95) BOD (27.131 mg L^{-1}), COD (68.543 mg L^{-1}), from the inlet pond while from the outlet pond, they are pH (7.31), BOD (374 mg L^{-1}), and COD (2.473 mg L^{-1}). This indicates that the pollutants contained in the POME of PTPN VII, Bekri Unit, Lampung, are lower than the POME analysis data in the inlet ponds of palm oil mills in general.

Waste treatment can reduce pollutants in POME and able to turn it into good organic material for plants. Table 2 shows the results of the analysis of the nutrient content contained in the treated POME liquid waste at Research and Development Center Betung Unit Palm Oil Processing Plant.

Table 2. The results of the analysis of the nutrient content in Palm Oil Mill Effluent (POME).

Parameter	Unit	Nutrient Content
N-total	mg L^{-1}	265.25
P_2O_5- total	mg L^{-1}	95.39
K_2O	mg L^{-1}	13.53
MgO	mg L^{-1}	288.93
Ca^{2+}	mg L^{-1}	50.62

Source: Research and Development Center of Sucofindo Company, Palembang [11].

Table 2 shows that POME contains high levels of nutrients such as N-total, P_2O_5 total, K_2O, MgO, and Ca^{2+}. These elements are macro nutrients needed by plants. POME is also one of the soil amelioration material. Ameliorant is a material that can improve soil fertility through the improvement of physical and chemical conditions, and increase soil pH. Addition of amelioration materials that containing many polyvalent cations can also reduce the adverse effects of toxic organic acids. Besides nutrient content, the POME application is also very good for avoiding drought stress during the dry season [12].

3.2. Production component

The data on production and yield components of the research results were processed through analysis of variance and tested through the Independent T-test. The statistical analysis data showed that the application of POME could gives variations to the total amount and total weight of oil palm FFB productions.

Table 3. Comparison of the distribution of components in oil palm fresh fruit bunches in the POME land application environment and POME non-land application environment.

Observation Variable	*Land Application*		
	POME	Non POME	*Independent T-Test*
Total Number of Fresh Fruit Bunches (bunches /18 trees)	38	15	*
Total Weight of Fresh Fruit Bunches (kg/18 trees)	791.3	343	*
Average Bunch Weight (kg)	28.1	25.5	ns
Loose Fruits Weight (kg)	20	17.3	ns
Number of Fruits in One Spikelet (fruit)	20.47	18.33	ns
Number of Parthenocarpy Fruits (fruit)	788	900	ns
Parthenocarpy Weight (kg)	1.03	1.64	ns
Bunch Stalk Weight (kg)	2.64	2.56	ns
Number of Spikelets (fruit)	176	174	ns
Spikelet Weight (kg)	4.43	4	ns
Crude Palm Oil Level (% CPO)	42,54%	36,33%	tn

3.2.1 Total amount of fresh fruit bunches production (kg 18 trees^{-1} 1 month^{-1}). Based on the results of the independent T-test in table 3, it can be seen that the application of POME provides variation to the total amount of harvested FFB in each sample tree. The total FFB that could be produced by 18 sample plants in the POME land application block reached 38 FFB within one month of harvesting time. Whereas in the POME non-land application block, 18 sample trees were only able to produce 15 FFB within one month of harvesting time.

This means that all sample trees in the POME land application block are able to produce an average of 9.5 FFB per harvest rotation, while all sample trees in the POME non-land application block are only able to produce an average of 3.75 FFB per harvest rotation.

3.2.2 Total weight of fresh fruit bunch production (kg 18 trees^{-1} 1 month^{-1}). The results of the independent t-test in table 1 also show that there is a variation in the total FFB weight in the two research blocks. With a total harvest of 38 FFB/4 crop rotations, the sample plants in the POME land application block, were able to achieve an average total FFB weight of 791.3 kg, while the sample plants in the non-land application of POME block were only able to achieve a total harvest of 15 FFB per 4 crop rotations with an average total FFB weight of 343 kg per 4 times of crop rotation.

POME is one of the by-products from palm oil mills, used as a fertilizer or soil repairer or commonly referred to as a land application. POME from processing (anaerobic pond IV) channeled to oil palm plantations as land application through trenches (flatbeds) that have been made of dead trees. Flow back was carried out after the POME in the flatbed has receded. According to Oki C R [13], the land with POME applications has lower soil density, soil penetration resistance, and soil pH, as well as soil moisture content, dispersion ratio, and soil C-organic which is much better than that without POME application. Due to better land condition, oil palm plants on land with POME applications were able to obtain higher FFB production compared to land without POME application.

The higher amount of production and total weight of FFB on land with POME applications are caused by the effect of POME being able to provide water continuously. According to Hartley [14], the emergence of male and female palm fronds and flowers will be influenced by rainfall, which would provide variations in the development of flowers and the growth of fronds against differences in environmental conditions for plant growth. To convert flowers into FFB after pollination, oil palm plants take 5 to 6 months [15]. The rainfall data at the PTPN VII Bekri Unit showed a dry season in October 2018 (6 months before harvest time) with the amount of monthly rainfall of only 6 mm and one rainy day.

In dryland conditions, the potential for the male flower to emergence its fronds would be higher than female flowers. Still, in poor water conditions, the formation of male and female flowers would run stable. The FFB production on the POME treated land was higher than that on the non-POME treatment, probably because the oil palms had enough water throughout their life cycle. The plants only had light water stress during the dry season, which prevented them from drowning.

The total population in the 742 blocks (POME land application) consisted of 2,046 plants, and the production capacity per 18 trees was 38 FFB/ month. Average bunch weight on block 742 is 18 kg, and the total production weight per month in the POME land application block can reach 77.2 tons with productivity of 5.1 tons of FFB ha^{-1} $month^{-1}$. Whereas block 702 (non-land application POME) has a population of 2.139 plants with a production capacity of the 18 trees are 15 FFB/month. So with the average bunch weight on blocks of 17.8 kg, the production per month is only able to reach a total weight of 31 tons with a productivity level of 2.1 tons FFB ha^{-1} $month^{-1}$.

The study was in line with the previous research that the application of POME on the oil palm land increased its productivity by an average of 0.149 tons or 149 kg ha^{-1} or equivalent to an increase of 10.71% when compared to crop productivity on land without POME application [16]. As for the realization of production, the application of POME on oil palm land can increase the amount of yield by 8.25% compared to land without POME application.

4. Conclusions

The increase in production and yield components is due to POME application including a higher number and total weight of oil palm FFB compared to the plants on the land without POME application. There is a difference up to 40% between the amount of harvested FFB on the POME application land with number of harvested FFB of 38 bunches, and on that without POME application, the number of harvested FFB is only 15 bunches. In the total FFB weight variable, there is a different value up to 44% between the total FFB weight on POME applied land of 791.3 kg, and on the land without POME application, only 343 kg FFB. POME applications increased land productivity compared to land without POME applications. The results of this study showed the advantages on land with POME application, so it is strongly recommended that this treatment could be able to be applied to all oil palm plantations with high consideration on waste treatment before application. This result could also be applicable to introduce to smallholder plantations who can collaborate with big holding plantation so they can increase their productivity by implementing this treatement using certain application methods. Appropriate management of converting mill waste into organic fertilizer is also very profitable. Besides reducing the level of pollution in the nearby river, it is also able to provide additional nutritions to plants and create sustainability on the environment.

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