
Study of Proper Fertilizer Management on Growth and Yield of Oil Palm (*Eleais guineensis* Jacq.)

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Fertilizer is the most important thing on growth and yield of oil palm (*Eleais guineensis* Jacq.). Therefore, studies of proper fertilizer management on the growth and yield of palm oil were investigated at Chaloeam Phra Kiat district, Nakorn Sri Thammarat province during July 2558 - July 2559. The six-year-old plantation with spacing 9x9x9 meter was selected for study. The rate of fertilizer application were as follows; T1 (urea 2,040 gram/plant; ammonium phosphate 1,050 gram/plant; potassium chloride 2,800 gram/plant; kieserite 700 gram/plant and borate 56 gram/plant), T2 (70% of application rate in 1), T3 (130% of application rate in 1), T4 (application from soil and leaf analysis urea 2,040 gram/plant; ammonium phosphate 1,050 gram/plant; potassium chloride 3,792 gram/plant; kieserite 1,500 gram/plant and borate 56 gram/plant), T5 (70% of application rate in 4), T6 (130% of application rate in 4) and T7 (farmer practice). The fertilizer as three times a year. Randomized complete block design (RCBD) was performed and analysis of nutrients in the soil and leaves before the trial. The result revealed that the fertilizer at a rate of 4 from the analysis of nutrients in the soil and in the leaves are a reasonable rate of growth, that gave the highest response on growth (average of Leaf area at 4.37 m² and leaf dry weight at 3.06 kg) and yield of oil palm (number of branch at 2.65 branch/plant/month, fresh weight of branch at 16.94 kg/branch and fresh weight of branch 23.22 kg/plant/month). So the fertilizer based on the soil and leaves before management can reduce fertilizer costs down and net income of 22,612 baht per rai handles most fertilizers.

Keywords: genotype, growth, yield, oil palm

Introduction

Oil palm is an important economic crop in Thailand. Palm oil production can be used both economically and industrially. In addition, palm oil is a new alternative energy crop that produces renewable energy in biodiesel, to get a high yield and control the investment. Farmers should have proper management of the oil palm plantations, especially the management of nutrients. This is essential for increasing fresh weight. Oil palm is a perennial plant that needs nutrients to grow and produce high yields, estimates of nutrient accumulation during the 9 years of growth. The

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elements are nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and calcium (Ca) as follows: 196-275, 32-43, 296-398, 50-67, 84-115 kg/rai and analyzing the amount of nutrients lost to the yield. Fresh fruit bunch (FFB) was harvested every 1 tons (1,000 kg) which N, P, K, Mg and Ca were lost to the yields of 2.94, 0.44, 3.71, 0.77 and 0.81. Kg and compensate for the loss of productivity. If the palm oil is sufficient nutrients to meet the needs, the oil palm can grow high yield and good quality. A study of Nilnond *et al.* (2001) was conducted in different soil series in Krabi, Trang and Phang Nga province. Krabi was Tha Sae and Chumphon series. Trang was Na Tham series and Ruso series of Phang Nga. The experimental designs added different ratio of fertilizer. They are using fertilizer; urea, diammonium phosphate, potassium chloride, kieserite and borate were 2,040, 1,050, 2,800, 700 and 56 g/plant, respectively. The resulting of oil palm plantation was 4.41 (10 years), 2.74 (8 years), 3.27 (9 years) and 3.55 (8 years) tons/rai/year of oil palm yield, respectively, whereas farmer management gave the oil palm yield 2.5 tons/rai/year in 2000 (Economic Office Agricultural, 2012). The result shows that fertilizer and plant nutrient management is essential to increasing productivity because most of cost is 60-70% from fertilizer (Nilnond *et al.*, 2001). So the appropriate fertilizer management approaches to the growth and yield of palm oil. The nutrient status was evaluated by analyzing the nutrients in the soils and leaves of the oil palm prior to fertilizer management as a guideline for fertilizer planning for oil palm farmers. The oil palm plantation is fully grown and highest yield potential. The farmers have increased net income and it also reduces the production cost of fertilizer management.

Materials and methods

Six years of oil palm plantation in Chaloe Phra Kiat district as an experiments, a trial plot in a series of lowland soils (Land Development Department, 2007). The experiment was conducted from July 2015 to July 2016. The randomized complete block design (RCBD) was composed of seven ratio of fertilizers; T1 (urea (46-0-0), dihydrogenphosphate (18-46-0) kieserite (27% Mg₂O, 23% S) and borate at 2,040, 1,050, 2,800, 700 and 56 g/plant, respectively. T2 (70% application rate in 1), T3 (130% application rate in 1), T4 (data analysis from soil and leaf of oil palm by urea (46-0-0), dihydrogenphosphate (18-46-0) kieserite (27% MgO, 23% S) and borate at 2,040, 1,050, 3,792, 1,500 and 56 g/plant), T5 (70% application rate in 4), T6 (130% application rate in 4) and T7 (farmer practice).

Note: Before starting the experiment, one sack of chickens was added and put in January every year.

Fertilizer method management 1-6 rate were use urea, phosphorus chloride and kieserite three times each January, July and November,

dihydrogenphosphate and borate put one time in June. Put around the base plant about 80-120 cm and harvest every 15-20 days.

Weather is recorded between experiments. Soil sample is value analysis of chemical and physical properties in experimental area. Data were analyses by ANOVA. Means were separated with Duncan's multiple range tests (DMRT).

Results and Discussion

Chemical and physical analysis

The result of soil analysis showed that soil samples had an average pH of 5.89, which is the optimal value. The structure of soil is clay and average organic matter content was 2.97%, average organic carbon content was 0.46%, phosphorus content was 122.79%, potassium and magnesium were low at 20.41 and 34.33 mg/kg. The high level of 336.62 mg/kg of calcium and the CEC was low at 2.22. When analyzing the leaf chemical found that all nitrogen, phosphorus and calcium levels were appropriate value, except potassium and magnesium, the values were 2.97, 0.2, 1.12, 0.57 and 0.27%, respectively (Table 1). Different area gave the different respond on growth of oil palm. It can be seen that the oil palm had using the nutrient appropriately. Except the potassium and magnesium, it must be added to the normal rate. Compared with the correlations of leaf nutrient concentrations with the presence of nutrients in the oil palms of Teera *et al.* (2004). This information of nutrition from soil and leave analysis use applied in experiments 4-6.

Table 1. Value of chemical and physical properties in experimental area.

Soil depths (cm)	percent		Bray II	NH ₄ OAc Extract (mg/kg)			Meq/100 soil	1:5 H ₂ O
	O.M.	O.C.	Available P	K	Ca	Mg	CEC	pH
0-15	1.09	0.63	127.2	21.33	407.19	37.64	2.72	5.95
15-30	0.74	0.43	103.51	21.63	321.39	31.39	2.01	5.79
30-50	0.57	0.33	137.67	18.26	281.28	33.95	1.92	5.92
Average	2.97	0.46	122.79	20.41	336.62	34.33	2.22	5.89
Percent as day matter								
	Total N	P	K	Ca	Mg	-	-	-
Leave	2.97	0.2	1.12	0.57	0.27	-	-	-

Note: organic carbon (O.C), organic matter (O.M.), cation exchange capacity (CEC)

Weather information

Based on weather data from July 2015 to July 2016, it was found that in July 2016 the rainfall amounted to 1,160.95 mm per month. Whereas March-April 2016, there was no rainfall (Table 2). The data show that July 2015 to April 2016, there was very little rainfall, which was lower than the

average for oil palm plantations. The rainfall is at least 120 millimeters per month and don't had the rain more than 3 months because of the long drought made the number of female flowers decreased, increase the male flower, after that the yield was dropped in 19-22 months (Department of agriculture, 2012). In May 2016 had the maximum temperature was 31.05 degrees Celsius. However, each month had the atmospheric relative humidity been in the range of 78.55-95.42% and averaging 90.14%, which was enough for the growth of oil palm. In accordance with Goh (2000), Goh and Hardter (2003) reported that the reported average relative humidity is about 75%, which is suitable for the growth of oil palm.

Table 2. Data of Weather in July 2015 – July 2016.

Month	rainfall (mm./month)	Average temperature (°C)	Average Relative humidity (%)
July 2015	28.91	28.92	78.55
August 2015	24.86	28.25	82.98
September 2015	26.51	28.15	84.39
October 2015	32.21	27.64	82.98
November 2015	42.34	26.89	90.58
December 2015	12.06	27.26	87.83
January 2016	2.65	27.85	95.42
February 2016	1.09	26.50	95.14
March 2016	0.00	27.80	95.26
April 2016	0.00	29.50	94.33
May 2016	146.63	31.05	93.65
June 2016	372.3	29.60	95.33
July 2016	1,160.95	28.85	95.41
Average	142.35	28.33	90.14

The growth of oil palm

Rain fall affects affecting on growing of oil palm especially leaf area and leaf dry weight. The result showed that in July 2015, the growth rate before fertilizer application was not significant different, but it had fertilizer application gave the different respond on growth of oil palm. The highest leaf area was observed in April and July 2016 as a result of the rainfall in

July 2016, so the oil palm was grown very well. Fertilizer application rate of 4 gave the highest average of leaf area at 4.37 m² significant differences ($p \leq 0.01$) with another treatment (Table 3).

Table 3. Leaf areas of oil palm.

Rates	Leaf area (m ²)					Average rates
	July 2015	October 2015	January 2016	April 2016	July 2016	
1	2.42	4.01	4.20	2.50	4.33	3.49AB
2	2.46	2.26	2.27	2.40	5.21	2.92B
3	4.03	2.43	4.01	2.40	4.33	3.44AB
4	4.11	4.03	4.17	4.04	5.50	4.37A
5	4.20	2.35	2.40	2.38	5.15	3.29B
6	4.04	2.50	4.06	4.08	5.11	3.96AB
7	2.34	2.34	2.50	4.04	5.08	3.26B
Average months	3.37B	2.84B	3.37B	3.12B	4.96A	**
					CV.	20.62%

** = Significant difference at $P \leq 0.01$

Values followed by different letter are significantly different according to DMRT.

Leaf dry weight, it was found that leaf dry weight was statistically significantly different ($p \leq 0.01$) depend on different rain fall. Leaf dry weight in January - April 2016 gave the highest leaf dry weight after manure management of 304-3.11 kg (Table 4). When comparing the rate of fertilizer application to dry weight, T4 gave the highest leaf dry weight 3.06 kg, followed by fertilizer application rates of 2, 6 and 7 gave the leaf dry weight at 2.85, 2.84 and 2.75 kg, respectively, significantly different ($p \leq 0.01$) with another rate (Table 4).

Table 4. Data of leaf dry weight of oil palm.

Rates	Leaf area (m ²)					Average Rates
	July	October	January	April	July	
1	2.19	2.27	2.74	3.17	2.52	2.58B
2	3.00	2.30	3.01	3.01	2.95	2.85AB
3	2.60	2.53	2.63	2.66	2.28	2.54B
4	3.01	2.37	3.51	3.54	2.88	3.06A
5	2.84	2.01	3.05	3.16	2.53	2.72B
6	2.61	2.52	3.11	2.99	2.95	2.84AB
7	2.40	1.94	3.21	3.23	2.96	2.75AB
Average months	2.66B	2.28C	3.04A	3.11A	2.72B	*
					CV.	8.56%

* = Significant difference at $P \leq 0.05$

Values followed by different letter are significantly different according to DMRT.

The yield of oil palm

The amount of fertilizer per tree per month indicated that fertilizer application rate of 5 had a maximum yield of 2.65 bunch per tree per month, followed by fertilizer application rate of 4, 7 and 6, respectively. The average is 2.54, 2.53 and 2.48 bunches per tree per month. However, the statistical difference was significantly ($p \leq 0.01$) different with another rates. In July - September 2015, fertilizer application rates of 4 gave the highest number bunches at 5.00, 4.70 and 4.70 per tree per month, respectively. The number of bunches in October 2015 - April 2016 is the lowest number. Due to the low rainfall during the month, the ripening process is delayed so the harvest is less too and highest yield be back when the rainfall increasing (Table 5).

Weight per bunch showed that the application rate of 4 gave the maximum yield of 16.94 kg per bunch (Table 6). The statistically different were significant difference ($p \leq 0.01$) with other fertilizer rates. In September 2015 and March 2016, weights were up to 18.02 and 17.91 kg per bunch, respectively. The difference was statistically significant ($p \leq 0.01$) with other months. However, it was found that after the fertilizer management of oil palm, the weight gain increased. But when there is little rain and it weighs less too. Therefore, the amount of rain affects affecting on female inflorescence, proportion of sex ratio, mixing, development and mature fruit of oil palm (Teera, 2011).

Weight per tree per month was found that the application rate of 4 gave average weight of 23.22 kg per tree per month (Table 7). This is the fertilizer management of soil and leaf analysis, the weight was statistically significantly different ($p \leq 0.01$). In July 2015, fertilizer application rate of 4 was 28.91 kg per tree per month. The statistical difference was significant ($p \leq 0.05$) with other fertilizer application rates. The experiments showed that after the management of oil palm gave the weight increasing. However, the amount of rainfall was low, causing the weight to decrease again in the absence of rain. The results showed that the application of fertilizer by soil and leaf analysis (at the rate of 4) gave the number of bunch per month (2.54 bunches), the weight per bunch (16.94 kg) and maximum yield (23.22 kg) compared to other fertilizer rates. This may be due to soil and leaf analysis that we know the fertilizer needs including leaf analysis to know the amount of nutrients that plants use. Do not put more fertilizer than the needs of the plant. This is consistent with Goh and Hardter (2003) reported that fertilizer application should be sufficient to meet the needs of oil palm and over fertilizer makes the high costly. The palm oil is aged 1-3 years as the growth of the stem and leaf quickly. If appropriate fertilizer management from the beginning, they are making the high yield and always. However, the application of chemical fertilizers must take into account the type of soil that grows oil palm because each soil has different fertility. Fertilizer should be applied 2-3 times a year, as appropriate. Oil palm fertilizer age 4 years or

more, it should be fertilized according to the analysis of soil and leaves of oil palm, together with visible deficiencies been observed in oil palm plantations. Teera *et al.* (2004) reported that oil palm is a perennial plant with high fertilizer requirements for yield, by harvesting fresh produce. 1,000 kilograms of nutrients lost the nutrients nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and calcium (Ca) to about 2.94, 0.44, 3.17, 0.77 and 0.81 kg. Therefore, it must to add fertilizer instead that lost from yield so that it had a good yields and high valued.

Conclusion

Fertilizer management for oil palm is effecting on plant growth and high yield. Considering the need for fertilizer is important because over-fertilization has a negative impact on oil palm. It also cost overpriced. If the fertilizer is less than the demand for palm oil, it will grow and produce less. So, the right approach for managing palm oil is: applying soil and analysis before fertilizer management. The fertilizer can be kept up to the needs of the plant. It can be reduce the cost of fertilizer management and increase profits.

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Table 5. Effect of fertilizer application on number of bunch/tree/month (bunch).

Rates	No. bunch/tree/month (bunch)													Average Rates
	2015						2016							
	July	August	September	October	November	December	January	February	March	April	May	June	July	
1	3.10	3.30	3.50	1.10	1.10	1.90	1.00	3.20	1.60	1.50	2.70	2.90	3.10	2.31B
2	3.80	3.90	3.90	1.10	1.00	2.50	1.70	1.20	1.20	1.10	2.30	2.60	2.60	2.22B
3	3.80	3.70	3.80	1.10	1.20	1.30	1.10	1.80	1.70	1.60	2.80	3.00	3.10	2.31B
4	5.00	4.70	4.70	1.20	1.10	1.80	1.00	1.70	1.50	1.40	2.90	3.00	3.00	2.54AB
5	4.20	3.90	4.00	1.10	1.50	2.70	1.70	3.60	1.40	1.60	2.80	2.90	3.10	2.65A
6	3.70	3.70	3.90	1.10	1.10	2.30	2.00	2.20	1.10	1.70	3.00	3.20	3.30	2.48AB
7	4.30	4.00	4.00	1.00	1.60	2.10	1.10	1.90	1.60	1.50	3.20	3.20	3.40	2.53AB
Average Months	3.99A	3.89A	3.97A	1.10D	1.23D	2.09C	1.37D	2.23C	1.44D	1.49E	2.81B	2.97B	3.09B	**

CV. 15.95%

** = Significant difference at $P \leq 0.01$, Value followed by different letter are significantly different according to DMRT.**Table 6.** Effect of fertilizer application on fresh weight of bunch (kg/bunch).

Rates	Fresh weight of bunch (kg/bunch)													Average Rates
	2015						2016							
	July	August	September	October	November	December	January	February	March	April	May	June	July	
1	17.17	17.36	17.44	12.37	15.04	16.40	11.82	9.44	12.46	15.32	18.02	17.30	10.55	14.67B
2	16.80	17.30	17.13	13.17	15.89	16.48	13.68	10.40	18.46	16.32	16.86	17.32	12.2	15.54AB
3	17.76	17.96	18.78	13.94	15.70	16.35	11.80	11.25	22.44	15.54	14.14	17.66	11.23	15.73AB
4	15.92	18.22	18.66	14.34	15.48	17.68	14.60	19.30	24.28	13.95	17.39	18.18	12.187	16.94A
5	19.04	18.74	18.04	15.01	15.37	17.26	10.00	15.08	16.60	12.53	15.22	17.22	12.24	15.57AB
6	15.38	17.36	18.16	14.33	16.89	17.35	11.20	10.32	17.47	10.61	11.83	14.64	12.80	14.49B
7	15.06	16.84	17.96	14.61	15.07	16.66	11.20	11.31	13.65	11.11	14.38	14.98	13.25	14.31B
Average Months	16.73ABC	17.68AB	18.02A	13.97ED	15.63BCD	16.88ABC	12.04E	12.44E	17.91A	13.63ED	15.41CD	16.76A	12.06E	**

CV. 11.82%

** = Significant difference at $P \leq 0.01$, Value followed by different letter are significantly different according to DMRT.

Table 7. Effect of fertilizer application on yield (kg of bunch/tree/month).

Rates	Fresh weight of bunch (kg/bunch)													Average Rates
	2015						2016							
	July	August	September	October	November	December	January	February	March	April	May	June	July	
1	28.98	27.27	28.50	17.74	17.32	18.80	11.32	14.22	26.98	14.70	32.34	17.14	23.30	21.43AB
2	26.70	26.79	28.32	20.22	18.82	18.64	10.00	12.10	30.66	22.52	19.16	21.42	22.14	21.35AB
3	29.28	23.32	22.70	24.14	16.56	18.11	13.12	15.84	14.60	14.48	33.72	21.16	19.66	20.51AB
4	28.98	26.58	24.48	30.90	20.90	21.54	12.10	13.68	20.40	14.00	42.00	23.84	22.40	23.22A
5	28.82	23.88	32.70	17.94	21.33	19.16	11.54	16.08	23.96	16.64	24.04	20.60	24.00	21.59AB
6	31.80	24.71	25.50	17.78	23.58	20.14	11.06	11.62	27.34	14.38	20.76	14.56	20.66	20.30AB
7	27.80	21.45	23.34	14.88	17.92	18.48	9.70	12.38	25.48	16.92	18.20	17.28	16.88	18.52B
Average Months	28.91A	24.86ABC	26.51AB	20.51EDF	19.49EF	19.27EF	11.26H	13.70GH	24.20BCD	16.23FG	27.17AB	19.43EF	21.29CDE	**
														CV. 17.83

** = Significant difference at $P \leq 0.01$, Value followed by different letter are significantly different according to DMRT