The Combination of Plant Hole Size and Fertilizer Rates for Response of One Year Old Immature Oil Palm (*Elaeis guineensis* Jacq.)

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ABSTRACT— ***Plant hole is providing optimal root condition for plant, so that the size of plant hole must be according to the development of rooting. Generally, the plant hole size that use in oil palm plantation is 60-60-60 cm (length x width x height), plant hole size could be accelerate harvest time. Fertilization for One Years old Immature Oil Palm (1 IOP) is important activity for supporting vegetative growth of plant. Fertilization is done by using the standard fertilization from oil palm companies or research centers. The combination of plant hole size and precise fertilization expected to optimize oil palm growth in one year old immature oil palm. The objectives of this research are to know the response of vegetative growth of one year old immature oil palm with the plant hole size application and fertilizer rates, and to obtain the precise plant hole size and fertilizer rates for one year old immature oil palm. The experiment was conducted from April 2015 to May 2016 at Politenik Kelapa Sawit Citra Widya Edukasi Teaching Farm, Bekasi, Jawa Barat, Indonesia. The treatment was arranged in a factorial randomized complete design with two replications. The first factor, the plant hole size, consisted of 60-60-60 cm and 80-60-60 cm. The second factor, the fertilizer standard, consisted of standard fertilizer (based on recommendation fertilizer), (+) 25% of standard fertilization, and (-) 25% standard fertilization. The measured variables were morphological response : plant height, leaves number, stem diameter, and leaf area, and for physiological response : the density of stomata, biomassa (wet and dry matter), and plant analysis. The results showed that application of various fertilizer rates significantly affect for stem diameter in 2, 4, 5, 6, 7 and 8 MAP, and for leaf number only at 1 MAP. The interaction of these two factors significantly affected to stem diameter in 1, 3, 9, 10, 11, and 12 MAP. Plant hole size and fertilizer treatment produce palm oil with large stem diameter and lower plant height, it is supported the needed of field plant that prefer low palm oil tree for easier harvesting process later. The best combination treatment for one year immature oil palm is 80-60-60 cm with standard fertilizer.***

Keywords— plant hole size, standard fertilization, oil palm immature plant, stem diameter

1. INTRODUCTION

The oil palm (*Elaeis guineennsis* Jacq.) immature plant is oil palm that produce bunch of fruit under three kilogram (kg). Immature plant consist of three time are immature plant one year (0 or when planting in field-12 months), two year (13-24 months) and 3 (25-36 months). Immature plant is vegetative period of plants that need to attention and precise application of cultivation techniques, because the plant must be strengthen his organs to be able doing generative period in mature time. The cultivation activity that need to attention is using precise the plant hole size and fertilization..

Generally, the plant hole size that use in oil palm plantation is 60-60-60 cm (length x width x height), with that size oil palm could be harvesting in 3 years old. Whereas, when using larger plant hole size 80-60-60 cm the harvesting time could be more fast is 2 year 5 month (Nugraha 2016). This suggest that larger plant hole size could accelerate the harvesting time of oil palm fruits, but the data are not yet complemented by the quality of morphological and physiological of oil palm growth. Therefore, it is necessary to research observing the growth of morphology and physiology of oil palm planted on planting hole with larger size than generally. Larger planting holes are considered to stimulate and improve root growth, a faster roots will make the plant grow optimally. Watson et al. (1992) suggest that the increase in root growth will be in line with the larger size of plant hole that used. Lakitan (2010) has reported that root system of plants affected by soil condition or growth media. Smaller plant hole size makes less development of

roots, it because soil physics condition is too hard, so that the fiber root of oil palm would be more difficult to developing than larger plant hole size. Planting oil palm with the larger plant hole size could improve oil palm production in adult age (Alqamari 2012).

The obtain of fertilization in oil palm immature plant one year is to improve soil fertility through the addition of nutrients, both macro and micro useful for the growth and development of oil palm. Some research showed that response of plant to fertilization could be increasing the plant growth and productivity (Sutarta et al. 2005). Oil Palm needs high nutrients, considering that 1 ton fresh fruit bunch (FFB) equivalent with 6.3 kg Urea, 2.1 kg TSP, 7.3 kg MOP, dan 4.9 kg Kiserit. Oil palm fertilization rates is generally given in accordance with the results of nutrient content analysis on leaf 9 and 17. Therefore, recommendation dosage is used by oil palm company generally different. The role of important planting and fertilization holes makes it necessary to doing research to know the effects of these two factors on the morphology and physiology of oil palm. This research was used to know the effective growth of oil palm plantations in one year old immature oil palm period, so find the accuracy of planting hole size and appropriate rates of fertilization in oil palm one year old immature oil palm.

The objectives of this work were to initiate the research on the correlations, between the planting hole size at young stage, and good fertilization level as well as the productivity in adult age.

2. MATERIALS AND METHODS

2.1 Experimental Site and Materials

The experiment was conducted from April 2015 to Mei 2016 at Politenik Kelapa Sawit Citra Widya Edukasi Teaching Farm, Bekasi, Jawa Barat, Indonesia. Plant tissue analysis was performed at the laboratory of Agronomy and Horticulture, Faculty of Agriculture, IPB Bogor. The materials used were one year old immature oil palm Tenera Sue Supreme Mekar Sari variety, single fertilizer of Urea, TSP, MOP, Kieserite, HGFB. The research tools used were scales (Electronic Kitchen Scale tipe sf-400), oven, stationery and camera.

2.2 Experimental Design and Treatment

A factorial combination 2 x 3 in a Randomised Complete Block Design (RCBD) with 2 replications, in 2 blocks was used. Two factors were tested. First, represented by the plant hole size consist of 2 levels : (i) 60-60-60 cm and (ii) 80-60-60 cm. Second, corresponding to fertilization level, was constituted of 3 levels : (i) standard fertilizer (based on recommendation fertilizer, TSP: 800 g, Urea: 800 g, MOP: 350 g, Kieserite: 250 g dan HGFB: 50 g/plant), (ii) (+) 25% of standard fertilization (TSP: 1000 g, Urea: 1000 g, MOP: 437,5 g, Kieserite: 312,5 g dan HGFB: 62,5 g/plant), and (iii) (-) 25% standard fertilization (TSP: 600 g, Urea: 600 g, MOP: 262,5 g, Kieserite: 187,5 g dan HGFB: 37,5 g/plant). Two plant samples were used. Treatment was composed of one level of the plant hole size and of one level of the fertilization, repeated twice in 2 blocks. In all, 24 treatments were used to conduct the experimentation

2.3 Experimental Procedures

The holes digging was done at the beginning of research by using the manual tools. One month later, the holes digging, the oil palm seedlings were planted and TSP fertilizer was laid out in plant hole. Fertilizer treatments was given on planting hole (when planting oil palm) with 350 g TSP, the next fertilization applied on circle area with the rates are : on 1 month with 200 g Urea, 3 month with 350 g MOP, 250 g Kieserite and 15 g HGFB, 4 month with 250 g urea, 6 month with 450 g TSP and 35 g HGFB, and 8 month with 350 g Urea. That rates is standar fertilization treatments, for (+) 25% treatments that rates would be adding 25% more dosage for each fertilizer, and so that for (-)25% treatments that more less 25% from standard fertilization.

2.4 Data Collection

Morphological variables were observed every month for 1 year. Physiological variable observed on Mei 2016 (the end of research). The morphological variables were : (i) plant height (cm), (ii) leaf number (strands), (iii) stem diameter (cm), (iv) leaf area (mm^2), whereas the physiological ones were : (i) the density of stomata, (ii) biomassa (g), and (iii) plant nutrients content.

2.5 Data Analysis

The data was analysis of variance. If the analysis variance test result was significant at 5%, then it continued by T test (Least Significance Different, LSD). Analysis will be done by STAR (Statistical Tools for Agricultural Research) Program.

3. RESULT AND DISCUSSION

3.1 Morphological Response of One Year Immature Oil Palm

Plant Height

Application of plant hole size and fertilizer rates not significantly affect singularly for plant height on 1-12 Months after Planting (MAP). Growth of plant height in plant hole treatment showed that monthly increase with an average value increase in every month are 2.03 cm in 60-60-60 treatments, and 2.60 cm in 80-80-80 cm (Figure 1). Meanwhile, in fertilizer rates treatment the average value increase in every month are 2.85 cm in standard, 2.43 cm in (+) 25% standard, and 1.69 cm in (-) 25% standard treatment (Figure 2).

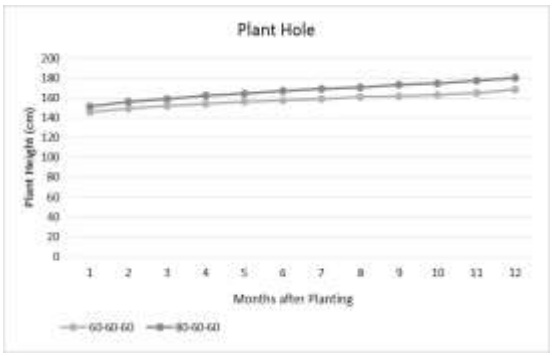


Figure 1. Application of plant hole to plant height

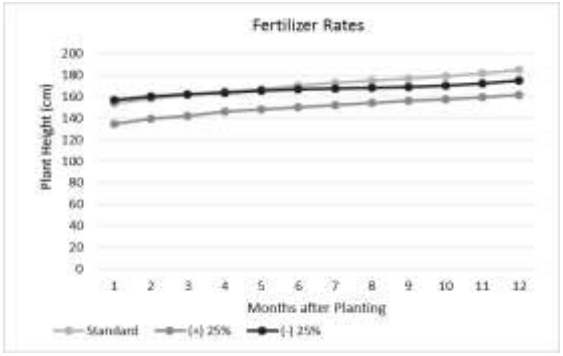


Figure 2. Application of fertilizer rates to plant height

The highest plant in plant hole factor obtained by 80-60-60 treatment in 12 MAP (180.00 cm), it showed that the larger plant hole size effectively increase plant growth with the application of larger root chambers. The larger plant hole size could make optimal condition for root, because there are wider place for developing. The good process of root development would be make nutrients absorption easier, so the formation process of organ would be working maximally. Berg dan Mc Donnell (2014) stated that digging of plantin holes is carried out a size wider than the normally size of root, with this method would be make soil condition that facilitate new roots to grow and support plant growth.

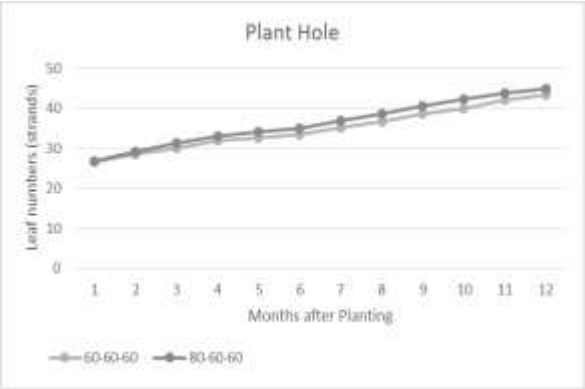
The results of observation in plant height on 12 MAP showed that the highest plant height is in standard fertilization treatment (185.25 cm). This suggests that higher rates of fertilization may not be appropriate to increase vegetative growth of plants. The patterns of plant height follows the low of diminishing return. Standard fertilization treatments has had the right nutrients and dosage for the needs of the plant. Gardner et al. (2008) stated that the response of seedling growth to the addition of NPK fertilizer followed the decreasing pattern of returning law (the law of diminishing return), which means that each addition of fertilizer resulted in decreasing of crop yields.

Leaf Numbers

Application of fertilizer only significantly affect to leaf numbers on 1 MAP, meanwhile in the plant hole treatment there are no significantly affect to leaf numbers on every months. The highest leaf numbers on 12 MAP in plant hole size factor is 80-60-60 treatment (45.00 strands), and in fertilizer rates is standard fertilizer (43.75 strands), that two factors not showed significantly effect from 2 until 12 months, but the graphic of leaf numbers growth showed the increasing leaf numbers in every month (Figure 3&4).

The treatment had the highest numbers of leaves is same with the treatment that the highest plant height too. It showed that the sufficient of leaf numbers could be support plant height growth optimally. The measurement of plant height is also influenced by the number of leaves, because the measurement is done by gluing all the leaves up. Therefore, more leaves will increase the plant height. Sari (2013) stated that when the growth of plant height increase then the number of leaves, stem diameter and chlorophyll content also increases. Many and healthy leaves could be make physical appearance more higher and strong.

The highest leaf numbers would optimize the growth of plant because in leaves have many reaction for produce energy and carbohydrate for plant. So that, the increase of leave numbers showed that many reactions would be happen and increase the growth of plant.. Semakin banyak daun, maka reaksi fotosintesis akan semakin sehingga kebutuhan energi dan makanan tanaman akan tersedia dengan baik.



Stem Diameter

Growth of stem diameter showed significant affect by singular on 4, 5, 6, and 8 MAP to fertilizer rates (Table 4). The interaction between these 2 factor to stem diameter significantly affect on 1, 3, 9, 10, 11, 12 MAP. On 12 MAP, the widest stem diameter is in plant hole size 80-60-60 cm and standard fertilizer. However, not significantly different with 60-60-60 cm and standard fertilizer, and plant hole size 80-60-60 cm and (+) 25% standard fertilizer (Table 5).

Table 4. The influence of plant hole size and fertilization to stem diameter

Treatment	Months After Planting (MAP)					
	2	4	5	6	7	8
Plant Hole Size				---------- mm ----------		
60 - 60 - 60	19.67	22.17	23.58	24.67	25.83	27.17
80 - 60 - 60	19.50	21.92	23.75	25.42	26.58	27.92
Fertilizer Rates						
Standard	20.50	23.38a	25.12a	26.25a	27.38	28.62a
(+) 25% Standard	20.38	22.62a	24.25a	25.62a	26.88	28.62a
(-) 25% Standard	17.88	20.12b	21.62b	23.25b	24.38	25.38b

Remarks : Value followed by the same letter in the same column not significantly different according to *Duncan Multiple Range Test at* 5%; NSA : Not Significantly Affected

The combination of plant hole size 80-60-60 cm with standard fertilization treatment resulted that widest stem diameter (35.25 cm) on 12 MAP, and not significantly affect with 80-60-60 and (+) 25% standar treatment and 60-60-60 cm and (-) 25% standar treatment. Palm oil that had a large stem diameter could made the plant physically better, because it could be support leaf midrib that increasingly large size and amount. At present, palm oil trees that don't tall with larger stem diameter are also more desirable because lower trees could be easier when harvesting later.

Table 5. The interaction between plant hole size and fertilization to stem diameter

MAP	Plant Hole Size	Fertilizer Rates		
		Standard	(+) 25% Standard	(-) 25% Standard
		---------- cm ----------		
1	60 - 60 – 60	21.00a	16.75a	16.50a
	80 - 60 – 60	16.25b	20.00a	16.50a
3	60 - 60 – 60	23.00a	20.00a	19.00a
	80 - 60 – 60	20.25a	22.75a	18.25a
9	60 - 60 – 60	30.25a	27.75a	26.75a
	80 - 60 – 60	30.25a	31.50a	25.50a
10	60 - 60 – 60	31.25a	29.00b	28.00a
	80 - 60 – 60	31.75a	32.75a	26.25a
11	60 - 60 – 60	32.50a	30.50b	29.00a
	80 - 60 – 60	33.50a	33.75a	27.25a
12	60 - 60 – 60	33.50a	31.25b	30.25b
	80 - 60 – 60	35.25a	35.00a	26.50b

Remarks : Value followed by the same letter in the same column not significantly different according to *Duncan Multiple Range Test at* 5%; MAP : Months After Transplanting

Therefore, the growth of oil palm seedlings with large stem diameter would be made superior seedlings and according to the needs in the field. Yudistina el al. (2017) reported that a 2-year-old palm oil with large stem diameter (980 cm) produce more leaf midrib per tree of 172 midrib, while medium size stem diameter (565 cm) and small size stem diameter (255 cm) each produce leaf midrib are only 124 midrib and 87 midrib. Trees with large stem diameter also produce oil palm fruit bunch more than small size. In-an 8-year-old palm oil, the numbers of fruit bunch in large stem diameter (1447 cm) is 60 bunch, while in small size is 48 bunch per trees.

Leaf Area

Application of plant hole size and fertilizer rates not significantly affect by singular for leaf area 12 MAS. In plant hole size treatment, the widest leaf area is 80-60-60 cm treatment, and in fertilizer rates is standard fertilization (Table 6). The wide leaf surface indicates that there are large space available for photosynthesis process, because in leaf contains chloroplast that become the site of photosynthesis. The increased of surface leaf would be increase the ability of plants to produce photosynthates that needed by plants to grow and develop. Wijaya et al. (2015) reported that the widest leaf area (167.11) of oil palm seedlings in pre nursery was NPKMg fertilizer 2.5 g per seedlings, this treatment also showed the highest plant height and (29.07 cm) and stem diameter (8.46 mm).

Table 6. The influence of plant hole size and fertilization to leaf area

Treatment	12 MAP
Plant Hole Size	---------- mm^2 ----------
60 - 60 – 60	3940.2
80 - 60 – 60	4029.5
Fertilizer Rates	
Standard	4130.3
(+) 25% Standard	3956.8
(-) 25% Standard	3867.5

Remarks : MAP : Months After Transplanting

3.2 Physiological Response of One Year Immature Oil Palm Density of Stomata

Application of plant hole size and fertilizer rates significantly affect by singular for the density of stomata on 12 MAS. The most density of stomata on 12 MAS was 80-60-60 treatment, and not significantly different with 60-60-60 cm treatment (Tabel 7). Density of stomata in 80-60-60 cm treatment was 204.00 mm2, the amount is appropriate with the average numbers of density of stomata in normal leaf. Siallagan et al. (2014) stated that the average of density of stomata in research ranged from 192-226 mm^2. The density of stomata in oil palm leaves depend on the characteristics of region. The density of oil palm leaves in Nigeria is 146 mm2 and in Malaysia 175 mm2, stomata in oil palm leaves has a structure to adapt in long dry periods (Corley dan Tinker 2003). Taiz dan Zeiger (2006) stated that high density and numbers of stomata very affected by plant adaptation to its environment.

Table 7. The influence of plant hole size and fertilization to the density of stomata

Treatment	12 MAP
Plant Hole Size	---------- mm^2 ----------
60 - 60 – 60	204.33
80 - 60 – 60	214.50
Fertilizer Rates	
Standard	221.00a
(+) 25% Standard	203.50b
(-) 25% Standard	203.75b

Remarks : Value followed by the same letter in the same column not significantly different according to *Duncan Multiple Range Test at* 5%; MAP : Months after planting.

Biomass

Measurement of biomass was done at the end of observation (12 MAP) in root and canopy of plant. Oil palm sample that choosen was 80-60-60 cm and standard fertilization treatment and control treatment (60-60-60 cm and standard fertilization treatment). In Table 8 showed that the result of measurement canopy wet and dry matter (Table 8).

Table 8. The influence of plant hole size and fertilization to canopy dry matter

Treatment	Wet matter (*g*)	Dry matter (*g*)
Control (60-60-60 cm, standard fertilizer)	3043.4	1008.8
Best treatment (80-60-60 cm, standard fertilizer)	4624.5	2030.3

The difference wet matter of control and best treatment are 1581.1 g, while in dry matter is 1021.5 g. High biomass value showed that the result of photosynthesis in form that carbohydrate and energy could distributed well to all parts of the plant, so the plant could grow and produce optimally. It also means nutrients that given through fertilization could be absorbed well and help the metabolic reactions in the plant. Taufiq (2000) said that dry weight (roots and canopy) showed that the level of metabolic efficiency of the plant.

Nutrition Content of Leaf Tissue

Analysis of nutrition content of leaf tissue was done at 12 MAP (the end of observation) to control and best treatment (80-60-60 cm and standard fertilization). The result of analysis nutrition content of leaf tissue showed in Table 9.

Table 9. The result of nutrient content of leaf tissue

Nutrient Analysis	Control	Best Treatment
Total N	3.18 %	3.18 %
P	0.14 %	0.14 %
K	0.45 %	0.81 %

Remarks : based on the result of analysis in Plant Tissue Analysis in Agronomy and Horticulture Department, Faculty of Agriculture IPB

The result of nutrient content of leaf tissue of analysis has only different values for potassium, while Nitrogen and Phosphorus do not different for control and best treatment. Potassium content in control treatment was 0.45%, while the best treatment was 0.81%. Potassium is used for regulating carbohidrat metabolism, nitrogen dan protein synthesis, accelerates meristematic tissue, plays an important role in cell enlargement, opening and closing of stomata (Dietrich et al., 2001). That result also showed that leaf had a tissue nutrient concentration in sufficient zone when compared with nutrient status in immature oil palm, the value of sufficient nutrient was 2.50% N, 0.16% P, and 0.90% K (Ollagnier dan Ochs 1981).

4. CONCLUSION

1. Application of various fertilizer rates significantly affect for stem diameter in 2, 4, 5, 6, 7 and 8 MAP, and for leaf number only at 1 MAP. The interaction of these two factors significantly affected to stem diameter in 1, 3, 9, 10, 11, and 12 MAP.
2. Plant hole size and fertilizer treatment produce palm oil with large stem diameter and lower plant height, it is supported the needed of field plant that prefer low palm oil tree for easier harvesting process later.
3. The best combination treatment for one year immature oil palm is 80-60-60 cm with standard fertilizer.

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