# Optimization and Effect of N , P, and K Single Fertilizer Package Rate on Two Years Old Immature Oil Palm (*Elaeis guineensis* Jacq.)

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**ABSTRACT**--- ***Fertilizing must be considered in cultivation of oil palm especially the type and rate of a fertilizer. The use of the type and rate of a fertilizer should be acurate to support the growth and the production of oil palm. The objectives of this research were to study the pattern of the plant growth response and to determine the optimum rate of the N, P, and K single fertilizer package rate on two years old immature oil palm. This research was conducted from April 2014 to march 2015 at IPB-Cargill Teaching of Oil Palm, Jonggol, Bogor, West Java, Indonesia. The design was used randomized block design with one factor and three replications. The fertilizer treatment were four packages, they were: control (P0), fertilizer 1125 g urea + 975 g SP-36 + 1125 g KCl + 50 g borat + 50 g $CuSO_4.5H_2O$ each plant (P1), fertilizer 2250 g urea + 1950 g SP-36 + 2250 g KCl + 50 g borat + 50 g $CuSO_4.5H_2O$ each plant (P2), fertilizer 4500 g urea + 3900 g SP-36 + 4500 g KCl + 50 g borat + 50 g $CuSO_4.5H_2O$ each plant (P3). The result showed that the application of N, P, and K single fertilizer package linearly significant to plant height, stem girth, leaf number, and frond length number nine but did not significant to leaf area of frond number nine and all of physiological variables. The optimum rate of N, P, and K single fertilizer package can not be set because the effect of fertilizer still linier.***

**Keywords**--- vegetative growth, inorganic, recommendation, nutrient level

## 1. INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is a major comodity from plantation sector and it grows really fast [1]. Plantation product that comes from oil palm has a really wide market because can be used for commercially product such as vegetable oil, margarine, soap, and wax [2]. [3] estimated that in 2050 the need for oil palm in the world will be 120-156 million tons.

The phase of immature oil palm is require intensive maintenance to achieve maximum vegetative growth. Maximum vegetative growth will be increase the optimal production. One of the factor that play a role in the maintenance of this immature plants phase is fertilization activities [4]. The fertilization aims to ensure the sufficiency and stability of plant nutrition so that the growth of seeds can be maximized. The need of nutrition for oil palm is different in each phase of growing. The lost of nutrition due to leaching, evaporating, and physical and chemical of soil should be estimated to determine the amount of nutrition that will be added through fertilization [5]. The effect of fertilizer with the lower rate will not be optimal to the quality and quantity of the plant growth and production. The higher rate of fertilization can degrade the quality of environment, plant growth, and productivity [6]. Furthermore [7] stated that the optimum fertilization not only aimed to get the good quality and quantity of the plant but also to avoid toxicity in plant and environment degradation. The information regarding the accuracy of the type and rate in fertilization will be important to increase the efficiency and effectiveness of fertilization [8].

The nutrition that can be added through fertilization can be found from single inorganic fertilizer. Single fertilizer have only one nutrient so the amount of nutrition that will be given can be determined according to their needs. Oil palm usually takes single fertilizer from urea and ZA as N nutrition sources. Triple Superfosfat (TSP), Rock Phosphate (RP), and SP-36 as P nutrition sources, Muriate of Potash (MoP) as K nutrition source, kieserit and dolomit as Mg nutrition

source. [9] showed that the application of N, P, and K fertilizer increased the plant height, stem girth, leaf number, and leaf area of frond number nine of one year old immature oil palm.

This research was continuation from [4] on one year old of immature oil palm by using a compound NPK fertilizer treatment. The objectives of this research were to study the pattern of the plant growth response and to determine the optimum rate of the N, P, and K single fertilizer package rate on two years old immature oil palm at IPB-Cargill Teaching of Oil Palm, Jonggol, Bogor, West Java, Indonesia.

## 2. MATERIALS AND METHODS

This research was conducted from April 2014 to March 2015 at IPB-Cargill Teaching of Oil Palm, Jonggol, Bogor, West Java, Indonesia with the coordinates 06$^o$ 28,319' South, 107$^o$ 01,103' East and an altitude of 116 m above sea level. The materials used were immature oil palm Tenera Damimas variety aged 16 months, the single fertilizer of Urea, SP-36, KCL, terusi ($CuSO_4.5H_2O$), and Borat. The tools used were gauge, analitic scale, SPAD-502 plus chlorophyll meter, and microscope.

The design used in this research was randomized block design one factor with three replications. Each experimental unit consisted of five oil palms so the total unit of experiments were 60 plants. All of oil palms have been given basic fertilizer before treatment with organic fertilizer 60 kg, Rock Phosphate 500 g, and 500 g dolomite each plant. Fertilizer treatment consisted of four packages, they were: control (P0), 1125 g urea + 975 g SP-36 + 1125 g KCl + 50 g borat + 50 g terusi ($CuSO_4.5H_2O$) each plant (P1), 2250 g urea + 1950 g SP-36 + 2250 g KCl + 50 g borat + 50 g terusi ($CuSO_4.5H_2O$) each plant (P2), 4500 g urea + 3900 g SP-36 + 4500 g KCl + 50 g borat + 50 g terusi ($CuSO_4.5H_2O$) each plant (P3). Fertilizer application was given two times every six months at the age of 16 and 22 months after planting. The rate of fertilizer was half of the total rate. The fertilization was given by spreading the fertilizer around the plate of oil palm .

The observation of plant morphology variables were plant height, stem girth, leaf number, frond length number nine, and leaf area of frond number nine. The plant height observed every two months for 12 months. Stem girth, number of leaf, frond length, and leaf area number nine observed every month for 12 months. The observation of plant physiology variables were leaf chlorophyll content using SPAD 502 plus chlorophyll metter, the density of stomata, N, P, and K content of leaf frond number nine observed at the age 18 and 24 months.

The data obtained were analyzed of variance at level α of 5%, if significant was determined with orthogonal polynomial test at level α of 5%. Analysis will be done by SAS (*Statistical Analysis System*) program.

## 3. RESULT AND DISCUSSION

### *3.1 Plant morphology response*

The application of N, P, and K single fertilizer package showed linearly significant to plant height (24 months), stem girth (18-20 months), leaf number (13-24 months), and frond length number nine (13 and 22 months) but did not significant to the leaf area of frond number nine (Table 1). Linier effect showed that, by adding the rate of single fertilizer (P1, P2 and P3) increased the plant height, stem girth, leaf number, and frond length number nine until the highest rate (P3) (Figure 1) so the optimum rate in this research still can not be determined. [10] stated that the environment factors such as fertilizer application with different rate really affected the growth of seed and phenotype appearance of the plant.

The highest increasing of growing was at the aged of 24 months, occur to the leaf number variable up to 8.94% compared to the control. Correlation value showed that leaf number has a positive correlation to the plant hight (0.837). Correlation value explained that if the leaf number increased, the hight plant will be increased too. The process of photosynthesis in plants will be increased if the leaf number increased because assimilates produced will be more, resulting in better plant growth. Moreover, with the increasing photosynthesis will be increase growth and cell renewal, so that the high growth of plants will be higher [11]**.** The plant hight of oil palm increased due to the application of P fertilizer at age 5 Month After Planting (MAP) [12]. Furthermore [13] stated that the application of N, P, and K single fertilizer to the one year old immature oil palm increased the frond production which will is affect the number of oil palm leaf.

Nitrogen is a nutrition to constituent of chlorophyll that increase of photosyntate to build new cells, partition compiler materials and for growing of the parts that active to cleave [14]. Phosphorus has a role as a moleculer components as energy transfer for ATP and ADP, also NAD and NADPH which are needed by the plant to do photosynthesis, respiration, protein synthesis and amino acid, and nutrition transfer [15]**.** Potassium is important to the cell growth through the effect of the cell extension [16].

Table 1: The influence of N, P and K single fertilizer package rate towards plant morphology variables in 14, 16, 18, 20, 22, and 24 months

| Rate of single fertilizer package | Plant height (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 14 months | 16 months | 18 months | 20 months | 22 months | 24 months |
| P0 | 362.47 | 392.53 | 417.47 | 429.67 | 455.93 | 477.13 |
| P1 | 362.13 | 390.53 | 418.93 | 431.33 | 472.33 | 501.07 |
| P2 | 379.27 | 418.00 | 441.73 | 455.07 | 477.55 | 503.33 |
| P3 | 381.73 | 406.33 | 438.40 | 452.73 | 489.60 | 509.93 |
| Respons pattern ¢ | ns | ns | ns | ns | ns | * L |
| | Stem girth (cm) | | | | | |
| P0 | 85.20 | 96.60 | 107.87 | 115.60 | 124.93 | 131.80 |
| P1 | 85.30 | 98.60 | 111.00 | 120.00 | 129.87 | 139.60 |
| P2 | 89.20 | 102.60 | 116.20 | 123.47 | 122.80 | 140.52 |
| P3 | 91.60 | 105.40 | 117.60 | 126.60 | 133.13 | 140.53 |
| Respons pattern¢ | ns | ns | *L | *L | ns | ns |
| | Leaf number (leaves) | | | | | |
| P0 | 47.07 | 52.33 | 58.20 | 62.60 | 68.60 | 74.60 |
| P1 | 49.40 | 54.93 | 61.00 | 66.07 | 72.07 | 78.07 |
| P2 | 51.60 | 57.53 | 63.47 | 68.93 | 74.78 | 80.78 |
| P3 | 52.33 | 57.6 | 64.13 | 69.27 | 75.27 | 81.27 |
| Respons pattern¢ | **L | **L | **L | **L | **L | **L |
| | Frond length number nine (cm) | | | | | |
| P0 | 264.67 | 276.73 | 305.07 | 322.13 | 355.80 | 365.47 |
| P1 | 257.27 | 282.33 | 319.93 | 332.80 | 360.00 | 364.20 |
| P2 | 266.93 | 286.67 | 311.93 | 333.07 | 364.08 | 366.33 |
| P3 | 276.47 | 305.33 | 321.93 | 346.13 | 378.40 | 382.20 |
| Respons pattern¢ | ns | ns | ns | ns | *L | ns |
| | Leaf area number nine ($m^2$) | | | | | |
| P0 | 1.99 | 2.61 | 2.32 | 2.64 | 3.36 | 3.19 |
| P1 | 2.29 | 2.58 | 2.34 | 3.09 | 3.38 | 3.27 |
| P2 | 2.32 | 2.52 | 2.33 | 2.95 | 3.39 | 3.10 |
| P3 | 2.46 | 2.52 | 2.29 | 2.95 | 3.67 | 3.42 |
| Respons pattern¢ | ns | ns | ns | ns | ns | ns |

Notes : ¢: orthogonal polynomial test; L: Linier, ns: non significant, *: significant at P<0,05, **: significant at P<0,01. P0: organic fertilizer 60 kg, *Rock Phospate* 500 g and dolomite 500 g per plant, P1: 1125 g urea + 975 g SP-36 + 1125 g KCl + 50 g borat + 50 g $CuSO_4.5H_2O$, P2: 2250 g urea + 1950 g SP-36 + 2250 g KCl + 50 g borat +50 g $CuSO_4.5H_2O$, P3: 4500 g urea + 3900 g SP-36 + 4500 g KCl + 50 g borat +50 g $CuSO_4.5H_2O$ per plant, P1 – P3 were added with P0

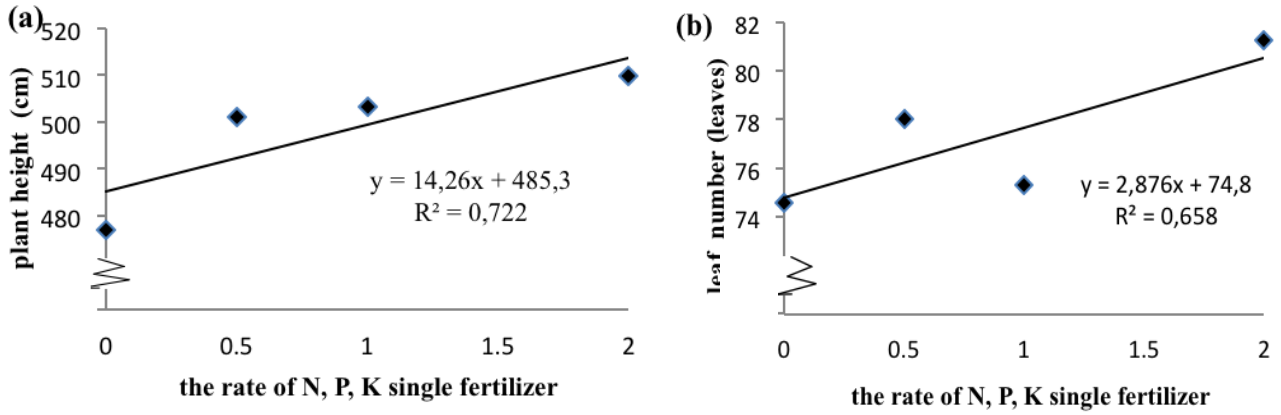


Figure 1: Regression equations and curve responses of plant height (a) and the leaf number (b) to increasing the rate of N, P, K single fertilizer package rate at the age of 24 months

### *3.2 Plant physiology response*

#### *3.2.1 The chlorophyll content and the density of stomata*

The application of single fertilizer package rate did not significant to the chlorophyll content at the 18 and 24 months (Tabel 2). The chlorophyll content related to the sufficiency of nitrogen nutrition [17]. Nitrogen content in the leaf tissue is high enough, between 2.83-3.07% (Table 3). According to [18] that the value of N critical nutrient level at the leaf number nine is 2.5-2.75%. The high content of N could become a reason the chlorophyll content did not significant. Nitrogen with high accumulation will be translocated to the younger tissue in order to keep the cell osmotic balance [19].

The result also showed that the application of single fertilizer package rate did not significant to the density of stomata at 18 and 24 months (Tabel 2). Siallagan *et al.* (2014) stated that the density of stomata influenced by temperature, light intensity, and the adaptation of plants to their environment.

Tabel 2: The influence of N, P, and K single fertilizer package rate towards chlorophyll content and the density of stomata at 18 and 24 months

| Rate of single fertilizer package | Chlorophyll content (mg $cm^{-2}$) | | Stomata density ($mm^{-2}$) | |
|---|---|---|---|---|
| | 18 month | 24 month | 18 month | 24 month |
| P0 | 0.045 | 0.043 | 205.80 | 214.86 |
| P1 | 0.044 | 0.044 | 190.52 | 211.46 |
| P2 | 0.041 | 0.043 | 182.31 | 217.41 |
| P3 | 0.043 | 0.041 | 193.35 | 220.81 |
| Respons pattern¢ | ns | ns | ns | ns |

Notes : ¢: orthogonal polynomial test; ns: non significant. P0: organic fertilizer 60 kg, *Rock Phospate* 500 g and dolomite 500 g per plant, P1: 1125 g urea + 975 g SP-36 + 1125 g KCl + 50 g borat + 50 g $CuSO_4.5H_2O$, P2: 2250 g urea + 1950 g SP-36 + 2250 g KCl + 50 g borat +50 g $CuSO_4.5H_2O$, P3: 4500 g urea + 3900 g SP-36 + 4500 g KCl + 50 g borat +50 g $CuSO_4.5H_2O$ per plant, P1 – P3 were added with P0

#### *3.2.2 Nutrition content of leaf tissue*

The application of single fertilizer package rate did not significant to all leaf nutritions content at 18 and 24 months (Table 3). The application of single fertilizer rate has not be able to increase the content of N, P, and K nutrition to the plant leaf tissue.

Tabel 3: The influence of N, P, and K single fertilizer package rate towards the leaf of frond number nine at 18 and 24 months

| Single fertilizer dose package | Nutrition content of leaf tissue | | | | | |
|---|---|---|---|---|---|---|
| | N (%) | | P (%) | | K (%) | |
| | 18 months | 24 months | 18 months | 24 months | 18 months | 24 months |
| P0 | 2.83 | 2.76 | 0.17 | 0.20 | 0.78 | 0.88 |
| P1 | 3.07 | 2.67 | 0.18 | 0.20 | 0.78 | 0.89 |
| P2 | 2.95 | 2.57 | 0.18 | 0.19 | 0.82 | 0.98 |
| P3 | 2.96 | 2.57 | 0.18 | 0.20 | 0.78 | 0.91 |
| Respons pattern¢ | ns | ns | ns | ns | ns | ns |

Notes : ¢: orthogonal polynomial test; ns: non significant. P0: organic fertilizer 60 kg, *Rock Phospate* 500 g and dolomite 500 g per plant, P1: 1125 g urea + 975 g SP-36 + 1125 g KCl + 50 g borat + 50 g $CuSO_4.5H_2O$, P2: 2250 g urea + 1950 g SP-36 + 2250 g KCl + 50 g borat +50 g $CuSO_4.5H_2O$, P3: 4500 g urea + 3900 g SP-36 + 4500 g KCl + 50 g borat +50 g $CuSO_4.5H_2O$ per plant, P1 – P3 were added with P0

The leaf nutrition content of frond number nine aged 24 months were 2.57-2.76% for N, 0.19-0.20% for P, and 0.88-0.98% for K (Tabel 3). Meanwhile, critical nutrient level in the leaf of frond number nine of immature oil palm plant were 2.5-2.75% N, 0.15-0.16% P, and 1.00-1.25% K [18]. This result showed that the nutrition content of N and P has passed critical nutrient level, but the nutrition content of K has not passed critical nutrient level. The data showed that the leaf of N nutrition content was decreased at aged 24 months compared with 18 months but still in the range above the critical nutrient level. It might be the N fertilizer at the second application used to increase the vegetative growth than the leaf nutrient content, while the soil nutrient content at the rate of P0 still able to support the N nutrient content sufficiently. By knowing the content of nutrition in the plant, the estimation of fertilizer that will be applied can be accurate [20]. The estimation of optimum rate in this research has not been specified because all of nutrients analyzed in this research showed did not significant.

## 4. CONCLUSSION

The application of N, P, and K single fertilizer package rate could increase linearly the growth of oil palm morpholy toward the variable of plant height, stem girth, leaf number, and frond length number nine, but not for all plant physiology variables. The optimum rate of N, P, and K single fertilizer package for two years old immature oil palm has not been determined in the range of rate used, because the pattern of growth response still linier. Therefore, the rate of fertilizer need to be improved in order to form quadratic pattern, so that the optimum package application of N, P, and K can be estimated.

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