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Optimization of Nitrogen and Phosphorus Fertilizer on Two Years Old of Oil Palm(*Elaeis guineensis* Jacq.)

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ABSTRACT----- ***Fertilization is the one of the important factors to increase the growth of the two years old of oil palm. Fertilization can increase the availability of nutrient that needed by the plant. The one type of fertilizer that can be used as an alternative to improve soil fertility is single anorganic fertilizer. The purposes of this research were (1) to study the effect of N and P fertilizer on two years old plant of oil palm and (2) to determine the optimum rate of N and P fertilizer on two years old plant of oil palm. The research were conducted at IPB-Cargill Teaching Farm of Oil Palm, Jonggol, Bogor Indonesia from April 2014 to March 2015. This research consisted of two experimentation namely: (1) optimization of nitrogen fertilizer rate, and (2) optimization of phosphorus fertilizer rate. Each experimentation consisted of single factor using randomized block design with three replications, there were five levels of nitrogen fertilizer rate (0, 316, 632, 948, 1264 g N plant^{-1} year^{-1}) , and five levels of phosphorus fertilizer rate (0, 226, 453, 679, 905 g P_2O_5 plant^{-1} year^{-1}). The result showed that nitrogen fertilizer increased plant height, number of stomata, stem girth and frond production quadratically. Phosphorus fertilizer increased frond production, stem girth, leaf area of 17th frond,, leaf chlorophyll content, and number of stomata quadratically, but phosphorus fertilizer increased leaf nutrient content linearly. The optimum rate of nitrogen and phosphorus fertilizer were respectively 978 g N, and 615 g P_2O_5 plant^{-1} year^{-1}for two years old of oil palm.***

Keywords--- Oil palm, optimization, fertilizer, anorganic.

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1. INTRODUCTION

The optimal production and sustainable of oil palm can be achieved by a good fertilizer technology management (Goh and Hardter 2003). The low of oil palm production belong to farmers generally due to be ineffective fertilizer management. Plant tissue analysis, and monitoring of plant morphology can determine fertilizer rate appropriately (Webb *et al*. 2011). Adequate nutrition of oil palm plant in two years old, can increase vegetative growth (Noor *et al*. 2012).

Nitrogen and phosphorus application increased leaf production and stem girth at the main nursery of oil palm (Sudradjat *et al*. 2014). Acording to Shintarika (2014) that nitrogen and phosphorus also increased plant height, stem girth, frond production, leaf chlorophyll, and leaf area of 9th frond of one year old plant of oil palm.

Nitrogen is the element that supports to increase the greenness of leaves. Chlorophyll is very important for photosynthesis. The high chlorophyll on leaves will provide the energy to support plant growth optimally (Suharno *et al*. 2007). The application of nitrogen increased palm kernel oil significantly, but nitrogen deficiency affected chloroplast development and it's function (Goh and hardter 2003).

Phosphorus is the essential element of nucleic acids involved in the storage and transfer of genetic information (Marschner 2012). Law *et al*. (2012) found that phosphorus give the same effect on all oil palm genotypes growth, but phosphorus susceptible to erosion and runoff. Phosphorus deficiency causes the ratio between the root and shoots greater, it is caused by the proportion of assimilates allocated for root growth is greater than the shoots (Goh and Hardter 2003).

Optimization of fertilizer rate for oil palm at the main nursery and one year old was conducted by several researchers. Optimization of fertilizer rate could be determined based on morphology and physiology variables of plants. According to Siallagan *et al*. (2014), the optimum level can be obtained by lowering the regression equation at quadratic curve on significant parameters of plant morphology, while according to Sudradjat *et al*. (2014), the optimum level can be determined based on the most responsive variable of morphology or physiology.

2. MATERIAL AND METHOD

The research were conducted at IPB-Cargill Teaching Farm of Oil Palm, Jonggol, Bogor on Avril 2014 to March 2015. The plant material used was the oil palm Tenera var. Damimas, aged one year which planted on November 2012. The distance between plant was 9.2m x 9.2 m x 9.2 m triangular system, so the population was 136 trees hectare^{-1}.

This research consisted of two experimentations namely: (1) optimization of nitrogen fertilizer, and (2) optimization of phosphorus fertilizer. Each experimentation consisted of single factor with five level of treatment using randomized block design with three replications, there were five levels of N fertilizer rate (0, 316, 632, 948, 1264) g plant^{-1} year^{-1}, and five levels of P_2O_5 fertilizer rate (0, 226, 453, 679, 905) g plant^{-1} year^{-1}. Nitrogen and phosphorus applied twice a year with six months interval.

The variables observed in this research were morphological and physiological variables. Morphological variables counsisted of plant height, stem girth, and leaf area of 17th frond. Physiological variables counsisted of stomata density, leaf chlorophyll content and leaf nutrient content. Physiological variables were measured at 18 and 24 month after field planting (MAP). The effect of treatments were analyzed by ANOVA than further analysed using polynomial orthogonal test and regression test and considered significant at P<0.05.

3. RESULT AND DISCUSSION

3.1 Optimization of Nitrogen Rate on Two Years Old of Oil Palm

1. Morphological Response

Plant Height

Nitrogen fertilizer increased plant height at 14 months after planting (MAP) linearly and at 24 MAP quadratically. Application of 948 g N increased 8.75% plant height compared to control at 24 MAP. The effect of nitrogen fertilizer on plant height are presented in table 1.

Table 1 Effects of nitrogen fertilizer on plant height

N Level (g)	Plant Height (cm)					
	14 MAP	16 MAP	18 MAP	20 MAP	22 MAP	24 MAP
0	353.73	402.93	431.40	475.00	487.67	496.40
316	380.00	418.67	440.20	488.60	500.93	514.33
632	384.87	421.13	448.93	486.47	505.93	520.40
948	396.40	426.60	445.27	486.13	512.07	539.83
1264	398.87	429.67	447.80	488.20	507.47	519.93
Response ¢	L**	ns	ns	ns	ns	Q*

Notes : ¢: orthogonal polynomial test; L: Linear, Q: Quadratic, ns: non significant, *: significant at P<0.05, **: significant at P<0.01, MAP: months after planting.

Stem Girth

Nitrogen fertilizer increased stem girth quadratically on 14-24 MAP. Application of 948 g N increased 9.06% stem girth compared to control at 24 MAP. The effects of nitrogen fertilizer on stem girth are presented in table 2.

Table 2 Effects of nitrogen fertilizer on stem girth

N Level (g)	Stem Girth (cm)					
	14 MAP	16 MAP	18 MAP	20 MAP	22 MAP	24 MAP
0	105.47	125.33	134.40	146.00	159.60	167.00
316	117.47	131.60	140.87	154.60	167.47	175.80
632	118.13	132.87	142.40	156.33	171.93	179.60
948	119.00	133.80	143.20	156.80	173.33	182.13
1264	118.93	133.60	143.13	155.80	172.80	180.42
Response ¢	Q*	Q**	Q**	Q*	Q**	Q*

Notes : ¢: orthogonal polynomial test; Q: Quadratic, *: significant at P<0.05, **: significant at P<0.01, MAP: months after planting.

Leaf Area of 17th Frond

Nitrogen fertilizer did not increase the leaf area of 17th frond at 14-24 MAP. The result showed that application of nitrogen up to1264 g plant^{-1} have not affect to the leaf area of 17th frond on two yeras old of oil palm. The effects of nitrogen fertilizer on leaf area of 17th frond are presented in table 3.

Table 3 Effects of nitrogen fertilizer on leaf area of 17th frond

N Level (g)	Leaf Area of 17th Frond (m^2)					
	14 MAP	16 MAP	18 MAP	20 MAP	22 MAP	24 MAP
0	1.92	2.25	2.46	2.87	3.24	3.24
316	2.02	2.48	2.38	2.90	3.50	3.23
632	2.00	2.56	2.67	3.22	3.52	3.20
948	2.11	2.67	2.70	3.31	3.73	3.36
1264	2.08	2.58	2.66	3.31	3.59	3.26
Response ¢	ns	ns	ns	ns	ns	ns

Notes : ¢: orthogonal polynomial test; ns: non significant, MAP: months after planting.

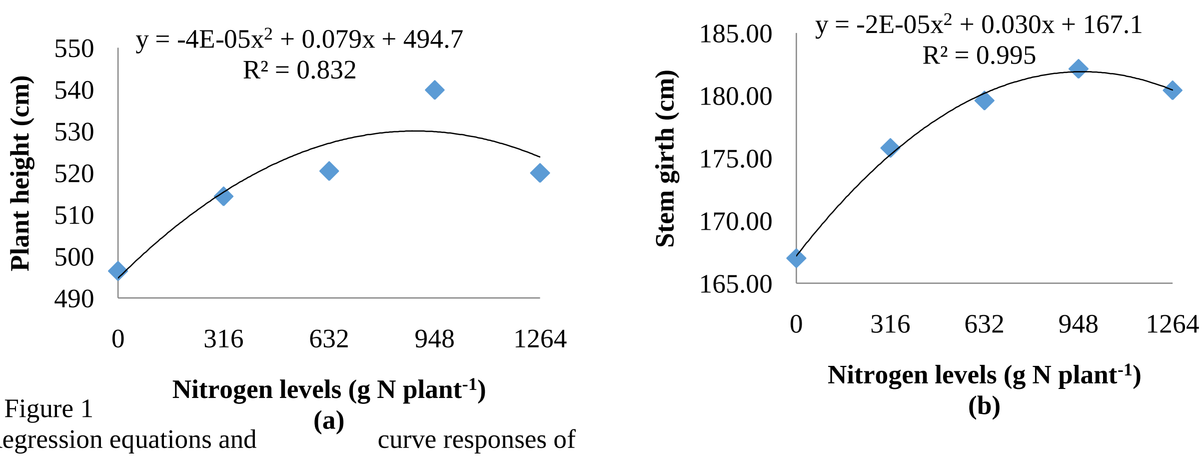

Figure 1 Regression equations and curve responses of plant height (a) and stem girth (b) to nitrogen fertilizer at 24 months after planting

Nitrogen fertilizer increased plant height and stem girth quadratically (Figure 1). There is a significant correlation between plant height and stem girth (0.771). Nitrogen increased the activity of leaf photosynthesis and assimilate product (Suharno *et al* 2007). Availability of assimilate can increase the growth of plant morphology (plant heightt and stem girth) optimally.

2. Physiological Response

Leaf chlorophyll content, stomata density and leaf nitrogen content

Nitrogen fertilizer increased stomata density at 24 MAP but it did not increase leaf chlorophyll content and leaf nutrient content. The high stomata density can increase gas exchange activity on the plant. But on the dry season, the low stomata density can reduce vulnerability to water deficit (Lestari 2006). Similar argument were shown by Mc Cree and Davis (1994) that stomata density associated with drought resistance.

The critical nitrogen content on leaf of 17th frond, less than 6 years from planting is 2.5% of dry matter (Von Uexküll and Fairhurst 1991; Ochs and Olvin 1977). Leaf nitroogen content in this research is still below compared to the standard critical level at 24 MAP. The decreased of nitrogen content in the leaf supposedly due to the change of climate condition, espesially rainfall. High rainfall on March 2015 (403 mm) during the second sampling, nitrogen dissolved in the leaves. Similar argument was shown by Tukey (1970) that high rainfall caused the dillution of nutrition in the soil or in the plant tissue. Nutrient tend to decrease because of the high water levels in leaf tissue. While at flowering stage, the plant changes from vegetative to generative stages. Nutrients then can move into the seed or fruit (Schweb *et al*. 2007). effects of nitrogen application on leaf chlorophyll content, stomata density and leaf nutrient content are presented in table 4.

Table 4 Effects of nitrogen fertilizer on leaf chlorophyll content, stomata density and leaf nitrogen content

N level (g)	Leaf Chlorophyll Content (mg cm^{-2})		Stomata Density (mm^{-2})		Leaf Nitrogen Content (%)	
	18 MAP	24 MAP	18 MAP	24 MAP	18 MAP	24 MAP
0	0.043	0.044	217.69	246.60	2.50	2.25
316	0.043	0.046	232.14	246.60	2.58	2.29
632	0.044	0.045	244.05	295.92	2.74	2.11
948	0.045	0.045	249.15	301.02	2.81	2.31
1264	0.045	0.046	250.00	265.31	2.70	2.38
Response ¢	ns	ns	ns	Q*	ns	ns

Notes : ¢: orthogonal polynomial test, Q: Quadratic, ns: non significant, *: significant at P<0.05, MAP: months after planting.

3. Optimization of nitrogen rate

The regression equetions of plant height and stem girth to estimate the optimum rate of nitrogen are presented in table 5. Based on these equations, the optimum rate of N fertilizer was 978 g N plant^{-1} year^{-1} for the second year of oul palm.

Table 5 Optimization of nitrogen rate

Variables	MAP	Equation	Optimum rate (g plant^{-1})
Height plant	24	y = -4E-05x^2 + 0,0793x + 494,77	991
Stem girth	14	y = -2E-05x2 + 0,030x + 106,6	750
	15	y = -8E-06x2 + 0,015x + 117,1	938
	16	y = -9E-06x^2 + 0,0179x + 125,8	994
	17	y = -9E-06x2 + 0,018x + 130,3	1000
	18	y = -1E-05x^2 + 0,0187x + 134,87	935
	19	y = -1E-05x^2 + 0,0241x + 137,52	1205
	20	y = -1E-05x^2 + 0,0254x + 146,62	1270
	21	y = -2E-05x^2 + 0,0284x + 153,64	710
	22	y = -1E-05x^2 + 0,0282x + 159,74	1410
	23	y = -2E-05x^2 + 0,0305x + 163,46	763
	24	y = -2E-05x^2 + 0,0307x + 167,17	768
	Average		978

Notes : MAP: months after planting

3.2 Optimization of Phosphorus Rate on Two Years Old of Oil Palm

1. Morphological Response

Plant Height

Phosphorus fertilizer did not increase height plant from 14 to 24 MAP. Goh and Hardter (2003) showed that phosphorus fertilizer can lost due to run off process when rainfall is high. The effects of phosphorus fertilizer on height plant are presented in table 6.

Table 6 Effects of phosporus fertilizer on height plant

P Level (g)	Height Plant (cm)					
	14 MAP	16 MAP	18 MAP	20 MAP	22 MAP	24 MAP
0	353.73	392.93	431.40	475.00	487.67	496.4
226	372.13	394.07	432.93	473.27	489.67	498.67
453	374.00	402.73	433.20	466.07	479.87	498.00
679	382.53	401.60	435.27	475.60	499.00	521.33
905	374.47	399.33	434.47	472.73	490.00	502.53
Response ¢	ns	ns	ns	ns	ns	ns

Notes : ¢: orthogonal polynomial test, ns: non significant, MAP: months after planting.

Stem Girth

Phosphorus fertilizer increased stem girth quadratically at 14, 20, 22, and 24 MAP. Application of 679 g P_2O_5 increased 10.7% stem girth compared to control at 24 MAP. The effects of phosphorus fertilizer on stem girth are presented in table 7.

Table 7 Effects of phosphorus fertilizer on stem girth

P Level (g)	Stem Girth (cm)					
	14 MAP	16 MAP	18 MAP	20 MAP	22 MAP	24 MAP
0	105.47	125.33	134.40	146.00	159.60	167.00
226	116.00	129.53	134.80	157.00	173.20	181.20
453	115.60	129.20	135.07	155.13	170.33	179.87
679	117.13	130.27	138.07	159.40	175.73	184.87
905	115.80	129.53	134.87	155.33	169.53	180.67
Response ¢	Q*	ns	ns	Q*	Q*	Q*

Notes : ¢: orthogonal polynomial test, Q: Quadratic, ns: non significant, *: significant at $P<0.05$, MAP: months after planting.

Leaf Area of 17th Frond

Phosphorus fertilizer increased leaf area of 17th frond at 24 MAP. Application of 679 g P_2O_5 increased 18.2 % leaf area of 17th frond compared to control at 24 MAP. Leaf area is a parameter that affects the light extent that can be captured by plants to photosynthesis (Hardon *et al*. 1969). The effects of phosphorus fertilizer on leaf area of 17th frond are presented in table 8.

Table 8 Effects of phosphorus fertilizer on leaf area of 17th frond

P Level (g)	Leaf Area of 17th Frond (m^2)					
	14 MAP	16 MAP	18 MAP	20 MAP	22 MAP	24 MAP
0	1.92	2.25	2.46	2.87	3.24	3.14
226	1.97	2.29	2.41	3.15	3.57	3.55
453	1.82	2.33	2.42	3.09	3.58	3.65
679	1.99	2.50	2.68	3.19	3.62	3.71
905	2.55	2.38	2.49	3.17	3.37	3.51
Response ¢	ns	ns	ns	ns	ns	Q*

Notes : ¢: orthogonal polynomial test, Q: Quadratic, ns: non significant, *: significant at $P<0.05$, MAP: months after planting.

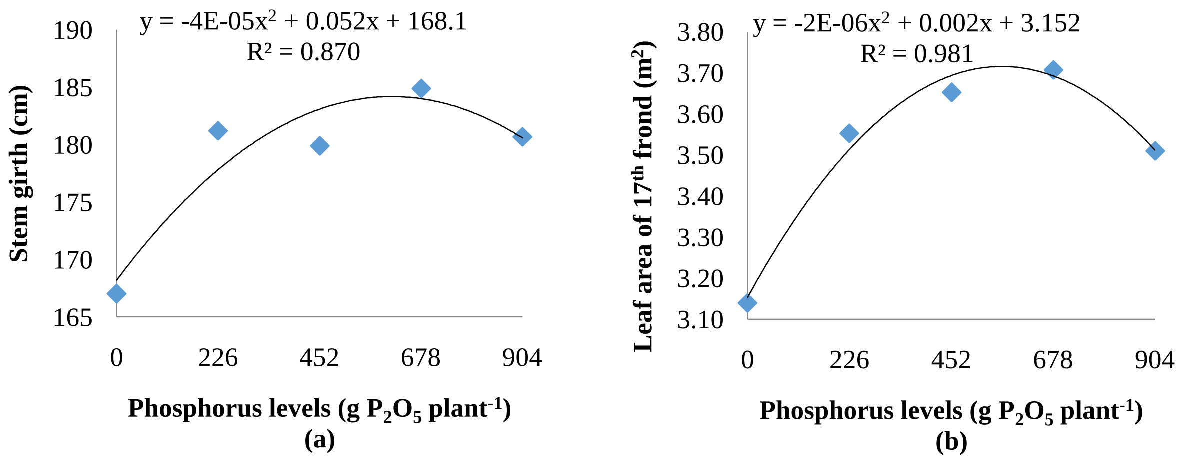

Figure 1 Regression equations and curve responses of stem girth (a) and leaf area of 17th frond (b) to phosphorus fertilizer at 24 months after planting

Phosphorus fertilizer increased stem girth and leaf area of 17th frond quadratically on 24 MAP. Stem girth and leaf area of 17th frond have a significant correlation (0.641). High leaf area will increase the leaf photosynthesis and the assimilates product. High assimilates product will produce the larger stem girth.

2. Physiological Response

Leaf Chlorophyll Content, Stomata Density and Leaf P_2O_5 Content

Phosphorus fertilizer increased leaf chlorophyll content and stomata density quadratically but it increased leaf P_2O_5 content linearly at 24 MAP. Application of 453 g P_2O_5 increased 9% leaf chlorophyll content and 14.2% stomata density compared to control. The optimum P_2O content on leaf of 17th frond, less than 6 years from planting are 0.16-0.19%. The critical P_2O_5 content on leaf of 17th frond, less than 6 years from planting is 0.15% (Von Uexküll and Fairhurst 1991; Ochs and Olvin 1977). The linearly results at 24 MAP showed that the leaf P_2O_5 content continues to increase over with increased level of phosphorus fertilizer.

Table 9 Effects of phosphorus fertilizer on leaf chlorophyll content, stomata density and leaf nutrient content

P Level (%)	Leaf Chlorophyll Content (mg cm^{-2})		Stomata Density (mm^{-2})		Leaf P_2O_5 Content (%)	
	18 MAP	24 MAP	18 MAP	24 MAP	18 MAP	24 MAP
0	0.043	0.044	217.69	245.75	0.17	0.18
226	0.044	0.047	248.30	272.11	0.16	0.18
453	0.044	0.048	258.50	280.61	0.18	0.18
679	0.045	0.046	246.60	274.66	0.17	0.19
905	0.044	0.047	247.45	263.61	0.16	0.21
Response ¢	ns	Q**	ns	Q*	ns	L*

Notes : ¢: orthogonal polynomial test, Q: Quadratic, L: Linear, ns: non significant, *: significant at $P<0.05$, **: significant at $P<0.01$, MAP: months after planting.

3. Optimization of phosphorus rate

The regression equetion of stem girth and leaf area of 17th frond to estimate the optimum rate of P_2O_5 are presented in table 10. The optimum rate of P fertilizer based on stem girth and leaf area of 17th frond regression equations was 615 g N $plant^{-1}$ $year^{-1}$.

Table 10 Optimization of phosphorus rate

Variabels	MAP	Equation	Optimum rate (g $plant^{-1}$)
Stem girth	14	$y = -3E\text{-}05x^2 + 0{,}0372x + 106{,}53$	620
	20	$y = -3E\text{-}05x^2 + 0{,}0396x + 146{,}94$	660
	21	$y = -5E\text{-}05x^2 + 0{,}0516x + 154{,}21$	516
	22	$y = -2E\text{-}05x^2 + 0{,}0332x + 154{,}21$	830
	23	$y = -4E\text{-}05x^2 + 0{,}0471x + 164{,}96$	589
	24	$y = -4E\text{-}05x^2 + 0{,}0522x + 168{,}17$	653
Leaf area of 17th frond	23	$y = -2E\text{-}06x^2 + 0{,}0022x + 2{,}9996$	550
	24	$y = -2E\text{-}06x^2 + 0{,}002x + 3{,}1528$	500
	Average		615

Notes : MAP: mounths after planting

4. CONCLUSION

Nitrogen fertilizer increased plant height and number of stomata at 24 months after planting (MAP), stem girth (14-24 MAP), and frond production (13-24 MAP). Phosphorus fertilizer increased frond production (13-24 MAP), stem girth (14, 20-24 MAP), leaf area of 17th frond (23-24 MAP), leaf chlorophyll content (24 MAP), number of stomata (24 MAP) and leaf nutrient content (24 MAP). The optimum rate of nitrogen and phosphorus fertilizer respectively were 978 g N, and 615 g P_2O_5 $plant^{-1}$ $year^{-1}$ for two years old of oil palm.

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6. REFERENCES

- Goh KJ, Hardter R, "General Oil Palm Nutrition, International Planters Conference on Management for Enhanced Profitability in Plantations", Kuala Lumpur (Malaysia): ISP 1994, pp. 191-230, 2003.
- Hardon JJ, Williams CN, Watson I, "Leaf area and yield in the oil palm in Malaya", Exploratory Agriculture, Vol. 5, pp. 25-32, 1969.
- Law CC1, Zaharah AR, Husni MHA, Akmar ASN, "Evaluation of nitrogen uptake efficiency of different oil palm genotypes using 15N isotope labelling method pertanika", J. Trop. Agric. Sci, Vol. 35, No. 4, pp. 743 – 754, 2012.
- Lestari EG, "The relation between stomata index and drought resistant at rice somaclones of Gajahmungkur, Towuti, and IR 64", Biodiversitas, Vol. 7, No. 1, pp. 44-48, 2006.
- Marschner H, "Mineral Nutrition of Higher Plants", third edition, London, Academic Press, pp. 158-165, 2012.
- Mc Cree KJ, Davis SD, "Effect of water stress and temperature on leaf and on size and number of epidermal cells in grain sorghum", Crop Science, Vol. 14, pp. 751-705, 1994.
- Noor J, Fatah A, Marhannudin, "Effect of NPK Compound Fertilizer on the Growth of Oil Palm Seedling (*Elaeis guineensis* Jack)", Media SainS, Vol. 4 No. 1, ISSN 2085-3548, pp. 48-54, 2012.
- Ochs R, Olivin J, "Le diagnostic foliaire pour le controle de la nutrition desplantations de palmiers à huile: Prélèvement des échantillions foliares", Oléagineux, Vol. 32, No. 5, pp. 211-216, 1977.
- Schwab GJ, Lee CD, Pearce R, "Sampling Plant Tissue for Nutrient Analysis", Department of Plant and Soil Sciences; W.O. Thom, Division of Regulatory Services, Director of Cooperative Extension Service, University of Kentucky College of Agriculture, 2007.
- Shintarika F, "Optimizing of Nitrogen, Phosphorus, and Pottasium Fertilizer in One Year Old Plant of Oil Palm (*Elaeis guineensis* Jack)", Thesis, Bogor Agricultural University, 2013.
- Siallagan I, Sudradjat, Hariyadi, "Optimizing Rate of Organic and NPK Compound Fertilizers for Immature Oil Palm", J. Agron. Indonesia, Vol. 42, No. 2, pp. 166 – 172, 2014.
- Sudradjat, Darwis A , Wachjar A, "Optimizing of Nitrogen and Phosphorus Rates for Oil Palm *(Elaeis guineensis Jacq.)* Seedling in the Main Nursery", J. Agron Indonesia, Vol. 42, No. 3, pp. 222 – 227, 2014.
- Suharno I, Mawardi, Setiabudi N, Lunga S, Tjitrosemito, "Nitrogen–use efficiency in different vegetation type at Cikaniki Research Station, Halimun-Salak Mountain National Park, West Java", Biodiversitas, Vol. 8, No. 4, pp. 287-294, 2007.
- Tukey HB, "The leaching of substance from plants", Ann. Rev. Plant Physiol, Vol. 21, pp. 305–324, 1970.
- Von Uexküll HR. and Fairhurst TH, "Fertilizing for high yield and quality the oil palm dalam Fairhurst TH dan Mutert E: Interpretation and management of oil palm leaf analysis data", Better Crops International, Vol. 13, No.1, pp. 48-51, 1991.
- Webb M, Nelson PN, Rogers LG, and Curry GN, "Site-specific fertilizer recommendations for oil palm smallholders using information from large plantations", J. Plant Nutr. Soil Sci, Vol. 174, pp. 311–320, 2011.