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Optimization of NPK Compound Fertilizer Package Rate on One Year Old Oil Palm (*Elaeis guineensis*, Jacq) Trees

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Abstract

The objectives of this research were (i) to study growth response and (ii) to determine the optimum rate of NPK compound fertilizer package for the promoting the growth of one year old oil palm trees. The experiment was conducted from March 2013 to February 2014 at IPB-Cargill Teaching of Oil Palm, Jonggol Bogor, West Java Indonesia. The experiment was arranged in randomized block design with one factor and three replications.

The treatments were four NPK compound fertilizer package as follow: control (P0), NPK 650 g + 25 g boric acid + 25 g $CuSO_4.5H_2O$ (P1), NPK 1,300 g + 25 g boric acid + 25 g CuSO4.5H2O (P2), NPK 2,600 g + 25 g boric acid + 25 g CuSO4.5H2O (P3) per palm. The result showed that application of NPK compound fertilizer package significantly increased the growth of young oil palm linearly as shown by plant height, leaf number, leaf area of frond number nine, chlorophyll content, N and P content of the leaves. Optimum rate of NPK compound fertilizer package for one year old oil palm trees has not been determined at this research because the plant growth response was still linear.

Keywords: inorganic; leaf frond number nine; optimum rate; response patterns.

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1. Introduction

Oil palm is the main estate crop that brought Indonesia as the main producer of palm oil in the world. Palm oil, both Crude Palm Oil (CPO) and Kernel Palm Oil (KPO), have been widely utilized by fractionation (edible oil), margarine, cosmetics, oleo-chemical and bio-diesel industries [1,2]. Oil palm productivity could be increased using the hybrid varieties, however the productivity is also influenced by other factors such as climate, soil, and palm oil maintenance [3,4].

Young oil palm stage requires intensive maintenance to attain maximum vegetative growth before entering into the mature oil palm stage. Fertilization is one of the main agronomic activity to provide nutritional status to reach the maximum growth and productivity of palm oil. Under intensive management and depending on characteristic of soil and climate conditions, fertilizers cost is about 50–70% of plant maintenance costs, or 30–35% of variable costs and about 25% of total cost production. Fertilization provides both macro and micro nutrients for oil palm to support the development and production [5]. Nutrient resources consist of single fertilizers such as Urea, Super Phosphate and Muriate of Potash and compound fertilizer (NPK compound).

NPK compound fertilizer is commonly used by small-holders and estate plantation. Compound fertilizer containing at least two nutrients, therefore NPK compound consist of nitrogen, phosphor and potassium. Application of NPK compound could be implemented so that nutrients in the soil are in balance, finally the plant develop well and the production of the fruit increase significantly [6]. The advantages of NPK compound include slow release fertilizer [7], effective and efficient and also easy to be applied [8].

Precise fertilization rate is required to increase the effectiveness at the young oil palm stage [5]. Researche to determine the rate of fertilizer for palm oil have been carried out by using an approach based on a single fertilizer, whereas in this research, the approach utilized is based on compound fertilizer package. This research is a research series to determine the optimum rate of fertilizer package for immature palm oil. The research to determine the optimum rate of single fertilizer package has been done [9]. The objectives of this research were (i) to study the response patterns and (ii) to determine the optimum rate of NPK compound fertilizer package for accelarating the growth of one year old oil palm trees at IPB-Cargill Teaching of Oil Palm, Jonggol Bogor West Java, Indonesia.

2. Materials and Methods

The experiment was conducted from March 2013 to February 2014 at IPB-Cargill Teaching of Oil Palm, Jonggol Bogor. Located at coordinates 06^o 28,319’ South, 107^o 01,103’ East and an altitude of 116 m above sea level. The materials used were young oil palm Tenera, Damimas variety, planted 3 months before treatment; NPK Phonska (13: 14: 17), $CuSO_4.5H_2O$ and boric acid (12% B).

The experiment was arranged in randomized block design with one factor and three replications. Each treatment plot had five plant samples, so total of the sample were 60 palms. The treatments were four NPK compound fertilizer packages as follow: control (P0), NPK 650 g + 25 g boric acid + 25 g $CuSO_4.5H_2O$ (P1), NPK 1,300 g

+ 25 g boric acid + 25 g $CuSO_4.5H_2O$ (P2), NPK 2,600 g + 25 g boric acid + 25 g $CuSO_4.5H_2O$ (P3) per palm. Fertilizer package was based on fertilizer recommendation of IOPRI [10]; which is 1,300 g of NPK, 25 g of borate acid and $CuSO_4.5H_2O$ per palm per year. Fertilizer application or treatment was conducted three times; each was for every four month period (in March, July and December 2013). Before application of treatment the circle weeding have been done.

Variables measured consisted of morphological responses such as plant height, number of leaf, stem girth and leaf area of frond number nine. Morphological variable responses were observed for morphology response observed every month for 12 months. Physiological responses of chlorophyll content [11], using SPAD 502 plus chlorophyll metter, N, P and K content of leaf frond number nine. The data were analyzed by analysis of variance at level α of 5%, if the ttreatment variance show a significant effect, then response model was determined with orthogonal polynomial test at level α of 5%.

3. Results and Discussion

3.1. Morphological Response

Application of NPK compound fertilizer package significantly and linearly increased plant height 12 months after application (12 MAP), leaf number (11-12 MAP) and leaf area of frond number nine (10-12 MAP), but were not significantly on stem girth and frond length (Table 1). Linear response shown that increasing compound fertilizer package rate (P1, P2 and P3) increased the plant height, number of leaf and leaf area of frond number nine until the highest rate (P3) of NPK compound fertilizer package (NPK 2,600g+25g boric acid+25g $CuSO_4.5H_2O$)

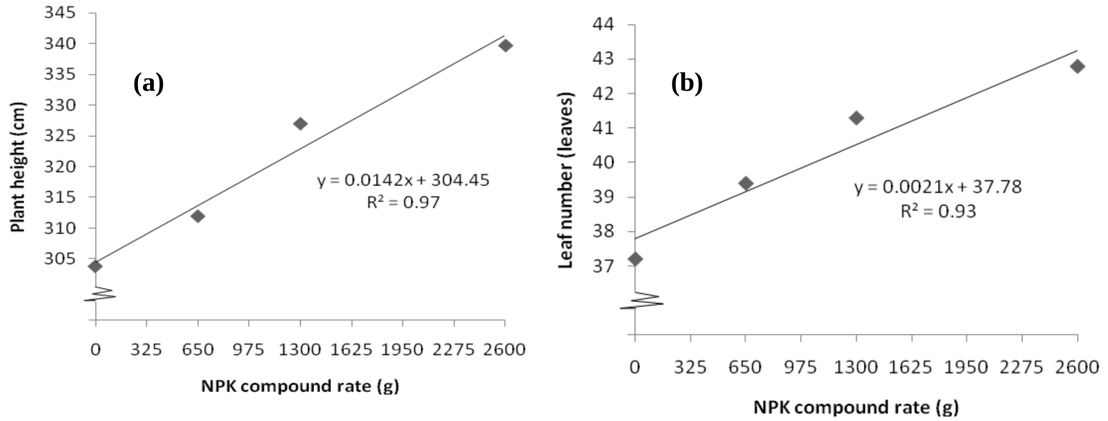
Table 1: NPK compound fertilizer package effect on morphological responses at 0, 4, 6, 8, 10, 11 and 12 MAP

Rate of compound fertilizer package	Plant height (cm)						
	0 MAP	4 MAP	6 MAP	8 MAP	10 MAP	11 MAP	12 MAP
P0	177.20	223.43	244.13	278.76	291.83	294.27	303.73
P1	155.40	212.36	239.30	279.83	295.10	299.30	311.90
P2	155.96	219.80	244.53	286.03	310.93	316.27	326.96
P3	165.40	222.23	248.66	289.86	322.33	329.90	339.70
Response pattern¢	ns	ns	ns	ns	ns	ns	L**
	Stem girth (cm)						
P0	20.26	35.7	41.40	46.06	49.66	51.10	52.96
P1	19.53	36.13	41.46	47.20	51.46	53.03	55.23
P2	18.46	37.43	42.60	48.03	52.53	54.36	56.60
P3	19.50	38.56	46.23	52.26	56.60	58.60	61.00
Response	ns	ns	ns	ns	ns	ns	ns

pattern[¢]							
			Leaf number (leaves)				
P0	13.6	21.4	25.6	28.8	33.4	34.6	37.2
P1	12.9	21.3	26.4	30.2	34.6	36.8	39.4
P2	13.6	22.5	27.5	31.4	36.6	38.8	41.3
P3	13.6	23.0	28.00	32.2	37.7	40.2	42.8
Response pattern[¢]	ns	ns	ns	ns	ns	L**	L**
			Leaf area number nine (m^2)				
P0	0.45	0.93	0.92	1.10	1.14	1.13	1.34
P1	0.51	0.94	0.92	1.17	1.16	1.13	1.44
P2	0.48	0.94	1.07	1.18	1.29	1.27	1.60
P3	0.58	1.05	1.06	1.32	1.38	1.40	1.72
Response pattern[¢]	ns	ns	ns	ns	L**	L**	L**
			Frond length number nine (cm)				
P0	104.03	134.36	147.00	163.13	176.86	192.36	197.20
P1	109.00	127.96	141.00	156.93	175.90	189.46	197.56
P2	106.10	130.93	146.60	159.93	183.06	199.46	208.23
P3	110.50	136.00	147.90	165.60	188.60	205.80	211.16
Response pattern[¢]	ns	ns	ns	ns	ns	ns	ns

Notes: [¢]: orthogonal polynomial test; L: Linier, Q: Quadratic, ns: non significant, *: significant at P<0,05, **: significant at P<0,01, BSP (months after treatment). P0: organic fertilizer 60 kg, *Rock Phospate* 500 g and dolomite 500 g per plant, P1: 650 g NPK + 25 g borat + 25 g $CuSO_4.5H_2O$, P2: 1.300 g NPK + 25 g borat + 25 g $CuSO_4.5H_2O$, P3: 2.600 g NPK + 25 g borat + 25 g $CuSO_4.5H_2O$ per plant, P1 – P3 were added with P0

The increasing of plant height, leaf number and leaf area frond number nine of the highest rate (P3) were 11.8%, 15.0% and 28.3% respectively compared to control at 12 MAP. Linear response also indicated that until the highest rate of fertilizer, the optimum rate of NPK compound fertilizer package has not been reached. To support growth of young oil palm, it requires large amounts of nutrients such as nitrogen, phosphorus and potassium [5].



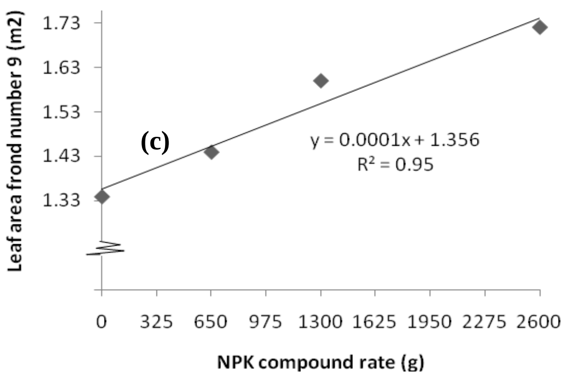


Figure 1: Regression equations and curve responses of plant height (a), leaf number (b) and leaf area number nine (c) to increasing rate of NPK Compound Fertilizer Package at 12 MAP.

The length of leaf number 9 increase 28.3% due to the application of NPK compound compared to the control treatment. The correlation test among parameters observed showed that leaf area frond number 9 had a positive, strong, and significant correlation with plant height (0.9) and the number of frond (0.72). Increasing of the leaf area enhanced the photosynthesis process of the palm to support the vegetative growth as plant height and number of frond. Application of nitrogen, phosphorus and potassium, fertilizer increased the dry weight of oil palm through increasing of leaf area and net assimilation rate of plant [12]. According [13], NPK compound application increased the plant height, frond number and leaf area frond number four of oil palm seedlings at the main nursery.

3.2. Physiological Response

3.2.1 Chlorophyll Content

Application of NPK compound fertilizer package significantly and linearly increased chlorophyll content at 8 and 12 MAP (Table 2). Increasing of fertilizer rate to highest rate gave as much as 17.5% of leaf chlorophyll content, it was higher than the control at 12 MAP (Figure 2). Similar results were shown by [13] that application of NPK compound fertilizer increased the chlorophyll content of oil palm seedlings in the main nursery. The chlorophyll and N content of leaf was significantly correlated (r = 0.95). Relative water content and chlorophyll a/b content were gradually decreased while leaf relative conductivity was increased quickly under water and nutrient stress conditions [14].

3.2.2. Nutrient Content of Leaf

Application of NPK compound fertilizer package significantly and linearly increased N and P content of leaf at 12 MAP (Table 2). Increasing fertilizer to highest rate (P3) gave as much as 15.4% and 13% of N and P content of leaf, consecutively, higher than the control rate at 12 MAP (Figure 2). Correlation test showed that N content of leaf had positive correlation with plant height (0.83), leaf number (0.84), leaf area of frond number nine

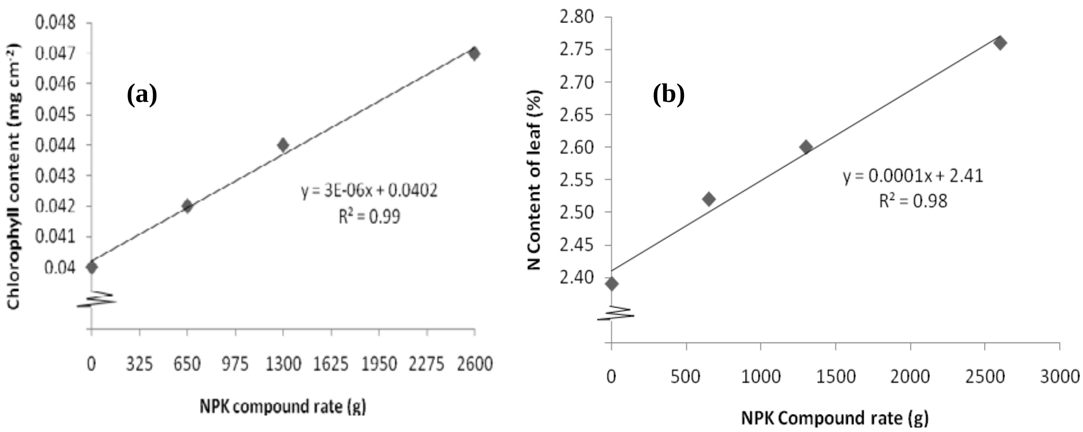
(0.92) and leaf chlorophyll content (0.95). Whereas P content of leaf had positive correlation with plant height (0.63) and leaf area of frond number nine (0.82). Nitrogen plays an important role to stimulate vegetative growth of plant, and also influence chlorophyll content, amino acids, proteins, and organic acids; while the role of phosphorus is to enhance the synthesis of ATP, nucleic acids, and phospholipids [15]. Oil palms at 9 months old showed significant effects in the N uptake as affected by P fertilizer application [16].

Table 2: NPK compound fertilizer package effect on chlorophyll content and N, P and K content of leaf at 4, 8 and 12 MAP

Rate of compound fertilizer package	Chlorophyll content (mg cm^{-2})			Nutrient content of leaf (%)		
				N	P	K
	4 MAP	8 MAP	12 MAP	12 MAP	12 MAP	12 MAP
P0	0.041	0.040	0.040	2.39	0.23	0.88
P1	0.043	0.041	0.042	2.52	0.25	0.89
P2	0.044	0.043	0.044	2.60	0.25	0.91
P3	0.046	0.045	0.047	2.76	0.26	0.99
Response pattern¢	ns	L**	L**	L**	L**	ns

Notes: ¢: orthogonal polynomial test; L: Linier, Q: Quadratic, ns: non significant, *: significant at P<0,05, **: significant at P<0,01, BSP (months after treatment). P0: organic fertilizer 60 kg, *Rock Phospate* 500 g and dolomite 500 g per plant, P1: 650 g NPK + 25 g borat + 25 g $CuSO_4.5H_2O$, P2: 1.300 g NPK + 25 g borat + 25 g $CuSO_4.5H_2O$, P3: 2.600 g NPK + 25 g borat + 25 g $CuSO_4.5H_2O$ per plant, P1 – P3 were added with P0

Nutrient content of leaf at 12 MAP were 2.39 - 2.76% N, 0.23-0.26% P and 0.88-0.99% K respectively, and the critical nutrient levels of frond number nine of young oil palm trees are 2.75% N, 0.16% P and 1.25% K [17].



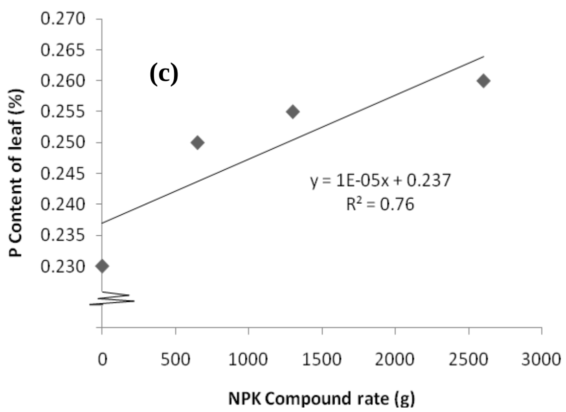


Figure 2: Regression equations and curve responses of chlorophyll content (a), N content of leaf (b) and P content of leaf (c) increasing rate of NPK compound fertilizer package at 12 MAP

These results indicate that the nutrient content of leaf up to the highest rate of N and P contents have been above the critical nutrient level of leaf, while K content of leaf was still under the critical nutrient level. The positive linearly plant growth response has a meaning that the optimum rate of NPK fertilizer has not been reached. Based on those facts, the possibility of unbalance of nutrient level has been occured, due to lack of K, caused the optimum rate of fertilizer for maximum growth has not been attained.

4. Conclusion

Application of NPK compound fertilizer package significantly increased the growth of young oil palm linearly as shown by plant height, leaf number, leaf area of frond number nine, chlorophyll content, N and P content of the leaves. Optimum rate of NPK compound fertilizer package for one year old oil palm trees has not been attained at this point; however, increasing rate of K in the package will probably give a better response of growth.

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