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The Role of Manure, Nitrogen, Phosphorus and Potassium Fertilizer on Growth of Two Year Old Palm Oil in Jonggol, Bogor, Indonesia

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Abstract

Indonesia is the first producer of oil palm in the world, followed by Malaysia and Thailand. The development of oil palm plantations in Indonesia today, has been more difficult due to limited of fertile land. To improve soil fertility, the use of organic and inorganic fertilizers become a key factor of success for the development of oil palm plantations. The objectives of this research were to study the role and to determine the best fertilizer package of manure, nitrogen, phosphorus, potassium on growth of morphological and Physiological parameteres of two year old oil palm. The research was conducted at IPB-Cargill Teaching Farm Jonggol, Bogor West Java, Indonesia from April 2014 to March 2015. The experimental design used was two factorials randomize block with three replications. The first factor was rate of manure fertilizer, there were control (M_0), 45 kg (M_1), and 90 kg (M_2) tree^{-1} year^{-1}. The second factor was inorganic fertilizer package, consist of control (S_0), 0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O (S_1) tree^{-1} year^{-1}, and 1.88 kg N + 1.34 kg P_2O_5 + 2.28 kg K_2O (S_2) tree^{-1} year^{-1}.

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The result of this research showed that manure fertilizer application had no effect on morphological parameters, however increased nitrogen, phosphorus, net assimilation rate and chlorophyll content. The application of nitrogen, phosphorus, potassium package increased plant height, trunk girth, frond production, frond length, chlorophyll content, nitrogen and phosphorus content in the leaves. The best fertilizer package of nitrogen, phosphorus and potassium is S1 package (0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O $tree^{-1}$ $year^{-1}$).

Keyword: net assimilation rate; single fertilizer; critical level; chlorophyll content

1. Introduction

Oil palm is the plantation main commodity in Southeast Asia, including Indonesia which is one of the largest oil palm producer in the world [1]. Oil Palm has been known as a producer of palm oil, foodstuffs, cosmetics, pharmaceuticals, and biodiesel [2]. Oil palm demand in the world is increasing from 120 to 156 million tons in 2050 [3,4]. Oil palm demand could be released if the plant growth is optimally reached on the available land.

Availability of the fertile lands are limited caused, diversification of oil palm plantations leads into marginal land area. Fertilization become an efforts to increase the productivity of oil palm addressed for suitably marginal soil conditions [5]. Organic and inorganic fertilizer application can overcome the problem on ultisol dry land management [6]. Ultisol land area is including marginal land that have a limiting factor such as high soil acidity, pH < 4.5; high Al saturation; and low macro nutrients P, K, Ca and Mg [7]. Organic fertilizers can improve the physical, chemical and biological content of the marginal land, improve water capacity, porosity, aeration, soil aggregation, cation exchange capacity and the activity of microorganism in the soil will increase the inorganic fertilizers uptake [8,9].

This experiment is a further research to the previous study on one-year old oil palm [10]. which had found out the best rates for the single N, P, K to one-year old oil palm. The objectives of this research were to study the role and to determine the best fertilizer package of manure, nitrogen, phosphorus, potassium on growth of vegetative and physiology parameteres of two-year-old oil palm.

2. Materials and Methods

The research was realized at IPB-Cargill Teaching Farm in Jonggol District, West Java, Indonesia from April 2014 to March 2015. Oil palm Tenera variety Dami Mas aged 12 months after planting was used in this reseacrch. Oil palm trees was planted by using plant space of 9,2 m x 9.2 m x 9.2 m, using of that distance, the population was 136 trees per hectare. Others materials used was dolomite, manure, urea (N), P_20_5 (P), K_2O (K).

The experimental design used was two factorials randomize block with three replications. The first factor was rate of manure fertilizer, there were control (M_0), 45 kg (M_1) and 90 kg (M_2) $tree^{-1}$ $year^{-1}$. The second factor was inorganic fertilizer package, consist of control (S_0), 0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O (S_1) $tree^{-1}$ $year^{-1}$, and 1.88 kg N + 1.34 kg P_2O_5 + 2.28 kg K_2O (S_2) $tree^{-1}$ $year^{-1}$. Plant sample for each treatmeat was 5 plants, so the total of plant sample was 135 plants. Fertilizer treatment was applied in April and November 2014, the fertilizer was spread it evenly in the circle weeding.

Morphology parameters observed bi-monthly was plant height, trunk girth, frond production, and frond lenght. Leaf chlorophyll content measured by using a SPAD-502 [11]; nitrogen, phosphorus, potassium leaf content of frond leaf number 9, was done at 18 and 24 MAP. Net assimilation rate was meaured using Li-Cor 6400 USA at at 18 MAP month. Data were analyzed by Analysis of Variance (ANOVA) methode, if the mean value is significantly different, it will be tested using Duncan Multiple Range Test (DMRT) with P <0.05. Analysis was carried out by using SAS 9.3 (Statistical Analysis System) and Microsoft Excel.

3. Results and Discussion

3.1 Morphological Response

3.1.1 Plant Height

Manure fertilizer application did not significantly affect plant height. Application of nitrogen, phophorus, potassium fertilizer package significantly affected plant height at 24 MAP (Table 1). Interaction of manure fertilizer and nitrogen, phophorus, potassium fertilizer package did not affected plant height. Inorganic fertilizer rate of S2 (1.88 kg N + 1.34 kg P_2O_5 + 2.28 kg K_2O $tree^{-1}$ $year^{-1}$) significantly increases on plant height. Research result done by Shintarika [13] indicated that nitrogen, phosphorus and pottassium increased the plant height on immature one year-old oil palm.

Table 1: Effect of manure and nitrogen, phophorus, potassium fertilizer package fertilizer on plant height

Treatment	Age of the plant (MAP)					
	14	16	18	20	22	24
	Plant height (cm)[a]					
Rates of Manure (kg. $tree^{-1}$ $year^{-1}$)						
M_0	274.04	311.21	321.81	343.21	361.99	377.14
M_1	285.51	325.58	345.80	353.21	377.38	385.60
M_2	283.01	324.48	331.74	353.16	374.30	397.77
Nitrogen, phophorus, potassium fertilizer package (kg.$tree^{-1}$ $year^{-1}$)						
S_0	279.16	320.36	323.84	329.04	349.76	359.96b
S_1	273.57	312.26	323.67	348.27	369.77	392.86ab
S_2	289.84	328.65	351.83	373.15	394.15	407.70a

Notes: [a]the following characters on number in the same column means not significantly different at DMRT test with level of α 5%, MAP: Month After Planting, M_0: organic fertilizer control, M_1: organic fertilizer 45 kg, M_2: organic fertilizer 90 kg, S_0: N,P,K fertilizer package control, S_1: 0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O, S_2: 1.88 kg N + 1.34 kg P_2O_5 + 2.28 kg K_2O

3.1.2 Trunk Girth

Manure fertilizer application did not significantly affect trunk girth. Application of nitrogen, phophorus,

potassium fertilizer package significantly affected trunk girth, staring from 14 to 24 MAP (Table 2). Interaction of manure fertilizer and nitrogen, phophorus, potassium fertilizer package did not affected trunk girth. Inorganic fertilizer rate of S_1 (0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O tree^{-1} year^{-1}) significantly increases trunk girth. Oil palm trunks represents 50% of the total upper ground biomass when the plants was 10 years old and oil palm trunk has a essential function to support structures of plant leaves, flowers, and fruit; as a carrier system of plant nutrients, water and photosynthesis product; and as the largest food storage at the plant [14]. The result confirmed that the nitrogen, phophorus, potassium fertilizer affects the increasing of trunk girth, whereas the ideal trunk grith give the greater girth impact to the high yield fruit production [15].

Table 2: Effect of manure and nitrogen, phophorus, potassium fertilizer package fertilizer on trunk girth

Treatment	Age of the plant					
	14	16	18	20	22	24
	Trunk girth (cm)[a]					
Rates of Manure (kg. tree^{-1} year^{-1})						
M_0	74.63	87.09	100.54	107.45	123.54	140.31
M_1	78.11	94.17	106.51	119.71	134.38	155.64
M_2	76.55	89.71	105.91	116.30	134.07	157.64
Nitrogen, phophorus, potassium fertilizer package (kg. tree^{-1} year^{-1})						
S_0	70.48b	82.60b	93.44b	102.57b	116.15b	132.35b
S_1	73.55ab	87.91ab	102.27ab	114.28ab	132.84ab	152.84a
S_2	85.25a	100.49a	117.25a	126.60a	143.00a	168.40a

Notes: [a]the following characters on number in the same column means not significantly different at DMRT test with level of α 5%, MAP: Month After Planting, M_0: organic fertilizer control, M_1: organic fertilizer 45 kg, M_2: organic fertilizer 90 kg, S_0: N,P,K fertilizer package control, S_1: 0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O, S_2: 1.88 kg N + 1.34 kg P_2O_5 + 2.28 kg K_2O

3.1.3 Frond Production

Application of manure fertilizer did not significantly affect frond production. Application of nitrogen, phophorus, potassium fertilizer package significantly affected frond production at 16, 20 and 24 MAP (table 3). There was no interaction between manure and nitrogen, phophorus, potassium fertilizer package. The inorganic fertilizer rate of S_1 (0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O tree^{-1} year^{-1}) significantly increases plant frond. Frond production is influenced by genetic factors rather than influenced by environmental factors. Producing frond for immature palm oil normally is bi-monthly [16]. Frond production at 18 MAP addressing lowest production due to dry season during the research. The results from field observations indicated that precipitation were lest than 60 mm, it is supported by the results on the study [10] that the long dry season could affect the production of the frond.

Table 3: Effect of manure and nitrogen, phophorus, potassium fertilizer package fertilizer on frond production

Treatment	Age of the plant					
	14	16	18	20	22	24
	Frond production (frond.month^{-1})[a]					
Rates of Manure (kg. tree^{-1} year^{-1})						
M_0	2.36	2.34	2.11	3.85	5.43	2.71
M_1	2.51	2.51	2.28	4.08	5.53	2.97
M_2	2.43	2.56	2.20	4.04	5.63	2.84
Nitrogen, phophorus, potassium fertilizer package (kg. tree^{-1} year^{-1})						
S_0	2.35	2.18b	2.33	3.51b	5.42	2.06b
S_1	2.30	2.60a	2.18	4.06a	5.69	3.04a
S_2	2.65	2.62a	2.08	4.41a	5.48	3.42a

Notes: [a]the following characters on number in the same column means not significantly different at DMRT test with level of α 5%, MAP: Month After Planting, M_0: organic fertilizer control, M_1: organic fertilizer 45 kg, M_2: organic fertilizer 90 kg, S_0: N,P,K fertilizer package control, S_1: 0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O, S_2: 1.88 kg N + 1.34 kg P_2O_5 + 2.28 kg K_2O

Table 5: Effect of manure and nitrogen, phophorus, potassium fertilizer package fertilizer on frond length

Treatment	Age of the Plant (MAP)					
	14	16	18	20	22	24
	Frond length (month^{-1})[a]					
Rates of Manure (kg. tree^{-1} year^{-1})						
M_0	187.91	200.29	215.38	229.76	262.08	271.72
M_1	197.88	208.30	230.02	245.47	275.11	296.60
M_2	197.74	210.83	229.31	243.46	279.70	296.07
Nitrogen, phophorus, potassium fertilizer package (kg. tree^{-1} year^{-1})						
S_0	188.35	191.96	204.82b	231.67	245.47b	268.44b
S_1	193.87	211.63	229.32a	235.87	275.96a	288.73ab
S_2	201.31	215.83	238.57 a	251.14	295.47a	307.21a

Notes: [a]the following characters on number in the same column means not significantly different at DMRT test with level of α 5%, MAP: Month After Planting, M_0: organic fertilizer control, M_1: organic fertilizer 45 kg, M_2: organic fertilizer 90 kg, S_0: N,P,K fertilizer package control, S_1: 0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O, S_2: 1.88 kg N + 1.34 kg P_2O_5 + 2.28 kg K_2O

3.1.4 Frond Length

Manure fertilizer application did not significantly affect frond length. Application of nitrogen, phophorus, potassium fertilizer package significantly affected frond length at 18 to 24 MAP, however, no real effect at 20 MAP (Table 4). Interaction of manure fertilizer and nitrogen, phophorus, potassium fertilizer package did not affected frond production. The inorganic fertilizer rate of S_1 (0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O $tree^{-1}$ $year^{-1}$) significantly increases frond length significantly. The frond length will increase toward plant age until the maximum length is reached [10].

3.2 Physiological Response

3.2.1 Leaf nutrient content

Manure application increased nitrogen and phosphorus leaf content at 24 MAP. Application of nitrogen, phophorus, potassium fertilizer package increased nitrogen leaf content at 18 and 24 MAP, however increase phosphorus leaf content at 24 MAP, and non affedted potassium leaf content (Table 5). The critical nutrient levels for immature oil palm leaves had not been yet reached e.i 2.50% for N, 0.16% for P, and 1.00% for K [17]. Based on that criteria, could assumed that the appropriate rate for maximum plant growth is S_2 (1.88 kg N + 1.34 kg P_2O_5+ 2.28 kg K_2O $tree^{-1}$ $year^{-1}$).

Table 5: Effect of manure and nitrogen, phophorus, potassium fertilizer package fertilizer on leaf nutrient content

Treatment	Age of the plant (MAP)					
	18			24		
	N (%)[a]	P (%)[a]	K (%)[a]	N (%)	P (%)	K (%)[a]
Rates of Manure (kg. $tree^{-1}$ $year^{-1}$)						
M_0	2.42	0.15	0.84	2.45a	0.23b	1.07
M_1	2.46	0.15	0.81	2.29b	0.23b	1.01
M_2	2.49	0.15	0.82	2.47a	2.24a	1.08
Nitrogen, phophorus, potassium fertilizer package (kg. $tree^{-1}$ $year^{-1}$)						
S_0	2.26c	0.15	0.85	1.99b	0.22b	0.99
S_1	2.46b	0.15	0.81	2.63a	0.23a	1.11
S_2	2.65a	0.16	0.80	2.59a	0.24a	1.06

Notes: [a]the following characters on number in the same column means not significantly different at DMRT test with level of α 5%, MAP: Month After Planting, M_0: organic fertilizer control, M_1: organic fertilizer 45 kg, M_2: organic fertilizer 90 kg, S_0: N,P,K fertilizer package control, S_1: 0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O, S_2: 1.88 kg N + 1.34 kg P_2O_5 + 2.28 kg K_2O

3.2.2 Chlorophyll Content and Net Assimilation Rate

Manure influenced the chlorophyll content, the application of 90 kg manure tree^{-1} year^{-1} showed the chlorophyll content increase significantly (Table 6). Application of nitrogen, phophorus, potassium fertilizer package significantly affected chlorophyll content. Applicaation S_1 (0.94 kg N + 0.67 kg P_2O_5 + 1.14 K_2O kg tree^{-1} year^{-1}) significantly increased the chlorophyll content. Chlorophyll content was from 0.032 to 0.043 mg.cm-2. Manure significantly affected the photosynthesis rate of leaves. The treatment of 90 kg manure tree^{-1} year^{-1} significantly increased the Net Assimilation Rate (NAR). The application of nitrogen, phophorus, potassium fertilizer packag did not significantly affect the NAR. Net Assimilation is affected by plant age, leaf position, and environmental factors [18].

Table 6: Effect of manure and nitrogen, phophorus, potassium fertilizer package fertilizer on chlorophyll content and Net Assimilation Rate

Treatment	Age of the plant (MAP)		
	18	24	18
	Chlorophyll content (mg.cm^{-2})		Net Assimilation Rate (µmol CO_2 m^{-2} S^{-1})[a]
Rates of Manure (kg.tree^{-1} year^{-1})			
M_0	0.036b	0.038b	13.50ab
M_1	0.037ab	0.041a	12.59b
M_2	0.038a	0.042a	14.56a
Nitrogen, phophorus, potassium fertilizer package (kg. tree^{-1} year^{-1})			
S_0	0.033b	0.037b	13.81
S_1	0.038a	0.041a	12.64
S_2	0.040a	0.042a	14.20

Notes: [a]the following characters on number in the same column means not significantly different at DMRT test with level of α 5%, MAP: Month After Planting, M_0: organic fertilizer control, M_1: organic fertilizer 45 kg, M_2: organic fertilizer 90 kg, S_0: N,P,K fertilizer package control, S_1: 0.94 kg N + 0.67 kg P_2O_5 + 1.14 kg K_2O, S_2: 1.88 kg N + 1.34 kg P_2O_5 + 2.28 kg K_2O

4. Conclusions

Manure aplication influenced plant physiology by enhancing nitrogen leaf content at 24 MAP, P leaf content at 24 MAP, net assimilation rate and chlorophyll content at 18 and 24 MAP. Application of nitrogen, phophorus, potassium fertilizer package increased plant height, trunk girth, frond production, frond length, nitrogen and phosphorus leaf content, leaf chlorophyll content, however did not significantly affect Net Assimilation Rate. The best rate of nitrogen, phophorus, potassium fertilizer package is application S_1 (0.94 N + 0.67 P_2O_5 + 1.14 K_2O kg tree^{-1} year^{-1}).

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