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The Effect of NPK 12-6-27 Fertilization on the Growth of Oil Palm Plants in the Main Nursery on Bogor Acid Dry Land

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Abstract: Research on the response to NPK 12-6-27 fertilization on oil palm seedlings was carried out on Oxisols acid dry soil from Bogor. Oil palm seedlings were planted in pots at the age of 3 months after the prenursery phase and maintained for 6 months. The purpose of the study was to determine the response of the NPK 12-6-27 fertilizer formula to the growth of oil palm plants in the main nursery and to obtain information on the optimum dose. The experimental design used was a randomized block with 7 treatments which were repeated 8 times. The treatments consisted of control, standard NPK, and five doses of NPK fertilizer formula 12-6-27. The results showed that the soil has a low level of soil fertility. Soil fertility constraints include acid soil pH (pH-H_2O = 4.7), level of C and N, P and K, cation exchange and cation exchange capacity (CEC) were low and high level of Al saturation (54%). At 6 months after application (BSA) fertilizers, application of NPK significantly increased oil palm plant height. The plant height in the Control treatment was about 71.4 cm and increased to 86.0 – 93.4 cm in the standard NPK and NPK 12-6-27 treatments. The standard NPK and NPK 12-6-27 treatments did not produce significantly different plant heights. The Control treatment resulted in stem dry weight of 114.3 g/pot and significantly increased to 158.2 – 207.0 g/pot with standard NPK and NPK 12-6-27. Fertilization of NPK 12-6-27 doses of 1.5 x and 2x resulted in plant dry weight of 206.3 g/pot and 207.0 g/pot higher and significantly different than standard NPK which resulted in plant dry weight of 158.2 g/pot. The RAE value of NPK 12-6-27 fertilizer is 120 – 211 higher than the standard NPK namely 100. The optimum dose of NPK 12-6-27 is 51 g/pot given for 6 months in the main nursery.

Keywords: NPK fertilizer; Oil palm seeds; Plant weight; Plant response; NPK fertilizer dosage; Oil palm seeds; Plant weights; Plant response; Optimal rate

Introduction

The potential of agricultural land resources in Indonesia for oil palm plantations is very large, both in dry land and swamp land. Potential land for annual crops including plantations and horticulture is on 66.72 million ha of dry land and 1.87 million ha of swampland (BBSDLP, 2015). Potential land for agriculture is land that is biophysically, especially from the aspects of topography/slope, climate, physical, chemical and biological properties of the soil suitable or suitable to be developed for agriculture (BBSDLP, 2008). Appropriate or suitable for agriculture indicates that technically the land is agronomically able to support plant growth optimally. Potential land has not considered social and legal aspects, such as land ownership and allotment status, but has already considered area status.

Dry land is dominated by Ultisols and Oxisols which have a wide distribution of around 47.5 million ha and 14.1 million ha. The spread of Oxisols is in South Sumatra, Kalimantan, Central Kalimantan, West Kalimantan, Lampung, Jambi, and a small part in West Java (Muljadi and Soepraptohardjo, 1975). The characteristics of Oxisol soils are low soil pH, low percentage of base saturation, and high content of Al, Fe, Si oxides (BBSDLP, 2015). Oxisols are classified as highly weathered soils with low easily weathered mineral content. The soil texture is generally clayey with a very low cation exchange capacity, which is less than 16 cmolc/kg-1. The low level of soil fertility is also related

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to high P fixation and low P availability. One effort to increase the fertility of Oxisols is by fertilizing, liming, and applying organic matter (Nurjaya, 2004). Oxisol fertility can be improved by applying humic acid accompanied by P fertilization, humic acid application can reduce the need for P fertilizer (Harahap et al, 2005; Herviyanti et al, 2012; Supriyo et al, 2013,). The use of Oxisol for oil palm nurseries needs to pay attention to its physical and chemical constraints in order to obtain good oil palm seeds. Kasno, (2019) stated that balanced fertilization is very effective and efficient on dry, acid soils. Balanced fertilization is carried out based on soil nutrient status and nutrient requirements by plants.

Fertilization is an effort to add nutrients to the soil so that plants can grow and produce optimally. Fertilization can improve plant vegetative growth and fresh fruit bunches (FFB) production (Sutarta et al, 1999). Fertilization improves plant growth and the health of oil palm seedlings. Fertilization can change the balance as well as the physiology and morphology of plants. (Harahap et al, 2005). Adnan et al, (2015) suggested that applying 142 g/pot NPK fertilizer to soil in polybags measuring 22x14 cm increased frond length at 9 months of age, crown dry weight and root dry weight of oil palm seedlings in the main nursery. Kasno and Anggria, (2016) suggest that the optimum dose of NPK 11-7-12 compound fertilizer on Ultisol soil for oil palm seedlings is around 65 – 198 g/tree/6 months.

Sudrajat et al., (2014) stated that the vegetative growth of oil palm seedlings increased by applying N and P fertilizers in Dramaga Bogor. At the age of 5 months in the main nursery, the application of N fertilizer had a significant effect on the amount of chlorophyll and had no significant effect on the density of stomata. The levels of N and P elements in leaf midrib number 5 at the optimum treatment were 3.43% and 0.28%, respectively. The recommended dose of N fertilizer for 6 months for oil palm seedlings in main nurseries is 20.06 g/plant and for P is 4.24 g/plant. Harahap et al., (2005) recommends the amount of fertilizer during the main nursery until the age of 8 months is 31.5 g N, 15.3 g P, 34.9 g K, and 12.6 g/plant.

The use of inorganic fertilizers is increasingly expensive, especially NPK, so it is necessary to find a solution so that the growth of oil palm seedlings remains good, but the cost of using inorganic fertilizers can be reduced. Hapsos et al., (2020) suggested using empty oil palm bunches in combination with biological fertilizers to reduce NPK doses. Potassium fertilizer application can increase N, K, and Mg absorption in plant roots (Fauzi et al., 2019). Application of Trichoderma enriched compost (Gede et al., 2015; Nur Wellys et al., 2019), use of dolomite and oil palm bunches (Amri et al, 2018), palm fronds (Ariyanti et al., 2017), and organic matter (Irma Sari et al., 2015) can make inorganic fertilizers efficient and improve seedling growth. Adnan et al., (2015) also found that the application of organic fertilizers could halve the dose of NPK fertilizer.

The aim of the study was to determine the response of NPK 12-6-27 fertilizer to the growth of oil palm seedlings in the main nursery and to obtain information on the optimum dosage.

Method

The experimental design used was a randomized block design (RBD) with 7 treatments and was repeated 8 times. The treatment consisted of Control, Standard NPK, and 5 doses of NPK 12-6-27 fertilizer. The NPK 12-6-27 fertilizer formula has a nutrient content of 12.0% N during analysis; 6.9 % P_2O_5 and 28.14 % K_2O. This fertilizer is classified as compound NPK fertilizer according to the criteria of Minister of Agriculture 36 of 2017. It is in the form of stem fertilizer with a trunk weight of around 100 grams.

The study used indicator plants for oil palm seedlings in the main nursery phase. The research was carried out at the Sindang Barang Installation, Laladon, Bogor Regency belonging to the Soil Research Institute. The planting medium uses Oxisols soil taken at a depth of 0-20 cm from Cikasungka Village, Cigudeg District, Bogor Regency, West Java Province. The study used pots in the form of polybags measuring 45 cm x 60 cm filled with dry soil as much as 20 kg/pot. The oil palm seedlings from the pre-nursery aged 3 months were then transplanted into the prepared pots. Seedlings are maintained in the main nursery phase for 6 months. The distance of the plants between the pots is one meter which is arranged using an equilateral triangle pattern. Every month, the location of the plants is randomized again.

Urea, SP 36, KCl, Kieserite and NPK fertilizers were used as treatment fertilizers. Fertilizer was given 16 times with the dosage and time as shown in Table 1. Fertilizer was given every 2-6 weeks after planting, while the 8th to 28th week of fertilizer was given every 2 weeks. Urea, KCl, NPK, and Kieserit fertilizers were given by tapping beside the plants with a distance of 5 cm from the base of the stem and a depth of about 5 cm, as many as 3 points/pot. Goat manure is used as basic fertilizer at a dose of 250 g/pot. Manure is given by immersing it in a circle at a depth of 3-5 cm.

Table 1. Arrangement of treatments and fertilizer doses used in the experiment on the effect of NPK fertilization on oil palm seedlings in the main nursery

Treatment	Fertilizer Dosage (g/pot)				NPK 12-6-27* (g/pot)
	Urea	SP-36	KCl	Kieserite	
Control	0	0	0	0	0
Standard NPK	0.67	0.53	0.57	0.21	0
NPK 12-6-27 (1.0x)	0	0	0	0.21	1.00
NPK 12-6-27 (1.5x)	0	0	0	0.21	1.50
NPK 12-6-27 (2.0x)	0	0	0	0.21	2.00
NPK 12-6-27 (2.5x)	0	0	0	0.21	2.50
NPK 12-6-27 (3.0x)	0	0	0	0.21	3.00

Information:
a) The first fertilization is given 2 weeks after planting/transferring to the main nursery at the rate shown in Table 1
b) Fertilizing week 2 - 3 doses of fertilizer according to Table 1, given per week
c) Fertilization week 4 - 6 doses of fertilizer 2x according to Table 1, given per week
d) Fertilization week 8 - 10 doses of fertilizer 3x according to Table 1, given every 2 weeks
e) Fertilization week 12 - 20 doses of fertilizer 4x according to Table 1, given every 2 weeks
f) Fertilization week 22 – 28 doses of fertilizer 6x Table 1, given every 2 weeks

Maintenance carried out includes watering, cleaning weeds, and controlling plant pests (OPT). Plant growth was observed every month for 6 times. Parameters observed were plant height, number of fronds, length of fronds, and stem diameter. Harvesting is done at 6 months in the main nursery phase. Harvesting is done by cutting the plants just above the ground, then separating the stems and roots. The wet weight is known by weighing the plants at harvest, while the dry weight is known by weighing the plants after the plant parts are oven-dried for 3 x 24 hours at 70^{o}C.

Research data were analyzed using SPSS version 25 for analysis of variance (ANOVA) and follow-up tests using Duncan Multiple Range Test (DMRT) at 5% level. Treatment response and effectiveness were analyzed using Relative Agronomic Effectiveness (RAE) (Machay et al., 1984).

Result and Discussion

Soil Chemical Properties

Soil Oxisols from Cikasungka Village, Cigudeg District, Bogor Regency are classified as acid soils. The topsoil has a dusty clay texture with a low organic matter content (1.44% C-organic) and a low N (Kjendahl) content of 0.13 N. Potential P and K levels (25% HCl) were 21 mg P_2O_5/100 g and 3 mg K_2O/100 g, respectively, which were low. The low levels of P and K are due to the fact that the soil is formed from acidic and highly weathered parent material, and poor in P and K nutrients. Ca (1.74 cmol$^+$/kg) and Mg (0.41 cmol$^+$/kg) content is low, and the cation exchange capacity (CEC) is 12.89 cmol$^+$/kg and a base saturation of 18% is low. The process of leaching exchange cations in the long term is responsible for low exchange cations and base saturation. The soil reaction is classified as acidic with a pH-H_2O of 4.7. Based on this description, fertility constraints include acidic soil pH, low levels of C and N, low levels of P and K, CEC, and low exchange cation counts and high Al saturation (54%). Al exchange rate of 3.09 cmol$^+$/kg (Table 2).

Fertility of highly weathered soils such as Oxisol can be improved by adding organic matter, either in fresh form, manure or compost (Aryanti et al., 2017), application of humic acid (Herviyanti et al., 2012). The content of organic acids has functional groups that are very reactive towards polyvalent cations, and release P into available forms. Irma Sari et al., (2015) suggested that one of the roles of organic fertilizers is to improve soil chemical properties, especially the cation exchange capacity (CEC). Herviyanti et al.,. (2012) stated that the application of organic matter can increase the amount of negative charge which causes an increase in the soil. Lime and application of organic matter can increase pH and decrease Al activity (Zahrah, 2009; Subandi and Widjanarko, 2013). The use of oil palm shell biochar can balance nutrients, increase CEC and C-organic soil Lithic Hapludults (Santi et al., 2017).

Plant Growth

In general, the effect of NPK treatment did not make a significant difference to the number of leaf midribs of oil palm seedlings at the age of 3-6 months after planting (BST). There was an increase in the number of leaf midribs from the start of planting (0 BST) to the age of 3 BST, from 4-5 fronds/plant increased to around 10-11 fronds/plant. At the age of 6 BST, the number of leaf midribs treated with NPK 12-6-27 was not significantly different, namely around 16-17 fronds/plant (Table 3).

Table 2. Soil chemical properties Oxisols from Cigudeg Bogor at a depth of 0-20 cm were used for the experiment

Parameter	Units	Score	Criterion[1)]
Soil Texture (Pipette Method)		Dusty clay	
Sand	%	2	
Dust	%	59	
Look	%	39	
Organic C and N			
C-organic (Walkley & Black)	g/100 g	1.44	low
N-organic (Kjendahl)	g/100 g	0.13	low
C/N		11	
Extract HCl 25%			
P_2O_5	mg/100 g	21	currently
K_2O	mg/100 g	3	low
P-Bray 1			
P_2O_5	mg/kg	9.3	currently
Extract NH_4OAC 1 M pH 7			
Na	$cmol^+/kg$	0.12	low
K	$cmol^+/kg$	0.04	low
Ca	$cmol^+/kg$	1.74	low
Mg	$cmol^+/kg$	0.41	currently
Amount	$cmol^+/kg$	2.30	low
KTK	$cmol^+/kg$	12.89	low
KB	%	18	low
pH-H_2O (1:5)	-	4,7	Sour
pH-KCl (1:5)	-	3.8	sour
Al dd	$cmol^+/kg$	3.09	
H dd	$cmol^+/kg$	0.34	
Saturation Al	%	54	currently

1) Badan Litbang Pertanian.2012

Table 3. The effect of treatment on the development of the number of fronds of oil palm in the main nursery phase

Treatment	Number of Leaf Sheaths						
	0BST[1)]	1 BST	2 BST	3 BST	4 BST	5 BST	6 BST
Control	5.00 b[2)]	5.00 b	7.50 ab	10.90 a	13.80 a	15.40 a	16.80 a
Standard NPK	4.60 ab	4.60 ab	7.30 b	10.80 a	13.60 a	15.50 a	17.40 a
NPK 12-6-27 (1.0x)	4.90 b	4.90 b	8.00 ab	10.80 a	14.00 a	15.90 a	17.60 a
NPK 12-6-27 (1.5x)	4.90 b	4.90 b	7.50 ab	11.00 a	14.10 a	16.30 a	17.10 a
NPK 12-6-27 (2.0x)	4.50 a	4.50 a	7.80 ab	10.60 a	13.80 a	16.00 a	17.00 a
NPK 12-6-27 (2.5x)	5.00 b	5.00 b	8.10 b	10.60 a	13.50 a	16.00 a	17.10 a
NPK 12-6-27 (3.0x)	5.00 b	5.00 b	8.10 b	10.90 a	14.00 a	16.30 a	16.80 a
CV (%)	7.70	7.70	9.30	4.90	5.90	5.00	6.60

1) BST = month after planting,

2) Numbers accompanied by the same letters are not significantly different based on the 5% DMRT test

The same results were shown by the diameter of the stem, where the effect of the treatment did not give different results from the control treatment at 0 - 3 BST. Stem diameter at the beginning of planting is around 1.3 – 1.5 cm increasing to around 2.9 – 3.2 cm at 3 BST. At the age of 4 to 6 BST, NPK fertilization produced significantly different stem diameters compared to the control. The application of standard NPK and NPK 12-6-27 is equally good in producing stem diameters. At 6 BST, the largest stem diameter was achieved by the NPK 12-6-27 treatment with a dose of 2.5 x, which was 6.4 cm (Table 4).

Table 4. The effect of treatment on the development of oil palm trunk diameter in the main nursery

Treatment	Stem Diameter(cm)					
	0 BST[1)]	2 BST	3 BST	4 BST	5 BST	6 BST
Control	1.50 a	2.00 a	3.00 a	3.70 a	4.60 a	5.00 a
Standard NPK	1.30 a	2.00 a	2.90 a	3.70 a	5.10 abc	6.20 b
NPK 12-6-27 (1.0)	1.40 a	2.10 a	3.10 a	4.10 b	5.20 bc	6.10 b
NPK 12-6-27 (1.5)	1.50 a	2.20 a	3.10 a	4.10 b	5.30 c	5.90 b
NPK 12-6-27 (2.0)	1.40 a	2.00 a	3.00 a	4.00 ab	5.50 c	6.20 b
NPK 12-6-27 (2.5)	1.50 a	2.00 a	3.20 a	3.80 ab	5.30 c	6.40 b
NPK 12-6-27 (3.0)	1.50 a	2.20 a	3.10 a	3.90 ab	4.70 ab	6.30 b
CV (%)	12.60	17.60	12.20	9.80	10.70	13.60

[1] BST = month after planting,
[2] Numbers accompanied by the same letters are not significantly different based on the 5% DMRT test

Until the age of 5 BST, Standard NPK Treatment had no effect on plant height compared to Control. This is probably due to the nutrients in the early soil are still able to meet the needs of plants. At 6 BST, NPK fertilization increased plant height which was significantly different compared to the control. Plant height in the control treatment of 71.4 cm increased to 86.0 – 93.4 cm. The NPK 12-6-27 treatment was not significantly different from the standard NPK for oil palm plant height in the main nursery. Likewise, an increase in the dose of NPK 12-6-27 was not followed by a significant increase in plant height. The growth performance of oil palm seedlings at 6 BST is shown in Figure 1.

Figure 1. Performance of NPK Fertilization Research on growth and dry weight of oil palm seedlings in the main Nursery

Table 5. The effect of treatment on the growth of oil palm plant height in the main nursery phase

Treatment	Plant Height (cm)						
	0 BST[1]	1 BST	2 BST	3 BST	4 BST	5 BST	6 BST
Control	33.00 ab[2]	34.40 a	35.70 ab	42.90 a	58.00 a	68.20 a	71.40 a
Standard NPK	31.80 a	33.30 a	33.60 a	42.400 a	58.40 a	74.70 ab	86.00 b
NPK 12-6-27 (1.0x)	33.80 abc	36.300 ab	35.90 abc	45.40 ab	64.20 ab	79.40 abc	89.50 b
NPK 12-6-27 (1.5x)	37.00 cd	38.30 bc	38.90 cd	49.90 bc	66.70 b	82.60 bc	93.20 b
NPK 12-6-27 (2.0x)	37.60 d	40.20 c	40.08 d	51.20 c	68.80 b	83.30 c	93.40 b
NPK 12-6-27 (2.5x)	36.20 bcd	37.90 bc	37.30 bc	47.50 bc	65.40 b	79.10 abc	89.80 b
NPK 12-6-27 (3.0x)	37.70 d	39.90 c	39.00 cd	46.60 ab	63.40 ab	75.70 bc	86.00 b
CV (%)	10.30	10.40	9.40	10.70	10.70	10.00	11.60

[1] BST = month after planting,
[2] Numbers accompanied by the same letters are not significantly different based on the 5% DMRT test

Plant Yield

At 6 BST, the length of the 3rd leaf midrib (hereinafter referred to as the 3rd midrib) in the control treatment was 33 cm which could be significantly increased to 40-46 cm by administering Standard NPK and 12-6-27 NPK. There was no significant difference between the standard NPK and NPK 12-6-27 treatments in the length of the 3rd frond (Table 6). The wet weight of the 3rd sheath in the Control treatment of 22 g could be significantly increased by giving standard NPK and NPK 12-6-27 to 32-35 g. The dry weight of the third frond in the control treatment of 5.4 g could be significantly increased by giving standard NPK and NPK 12-6-27 to 9.3 – 14.2 g. Administration of Standard NPK and 12-6-27 NPK did not produce a significant difference in the dry weight of the 3rd fronds.

Table 6. The effect of treatment on the weight of the roots and leaf sheaths of the 3 oil palm seedlings in the main nursery aged 6 BST

Treatment	Root Weight		3rd Leaf Sheath		
	Wet	Dry (g/tree)	Long (cm)	Wet (g)	Dry (g)
Control	77 a	22 a	33 a	22 a	5.40 a
Standard NPK	15 b	26 ab	40 b	33 b	10.60 ab
NPK 12-6-27 (1.0x)	118 b	27 ab	43 b	32 b	9.30 ab
NPK 12-6-27 (1.5x)	161 c	32 b	45 b	35 b	9.90 ab
NPK 12-6-27 (2.0x)	163 c	30 b	46 b	35 b	14.20 b
NPK 12-6-27 (2.5x)	145 bc	26 ab	45 b	32 b	11.20 b
NPK 12-6-27 (3.0x)	146 bc	27 ab	45 b	34 b	12.10 b
CV (%)	31.50	22.90	16.50	17.10	52.20

[1] BST = month after planting,
[2] Numbers accompanied by the same letters are not significantly different based on the 5% DMRT test

Dry root weight in the control treatment of 22 g/tree can be increased to 26-32 g/tree by administering standard NPK and NPK 12-6-27. The highest dry root weight of 30 – 32 g/tree was achieved by the NPK 12-6-

27 treatment at 1.5 x and 2 x doses. The control treatment resulted in a dry stem weight of 114.3 g/tree which increased significantly to 158.2 – 207.0 g/tree by administering standard NPK and NPK 12-6-27. NPK 12-6-27 fertilization doses of 1.5 x and 2x resulted in a dry stem weight of 206.3 g/tree and 207.0 g/tree higher and significantly different from standard NPK which produced a dry stem weight of 158.2 g/tree (Table 7).

Application of kieserite fertilizer significantly increased plant height, stem diameter, and dry biomass weight of oil palm Mg levels in soil and plants on Ultisols and Oxisols (Kasno and Nurjaya, 2011).

Relative Agronomic Effectiveness (RAE)

Inorganic fertilizers are said to be effective if the RAE value is $\geq$ 95. The standard fertilizer in this research using a single NPK fertilizer has an RAE value of 100% and Control has a value of 0. The RAE calculation results show that the RAE value at NPK 12-6-27 is greater than 100, namely between 120 – 210 (Table 7). Meaning that NPK 12-6-27 fertilizer is effective in increasing the growth and weight of oil palm plant stems in the main nursery.

Table 7. Effect of treatment on stem weight and RAE in oil palm seedlings in the main nursery aged 6 BST

Treatment	Dry Bar Weight	RAE
	g/pot	%
Control	114.30 a	0
Standard NPK	158.20 b	100
NPK 12-6-27 (1.0 x)	167.00 bc	120
NPK 12-6-27 (1.5 x)	207.00 d	211
NPK 12-6-27 (2.0 x)	206.30 d	210
NPK 12-6-27 (2.5 x)	190.00 cd	172
NPK 12-6-27 (3.0 x)	182.30 cd	155
CV (%)	21.40	

[1)] Numbers accompanied by the same letter are not significantly different based on the 5% DMRT test.

Referring to Table 1 the dose of NPK 12-6-27 fertilizer for 6 months for the Control treatment, 1x, 1.5x, 2x, 2.5x, and 3x NPK 12-6-27 are 0, 48, 72, 96, 120 respectively, and 144 g/tree/6 months. Based on the equation shown in Figure 1 ($Y = -0.0096x^2 + 1.86x + 112$, $R^2 = 0.64$) it is known that the higher the dose of NPK 12-6-27 to a certain extent can increase the dry stem weight of oil palm seedlings (Figure 2). The maximum dose of NPK 12-6-27 is 97 g/tree/6 months and the optimum dose is 51 g/tree/6 months. Similar results were obtained by Adnan et al. (2015) that the application of NPK fertilizer of 142 g/pot increased the dry weight of the roots of oil palm seedlings in the main nursery. The optimum dose of NPK 11-7-12 for oil palm seedlings is around 65 – 198 g/tree/6 months (Kasno and Anggria. 2016).

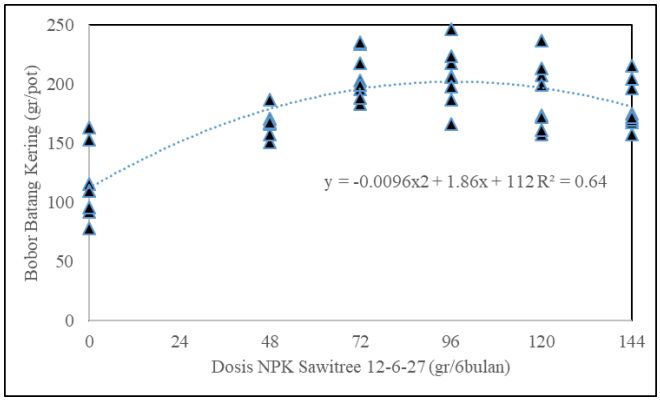

Figure 2. Correlation between dry stem weight and dose of NPK 12-6-27

Conclusion

Application of NPK fertilizer, both standard NPK and NPK 12-6-27 can increase the growth of oil palm seedlings in the main nursery as reflected by increasing plant height, stem diameter, stem weight and plant root weight. NPK 12-6-27 fertilization doses of 48 – 144 g/tree/6 months increased dry stem weight of oil palm seedlings and was significantly better than standard NPK as indicated by RAE values between 120 to 211. The optimum dose of NPK 12-6-27 was 51 gr/tree given for 6 months in the main nursery.

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