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Application of Various Concentrations of Liquid Waste from Oil Palm Mill on the Growth of Oil Palm Plant (*Elaeis guinensis*, Jacq)

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Abstract

Waste water from oil palm mill can be utilized for irrigation and fertilization on plantation land (*land application*) because it contains nutrients required by plant and its capability to decrease negative impact on environment. The waste water was sprayed on oil palm plant having 4 months, 8 months and 12 months old. This study was conducted within plastic house using Factorial Completely Randomized Design which consisted of liquid waste concentration with 6 levels as well as oil palm plant ages with three replications. The research objective was to determine the respond of oil palm plant at different ages to the addition of liquid waste concentrations from oil palm mill. The plants were planted within drum consisting of soil from tidal swamp land and liquid waste from private oil palm mill in Banyuasin District. Liquid waste characteristics of oil palm mill from anaerobe pond were as follows: BOD = 24,820.2 mg/l, N = 650.2 mg/l, P = 25 mg/l and K = 295.1 mg/l. Data was tested by using statistical method to determine treatments effect and followed by difference test amongst treatments. The results showed that plant age treatments had highly significant effect on plant height, numbers of stem and plant dry mater weight. Treatment of liquid waste doses had highly significant effect on plant height in 5 months after treatment and plant dry matter weight. Interaction between liquid waste doses and plant ages had no significant effect. Treatment of 12 months plant age and liquid waste of oil palm mill at dose of 2,500 mg/l was significantly different from other treatments.

Keywords: Waste Water of Oil Palm Mill -Plant Age – Plant Growth.

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1. Introduction

Agro-industry of oil palm processes raw material of fresh fruit bunches into *crude palm oil* (CPO). This activity besides produce *crude palm oil* also produce solid, liquid and gas wastes as the by product. These three wastes have opportunity to be utilized in order to decrease environmental pollution. Solid waste from empty bunches can be

utilized as compost, and solid waste from nuts can be used as activated carbon. Gas waste can be used for electricity power plant, whereas liquid waste can be used as liquid fertilizer and water supply for oil palm crops. The utilization of liquid waste can support environmental friendly development by managing waste water so that it has value or benefit for plantation activity.

Total production of oil palm plant in Indonesia for year 2006 was 14,200,000 tons of CPO covering area of 5,508,219 ha. According to [1], the area for oil palm plants in 2008 was 7 million ha and it was predicted to be 10 million ha in 2015. According to data from Business Competition Supervision Council of Indonesia (2006), total of national capacity was 11,861,615 tons of CPO. There were 50 units of oil palm mill in South Sumatra with total production 1.084.019 tons of CPO. If 1 ton of CPO requires 0.8 m^3 of water, then there will be available 867,215.2 m^3 of water or equivalent to 867,215,200 liters liquid waste of oil palm mill.

Oil palm plant can produce 20 tons to 25 tons fresh fruit bunch (FFB) per hectare. Besides producing CPO (*Crude Palm Oil*), oil palm mill also produces solid and liquid wastes. Processing of 1 ton fresh fruit bunch (FFB) requires 0.8 m^3 of water. It is predicted that oil palm production activities in South Sumatra will produce liquid waste about 943,154.4 m^3 or 943,154,400 liters. Waste characteristics from oil palm mill are as follows: pH of 4.0-6.0, BOD of 20,000mg/l to 60,000 mg/l, COD of 40,000 mg/l to12,000 mg/l, N of 500 mg/l to 900 mg/l, P of 90 mg/l to140 mg/l, K of 260 mg/l to 400 mg/l, Ca of 1,000 mg/l to 2,000 mg/l and Mg of 250 mg/l to 350 mg/l. According to [2], oil palm productivity can be influenced by their seeds origin, fertilizing technology and pest and disease management.

Oil palm plant can be differentiated into vegetative part and generative part. The vegetative part of oil palm consists of roots, stems and leaves, whereas the generative part as propagation mean consists of flowers and fruits. Oil palm crop has fibrous roots with very strong rooting system because they grow in downward and side directions to develop primary, secondary, tertiary and quarterly roots. The primary root grows underneath within soil up to water table surface boundary. The secondary, tertiary and quarterly roots grow parallel to water table surface even they grow into upper layer or sites that have rich nutrients content. In addition, aerial roots are also appears above or within water table. Root distribution is concentrated at upper layer [3].

According to [1], the growth of oil palm plant can be identified through crop age, numbers of stem, seeds height and trunk diameter. The growth standard description for oil palm plant are as follows: 4 months age has 4 stems and seed height of 25 cm; 8 months age has 12 stems and seed height of 64.3 cm; 10 months age has 15 stems and seed height of 101.9 cm and 12 months age has 18 stems and seed height of 126 cm.

Tertiary and quarterly roots are part of roots which have the closest distance to soil surface. These roots have many fine hairs protected by root cap. These root hairs are the most effective mean in absorbing water, air and nutrients from soil. These roots mostly found at distance of 2 m to 2.5 m from stem base and most parts are located outside the ring. Tertiary and quarterly roots also found up to 1 m beneath soil. Rooting system of oil palm crop even can grow up to 5 m beneath soil [4]. [5] found that oil palm plant at 10 years age has primary root diameter of 5 mm to 10 mm, secondary root has diameter of 1 mm to 4 mm and tertiary root has diameter of 0.2 mm to 0.5 mm. The crop radius of crop can achieve 3.5 m to 4.5 m. Some extreme study results in Malaysia showed that oil palm crop with 11 years old were mostly located at soil depth of 45 cm for water table depth of 1 meter.

Water requirement and nutrients requirement for oil palm crop are also relatively high. Oil palm crop during its growth period requires water with magnitude of 4.10 mm to 4.65 mm per day. Nutrients requirement for this crop in production stage is as follows: N of 0.49 kg, P of 0.08 kg, K of 0.63 kg, Mg of 0.14 kg and Ca of 0.13 kg [6].

The research objective was to determine characteristics of oil palm liquid waste, crop growth and biomass weight available at upper part of crop and roots after 6 months treatment application.

2. Materials and Method

Materials used in this research were liquid waste of oil palm mill, soil media was taken from tidal swamp land, oil palm plant with 4, 8 and 12 months old, and chemicals for laboratory analysis. Sampling stage for liquid waste of oil palm mill was done by survey method through purposive sampling at anaerobe pond. The depth of waste processing installation pond was 4 m so that water sample was taken at the one-third of pond depth and close to pond base which was subsequently composited as samples. Liquid waste sampling was done by using water sampler and samples were put into glass bottle and subsequently put into ice sample box for cooling.

Analysis of liquid waste from oil palm mill was done in Laboratory of Palembang Industrial Council. The pH measurement was done directly in the field, whereas analysis of BOD_5, COD, pH, N, P, K, Ca, Mg as well as oil and lipids were done in laboratory. Testing methods used in this analysis were as follows: BOD_5 (IK BIPA 5.4.1.15), COD (SNI 06-2504-1991), oil and lipid (IK BIPA 5.4.1.24), N (IK BIPA 5.4.1.24), P (IK BIPA 5.4.1.17), K (IK BIPA 5.4.1.18), Mg (IK BIPA 5.4.1.20), Ca (IK BIPA 5.4.1.19). SNI (Standar Nasional Indonesia), IK BIPA (Working Instruction of Palembang Industrial Council).

Experiment at plastic house was designed by using Factorial Completely Randomized Design that consisted of crop age treatment with three levels (4 months, 8 months and 12 months) and treatment of liquid waste from oil palm mill with six levels (without

Table 1: Characteristics of Liquid Waste from Oil Palm Mill.

No.	Variable	Values
1.	pH	7.30
2.	BOD-5 (mg/l)	24,820.2
3.	COD (mg/l)	54,258.8
4.	Oil and Lipid (mg/l)	635.09
5.	Nitrogen (mg/l)	650.2
6.	Phosphate (mg/l)	25.2
7.	Potassium (mg/l)	295.1
8.	Magnesium (mg/l)	67.9
9.	Calcium (Ca) (mg/l)	1.7

waste, 20,000 mg/l, 15,000 mg/l, 10,000 mg/l, 5,000 mg/l and 2,500 mg/l) and 3 replications for each treatment so that there were total of 54 drums or experimental pots.

Working procedures were as follows: 1). Preparation of oil palm plant having age of 4 months, 8 months and 12 months. 2). Soil preparation from tidal swamp land of Gasing area. 3). Soil was air-dried, crushed and sieved by using 2 mm Siever. 4). Soil field capacity was measured in the laboratory using pF meter. 5). Soils used put into no-hole pots, to stop percolation. 6). Total of soil weight at field capacity and pot weight was 30 kg. Soil to be used as media was weighted that consisted of soil weight at field capacity and pot weight of 30 kg. 7). Treatments of water application and liquid waste of oil palm mill were done at different concentrations according to treatments and weighht once in three days by maintaining soil weight at field capacity condition (media + plant = 30 kg). Different concentrations were achieved by diluting of BOD concentration in anaerobe pond with concentration higher than 20.000 mg/l.

3. Result and Discussion

Analysis results of liquid waste in anaerobe pond showed that pH value was neutral. The pH of liquid waste from oil palm mill had been treated before entering anaerobe pond. Treatment was done through cooling pond and acidifying pond. The addition of NaOH or lime was done in acidifying pond in order to increase pH so that decomposing microorganisms can work well in anaerobe pond having pH close to neutral.

High concentration of BOD showed that waste decomposition process was improper and application of this waste to crop results in nutrients competition between microorganisms which decompose waste and nutrients for the main crop. BOD (Biologycal Oxigen Demand) is quantity of oxygen required by microorganism to decompose organic. BOD showed oxygen quantity consumed by respiration of microorganisms. Study results from [7] showed that BOD_5 at concentration of 7000 mg/l in application

of liquid waste from oil palm mill on corn crop was the best treatment without urea addition.

COD value was 54,258.8 mg/l this showed that decomposition process was still at on-going stage. COD value shows organic matter content and inorganic matter content that can be degraded which represented by oxygen quantity required for degradation process by microorganisms. The lower the COD value, the smaller of substance that are degraded by microorganisms.

Oil and lipid within liquid waste of oil palm mill are carried substances during production process. These substances have effect on soil physical characteristics especially in term of total pore space and hamper evaporation. Discharging of oil and lipid to the environment can cause disturbance to water microbiology life and nekton life.

Nutrients available within waste are as follows: Nitrogen of 650.2 mg/l, Phosphate of 25.2 mg/l, Potassium of 295.1 mg/l, Magnesium of 67.9 mg/l and Calcium (Ca) of 1.7 mg/l. Application of nutrients on land for long period will be accumulated in soil and as nutrients source for plants. The study results from Reference [8] showed that treatment of liquid waste addition from oil palm mill could improve soil chemical properties in term of N, P, K, Ca and Mg at optimum dose of 750 l per plant.

Sampling for plant matter weight was conducted six months after treatments such as shown in Table 2. The crop matter weight was consisted of upper part weight composing midribs and leaves, whereas lower part weight was roots of crop. Results of statistical test showed that treatment of liquid waste from oil palm plantation had no significant effect on crop height at one month to four months old, but it had significant effect on crop height at five months old. Results of statistical test showed that liquid waste dose had significant effect on numbers of stem for crop at four and five months old, whereas crop age had highly significant effect on numbers of stem.

The interaction of plant age and liquid waste dose from oil palm mill showed no significant effect. Results of statistical test for each treatment showed significant to highly significant effects which indicate that treatments can be separately applied and affect the respond of oil palm crop in term of plant height and numbers of stem.

The single effect of liquid waste from oil palm mill on root dry weight for control treatment (water) was not significantly different than other treatments, but treatment of BOD 20,000 mg/l showed lower root dry weight than other treatments. Treatment of BOD 20,000 mg/l caused some roots of crop were spoiled and leaves had yellowish respond. The study by Reference [9] showed that application of liquid waste from oil palm mill had effect on pH, water holding capacity, organic carbon, total nitrogen as well as nutrients of K, Mg and Ca.

Results of statistical test as presented in Table 1 and Figure 1 showed that addition of liquid waste from oil palm mill had significant effect on numbers of stem. According to Reference [1], the growth of oil palm crop can be described by numbers of stem,

Table 2: The effect of liquid waste from oil palm mill and plant age on numbers of stem, plant height and matter weight.

Parameters Plant Age	Dose of OPM	Liquid Waste	Interaction
Plant Height			
1 month	**	ns	ns
2 months	**	ns	ns
3 months	**	ns	ns
4 months	**	ns	ns
5 months	**	**	ns
Numbers of Stem			
1 month	**	ns	ns
2 months	**	ns	ns
3 months	**	ns	ns
4 months	**	*	ns
5 months	**	**	ns
Wet Matter Weight	**	**	ns
Dry Matter Weight	**	**	ns
Wet root weight	**	**	ns
Dry root weight	ns	**	ns
Remarks: **: Highly significant effect, *: significant effect, ns: not significant			

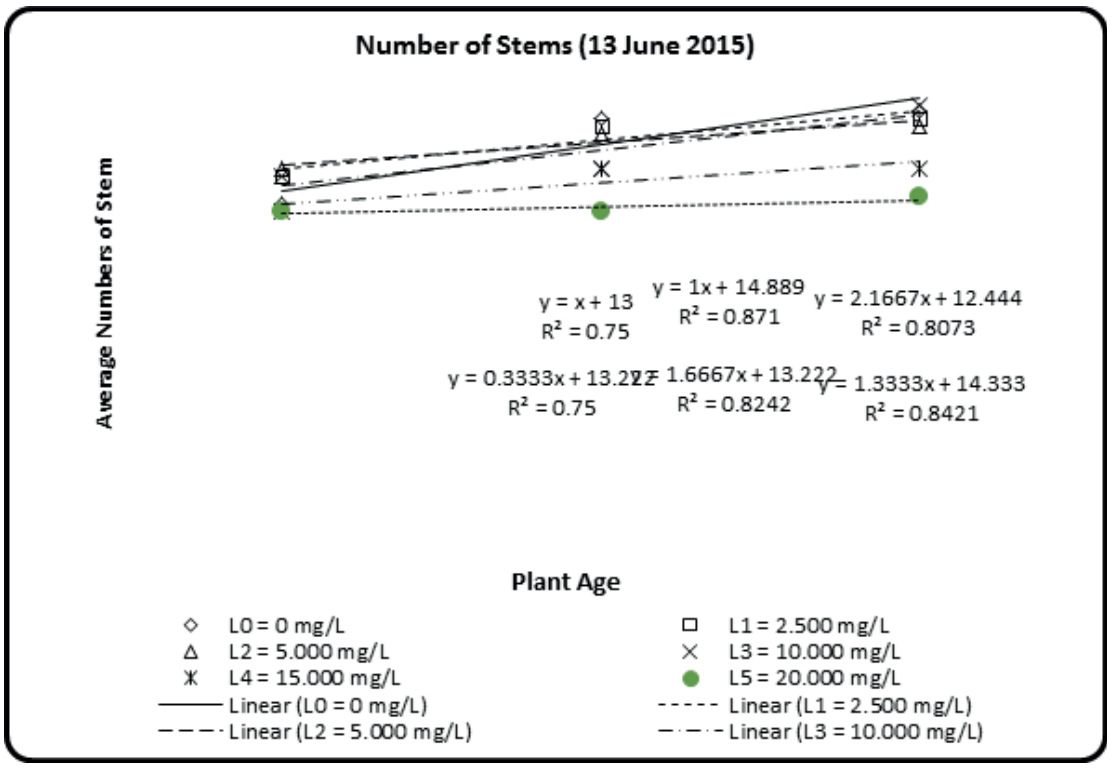

Figure 1: The effect of OPM liquid waste on numbers of stem.

Table 3: The Effect of OPM Liquid Waste on Matter Weight of Plant.

BOD waste treatment (mg/l)	Wet Weight of Roots (g)	Dry Weight of Roots (g)	Wet Weight of Plant Leave (g)	Dry Weight of Plant Leaves (g)
0	293.33 b	128.38 ab	1,081.11 c	789.20 d
2,500	297.78 b	133.08 ab	1,032.22 bc	759.53 cd
5,000	278.89 ab	137.90 ab	935.56 b	669.54 bc
10,000	308.89 b	154.63 b	944.44 b	678.17 bc
15,000	294.44 b	124.93 ab	848.89 b	629.01 b
20,000	215.56 a	88.35 a	696.67 a	514.86 a
LSD 0.05	70.05	52.77	122.31	110.86

crop height and trunk diameter. Figure 1 showed that oil palm crop at 12 months old had higher numbers of stem than that of others and there was a linear increase.

The BOD concentration treatment in form of control treatment (water) was not significantly different than that of BOD concentration 2500 mg/l in term of matter weight of upper part plant and plant dry matter weight. Data of least significance different (LSD) test in Table 3 showed that higher BOD concentration results in lower values of dry matter and wet matter weights of crop.

Data of average matter weight showed that the highest matter weight was found on BOD concentration 2500 mg/l and higher BOD concentration tend to produce lower matter weight of plant. The increase of element concentration might suppress plant growth. The extreme suppression might cause toxicity to plant. The other extreme signs might cause yellowish leaf and curly leaves on young plant as well as fruits and flowers falling for fruit producing plant or mature plant. On the other hand, study results from Reference [10] showed that addition of liquid waste from oil palm mill was capable to support significant plant growth.

Oil palm plant age at seedling is usually 12 months and subsequently the seeds are planted in the field. Oil palm plant will show the increase in numbers of stem and plant height in accordance to plant age. Young plant has better adaptation capability than older plant. However, the treated plant in this study had showed different responds such as shown in Table 4. The results of this study was in accordance to the work of [11] which showed that numbers of stem and palm oil plant growth on subsoil media added with liquid waste of oil palm mill were not significantly different than that of compost media. This was contrast with results of study from Reference [12] which showed that addition of liquid waste of oil palm mill with 25 percent activator was capable to support oil palm plant growth.

The results of Least Significant Difference test showed that oil palm plant at age 8 months and 12 months were not significantly different in term of root wet weight and root dry weight, but the results was significantly different for oil palm plant at age of 4 months. This condition showed that roots development of oil palm plant at 4 months

Table 4: The Effect of Plant Age on Matter Weight and Weight of Roots.

Treatments	Wet Weight of Roots (g)	Dry Weight of Roots (g)	Wet Weight of Plant (g)	Dry Weight of Plant (g)
4 Months	168.89 a	75.98 a	472.22 a	306.54 a
8 Months	333.89 b	136.22 b	991.11 b	689.44 b
12 Months	341.67 b	171.44 b	1306.11 c	1024.18 c
LSD 0.05	49.53	37.31	49.53	78.35

age was better than that of oil palm plant at 12 months age which was indicated by roots damage on oil palm crop at 12 months age added with high concentration of liquid waste from oil palm mill. The study results from [13] showed that crop growth and production were not only affected by water availability, but also by water quality. Roots were experienced purification and under developed as well showed the toxicity sign. The study results from [14] showed that media with water content of 25 percent during four weeks had significantly suppressed the growth of oil palm seeds which was shown by the decrease in water content of leaf, dry weight of crown, roots volume and water deficit occurrence.

Treatment of 12 months crop age had higher growth rate, dry matter weight and wet matter weight of crop's upper part than that of 4 and 8 months treatments such as shown by Least Significance Different test at 0.05% level given in Table 4. The differences in matter weight of plant's upper part were due to differences in initial condition of plant and application of liquid waste from oil palm mill was not capable to suppress the plant growth although there were differences in physiological performance of crop such as shown by yellowish sign on mature leaves. Other factor that affects the growth of oil palm plant is soil physical characteristics due to soil tillage operation. Soil tillage at depth of 30 cm could increase plant's roots growth up to 28 percent [15] and nutrients would affected distribution of plant's roots [16]. Application of liquid waste from oil palm mill had caused crop's root concentrated at depth of 30 cm and would be decreased at deeper locations.

4. Conclusion

Conclusions that can be derived from treatment results of liquid waste concentrations of oil palm mill at several plant ages were as follows:

1. The applied liquid waste of oil palm mill contained nutrients of Nitrogen, Phosphate, Potassium and Calcium as well high BOD concentration of 24,820.2 mg/l.

2. The plant's age treatments had significant effect on plant's height and number of stems, whereas liquid waste doses of oil palm mill had only significant effect

on plant's height at 5 months age as well as had significant effect on numbers of stem at 4 months and 5 months after treatments application.

3. No interaction found between plant's age and dose of liquid waste from oil palm mill. Liquid waste dose of 20,000 mg/l was significantly different than other treatments in term of root wet weight and root dry weight as well as dry matter and wet matter of plant's upper part.

4. The plant's age treatments showed significant different in term of root wet weight and root dry weight as well as dry matter and wet matter of plants. The chosen doses of liquid waste from oil palm mill to be applied were 2,500 mg/l, whereas the proper crop to be planted was 8 months old.

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