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Optimum Plant Nutrient Management for Oil Palm

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Abstract

Oil palm (Elaeis guineensis Jacq.) is an important economic crop of Thailand, including the lower South of Thailand. At present, farmers encounter the problem of increasing production costs, due to the lack of proper knowledge and understanding of nutrient management, resulted in low yields per land field and chemical fertilizers are expensive. Therefore, this research was conducted to test plant nutrient management for oil palm production to increase yield or reduce cost during the year of 2016-2021. From the test, it was found that the two recommended methods: fertilizing according to the leaf analysis and fertilizing according to leaf analysis in combination with mycorrhizal bio-fertilizer for 30 g./tree. The results reported that the production and the economic returns from the two methods were similar, but higher than the common fertilization method used by farmers. By fertilizing according to the leaf analysis value in combination with mycorrhizal bio-fertilizer for 30 g./tree, it resulted in an average of 4,125 kg. /rai/year of oil palm bunch, providing an average net income of 11,751 baht/rai/year. The average benefit cost ratio (BCR) was 3.34, which was not statistically different from the fertilization method according to the leaf analysis, which produced an average oil palm bunch yield of 4,107 kilograms per rai, resulting in an average net income of 11,728 baht/rai/year, with an average BCR of 3.38. In meanwhile, for the common method of fertilizing used by farmer, the average oil palm bunch was 2,812 kg/rai/year. This resulted in an average net income of 9,079 baht/rai/year with an average BCR of 4.75. By fertilizing according to both recommended methods, the yield of oil palm bunch is higher than the farmers' common fertilization for 46.69 and 46.05 percent respectively and resulting in higher net income than the farmers' common fertilization by 29.43 and 29.17 percent respectively. However, considering the soil before the experiment, the root infestation of endemic mycorrhizal bacteria was 57.15 percent. After the experiment, the average root infestation of mycorrhizal fungi was 50.00 percent for the first fertilizing method, followed by the third method - the common method of fertilizing used by farmer, at 39.17 percent, followed by the second method - the fertilizer application according to the leaf analysis and fertilizing according to leaf analysis in combination with mycorrhizal bio-fertilizer for 30 g./tree, which resulted 36.33 percent. Therefore, the increased yield of oil palm bunch from the recommended method is caused by fertilizing according to the leaf analysis, not from using mycorrhizal bio-fertilizer at the rate of 30 g./tree. In addition, fertilizing according to leaf analysis resulted in a marginal rate of return (MRR) of 105.49 percent. Hence fertilizing according to the leaf analysis is the optimum plant nutrient management for oil palm production in Songkhla Province.

Keyword: Value of leaf analysis, Mycorrhizal bio-fertilizer, Oil palm bunch yield

Introduction

Oil palm (Elaeis guineensis Jacq.) is an important economic crop of Thailand, including the lower South of Thailand which the area of planting is expanding continuously. In 2021, Thailand has oil palm planting areas of 6.29 million rai and a productive area of 6.03 million rai, producing 16.90 million tons of fresh palm, with the lower southern region having a planting area of 724,775 rai and a productive area of 675,286 rai, representing 93.17 percent of the total planting area [1] and there is a tendency to increase further. As the government, through the Ministry of Agriculture and Cooperatives, still gives importance to the reform strategy of oil palm and palm oil since 2017 to 2036. The government has a goal that in 2036, Thailand will be able

to produce oil palm bunch at 3.50 tons/rai/year, increase the planting area to 10 percent, and to increase the extracted palm oil to 23 percent [1]. However, in the production of palm oil, farmers are currently facing the problem of increasing production costs because palm oil is a plant that requires high nutrient for its growth and production of oil palm bunch. There is a loss of soil nutrients with a large amount of yield [2] while most farmers lack knowledge and understanding of correct nutrients management. As a result, the output of oil palm is below its potential. In addition, chemical fertilizers are expensive, thus affecting production costs. 60% of the cost of oil palm production comes from chemical fertilizers [3]. Including the selection of good palm varieties and good garden management. Therefore, the integrated plant nutrient management is suitable for the area and climate conditions in combination with the selection of good palm varieties and good garden management is a way to help reduce costs and increase the efficiency of oil palm production and is a way to increase sustainable oil palm production for further food security.

Methodology

Model and Experimental Method

Tenera hybrid oil palm plots were selected in the areas of farmers in Songkhla province for to 10 cases, each of 6 rai, totaling 60 rai. The test was conducted in 2016-2021 by comparing 3 methods as follows: Method 1 - Recommended method (fertilizing according to the leaf analysis: FER), Method 2 - Recommended method (fertilizing according to the leaf analysis with 30 grams of mycorrhizal bio-fertilizer / plant: FER+ AMF), and Method 3 - Farmer's common method (fertilizing according to the farmer's existing method: FARMER). The test was a comparative test between oil palm production technology from the research and the existing methods of farmers.

Experimental Method

Method 1: Recommended method (fertilizing according to the leaf analysis) and Method 2: Recommended method (fertilizing according to the leaf analysis with 30 grams of mycorrhizal bio-fertilizer/plant).

a) Soil samples were collected at a depth of 0-20 cm and leaf samples were collected (Oil Palm Frond 17) for nutrient analysis before and after the experiment.

b) The leaf analysis results were used to calculate nutrient content by comparing with the critical values according to the fertilizer application technology following the results of the leaf analysis. The concentration of nutrients in oil palm leaves was assessed by dividing into 2 groups of age: young palm, palm tree under 6 years old, and large palm, palm tree that is 6 years old and older, [3] as shown in (Table 1).

Table 1: The ranges of the nutrient concentration in leaves from the Oil Palm Frond 17 of oil palm under 6 years old and 6 years old and over.

Plant Nutrient Type	Oil Palm under 6 years Old			Oil Palm ages 6 years Old and Over		
	Lack	Appropriate	Exceed	Lack	Appropriate	Exceed
Nitrogen (%)	<2.47	2.60-2.90	>3.05	<2.28	2.40-2.80	>2.94
Phosphorus (%)	<0.152	0.16-0.19	>0.1995	<0.143	0.15-0.18	>0.189
Potassium (%)	<0.99	1.10-1.30	>1.43	<0.81	0.90-1.20	>1.32
Magnesium (%)	<0.20	0.30-0.45	>0.70	<0.20	0.25-0.40	>0.70
Boron (mg/kg)	<8	15-25	>40	<8	15-25	>40

Source: Adapted from Rankine and Fairhurst [3].

Concentration of plant nutrients from the results of the palm leaf analysis

- In the range of lacking to exceeding: the nutrient fertilizer should be added at the same rate.
- Below the lacking level: the nutrient fertilizer should be increased by 25 percent of the original rate.
- Higher than exceeding level: the nutrient fertilizer should be reduced by 20 percent of the original rate.

c) Add chemical fertilizer formula of 21-0-0, 0-3-0, 0-0-60, including kieserite and borate according to the results of the leaf analysis, by putting in the area around the radius of the canopy. The chemical fertilizer should be added for 3 times/ year.

d) Add mycorrhizal bio-fertilizer for 1 time around the canopy, at the rate of 30 g./plant (except Method 1).

e) Collect soil samples around the roots and oil palm roots (except Method 1).

Method 3: Farmer's common method (fertilizing according to the farmer's existing method)

i. Soil samples were collected at a depth of 0-20 centimeters and leaf samples were collected (Oil Palm Frond 17) for nutrient analysis before and after the experiment.

ii. Apply fertilizer following the normal practice of each farmer. Farmers applied chemical fertilizers, both straight and compound fertilizers, and with inappropriate amounts of fertilizer.

Data Collection

Data collection was soiling chemical analysis results from before and after the experiment, nutrient analysis results in the leaves (Oil Palm Frond 17) before and after the experiment, the amount of mycorrhizae in the soil surrounding the roots and in oil palm roots, the amount of oil palm bunch, and the economic information.

Statistical data were analyzed by comparing the mean differences and economic returns.

Results and Discussions

Plant Nutrient Concentrations in Oil Palm Leaves

Before the experiment, plant nutrient concentrations in oil palm leaves aged 4.5 - 6 years showed that the concentrations of nitrogen, phosphorus, potassium, magnesium, and boron in oil palm leaves were in the level of lacking to appropriate, with the percentages of 2.14-2.63, 0.12-0.15, 0.60-1.10, and 0.24-0.40, and 8-20milligram/kilogram, respectively [3] as shown in (Table 2).

After the experiment, plant nutrient concentrations in oil palm leaves aged 9.5 - 11 years showed that for the Method 1 - application according to the leaf analysis value, the concentration of all 5 types of nutrients in leaves was at a lacking to an appropriate level. The concentrations of nitrogen, phosphorus, potassium, magnesium, and boron were at the percentages of 2.18-2.75, 0.13-0.15, 0.62-1.07, and 0.20-0.25, and 14-28 milligram/kilogram, respectively. For Method 2 - fertilizing according to the leaf analysis with 30 grams of mycorrhizal bio-fertilizer/plant with concentrations of nitrogen, phosphorus, potassium, magnesium, and boron at the percentages of 2.18-2.70 0.13-0.15 0.63-1.11 0.16-0.27, and 13-30 milligram/kilogram, respectively. The concentrations of nutrients were at a lacking to an appropriate level [3]. For Method 3 - farmer's common method, the concentrations of nitrogen, phosphorus, potassium, magnesium, and boron were at the percentages of 1.85-2.52 0.11-0.15 0.51-1.05 0.18-0.36, and 10-26 milligram/kilogram, respectively. The concentrations of nutrients were at a lacking to an appropriate level, as shown in (Table 2). The concentration of nitrogen in each method was statistically different. The highest value was 2.46 percent from the Method 1, followed by 2.36 percent from the Method 2, and 2.21 percent from the Method 3. Concentrations of potassium and boron in the Method 2, fertilizing according to the leaf analysis with 30 grams of mycorrhizal bio-fertilizer/plant, were the highest at 1.00 percent and 22 milligram/kilogram, respectively, and were not significantly different from the Method 1 which had 0.84 percent 20 milligram/kilogram, respectively. However, it was statistically different with the Method 3, which had the lowest percentage at 0.75 percent and 16 milligram/kilogram, respectively. For the concentration of phosphorus and magnesium, they were not statistically different in all treatments (Table 3).

Plant Nutrients and Fertilizer Ratio Applied to Oil Palm

For the average amount of plant nutrients and fertilizer rates applied to oil palm annually showed that the Method 1, fertilizing according to the leaf analysis, had fertilizer ratio of 1.44-0.39-2.98 N-P2O5-K2O kilogram/tree/year, including using MgO fertilizer for 0.37 kilogram/tree/year, as well as using B fertilization for 135 gram/tree/year (Table 4), calculated as the fertilizer formula 21-0-0, 0-3-0, and 0-0-60, and kieserite at 6.86, 1.98, 4.97, and 1.42 kilogram/tree/year respectively, and borate 90 gram/tree/year. Similarity, the Method 2, fertilizing according to the leaf analysis with 30 grams of mycorrhizal bio-fertilizer/plant, had fertilizer ratio of 1.45-0.40-2.96 N-P2O5-K2O kilogram/tree/year, including using MgO fertilizer for 0.42 kilogram/tree/year, as well as using B fertilization for 128 grams/tree/year, calculated as the fertilizer formula 21-0-0 0-3-0 0-0-60, and kieserite at 6.90, 2.00, 4.93, and 1.62 kilogram/tree/year respectively, and borate 85 gram/tree/year. Both of the recommended methods used higher amounts of fertilizer than the Method 3, farmer's common method, and had fertilizer ratio of 0.59-0.31-1.18 N-P2O5-K2O kilogram/tree/year including 0.01 MgO kilogram/tree/year, as well as using B fertilization for 50 gram/tree/year, calculated as the fertilizer formula 21-0-0 0-3-0 0-0-60, and kieserite at 2.81, 1.55, 1.97, and 0.04 kilogram/tree/year respectively, and borate 33 gram/tree/year (Table 4).

Root Infestation of Endemic Mycorrhizal Bacteria

Prior to the experiment, the mean mycorrhizal infestation of oil palm roots was 57.15 percent. After the experiment, the infestation of mycorrhizal bacteria was found in all 3 experimental methods, including the method that did not use the mycorrhizal bacteria. For the Method 1, fertilizing according to the leaf analysis, it had an average of 50.00 percent of mycorrhizal root infestation and there was no statistical difference from the Method 3, farmer's common method, which had the infestation of mycorrhizal bacteria at the average of 39.17 percent. However, the Method 1 was significantly different from the Method 2, fertilizing according to the leaf analysis with 30 grams of mycorrhizal bio-fertilizer/plant, which had the mycorrhizal root infestation at the lowest mean, which was 36.33 percent (Table 5).

Production of Oil Palm Bunches from Palm Oil

Fertilizing according to the leaf analysis with 30 grams of mycorrhizal biofertilizer/plant yielded an average of 4,125 kg/rai/year, which was not statistically different from fertilization methods using the leaf analysis, which gave an average oil palm bunch yield of 4,107 kilograms per rai. On the other hand, the existing farmer's fertilization produced the oil palm bunch at the average of 2,812 kg./rai/year. The two recommended fertilization methods resulted in the yield of oil palm bunches at 46.69 and 46.05 percent higher than the farmers' fertilization method, respectively (Table 6).

Economic Returns

The economic returns between the two recommended methods, fertilizing according to the leaf analysis and fertilizing according to the leaf analysis with 30 grams of mycorrhizal bio-fertilizer/plant, were not different statistically. However, both recommended methods gave statistically significantly higher economic returns than the common farmer's fertilizer application. The average income from using fertilization method according to the leaf analysis with 30 grams of mycorrhizal bio-fertilizer/plant was 16,767 baht/rai/year, and the average variable cost was 5,016 baht/rai/year, resulting in an average net income of 11,751 baht/rai/year. The average benefit cost ratio (BCR) was 3.34. It was not statistically different from the fertilization methods using leaf analysis values. The method provided an average income of 16,657 baht/rai/year, with average variable costs of 4,930 baht/rai/year, granting farmers an average net income of 11,728 baht/rai/year with the average benefit cost ratio (BCR) of 3.38. In meanwhile, the existing fertilization method of farmer provided an average income of 11,499 baht/rai/year, with variable costs are 2,419 baht/rai/year, resulting in farmers having an average net income of 9,249 baht/rai/year. The average benefit cost ratio (BCR) was 4.75. Both recommended fertilizing methods resulted in higher net income than farmers' methods by 29.43 and 29.17 percent, respectively. In addition, it resulted in a marginal rate of return (MRR) of 102.86 and 105.49 percent, respectively. This indicated that the cost of 100 baht that increased from fertilizing according to the leaf analysis with 30 grams of mycorrhizal bio-fertilizer/plant and fertilizer application according to leaf analysis increased net income by 102.86 and 105.49 baht, respectively (Table 7).

Table 2: Plant nutrient concentrations in oil palm leaves of oil palm frond 17, before and after the experiment

Plant Nutrient Type	Plant Nutrient Concentrations in Oil Palm Leaves			
	Before the experiment	After the experiment		
		FER	FER+AMF	FARMER
N (%)	2.14-2.63	2.18-2.75	2.18-2.70	1.85-2.52
P (%)	0.12-0.15	0.13-0.15	0.13-0.15	0.11-0.15
K (%)	0.60-1.10	0.62-1.07	0.63-1.11	0.51-1.05
Mg (%)	0.24-0.40	0.20-0.25	0.16-0.27	0.18-0.36
B (mg/kg)	Aug-20	14-28	13-30	Oct-26

Source: From the experimental research.

Table 4: The average amount of plant nutrients (kg./tree/year) and the average rate of each type of fertilizer (kg./tree/year)

Method			
	FER; T1	**FER+AMF; T2**	**FARMER; T3**
Average amount of plant nutrients (kg./tree/year)			
- N	1.44	1.45	0.59
- P2O5	0.39	0.4	0.31
- K2O	2.98	2.96	1.18
- MgO	0.37	0.42	0.01
- B	0.0135	0.0128	0.005
Average rate of each type of fertilizer (kg/tree/year)			
-21-0-0	6.86	6.9	2.81
-0-3-0	1.95	2	1.55
-0-0-60	4.97	4.93	1.97
- MgSO4H2O	1.42	1.62	0.04
- B	0.09	0.085	0.033

Source: From the experimental research.

Table 5: The average percentage (%) of root infestation of endemic mycorrhizal bacteria after the experiment

Method	**Average root infestation of endemic mycorrhizal (%)**	**T-test**
FER; T1	50	1.58ns
FARMER ; T3	39.17	
FER+AMF; T2	36.33	0.39ns
FARMER; T3	39.17	
FER; T1	50	3.09*
FER+AMF; T2	36.33	

Source: From the experimental research

Remark: ns = There was no any statistical difference.

* = There was a difference at the significance level of 0.05 (t 0.05,9 = 2.26).

Table 7: Comparison of the yield of oil palm bunches and economic return within an average of 5-year

Method	**Oil palm bunch (kg/rai/year)**	**T-test**	**Average income (baht/rai/year)**	**T-test**	**Average net income (baht/rai/year)**	**T-test**
FER ; T1	4,107	7.47**	16,657	7.67**	11,728	4.68**
FARMER ; T3	2,812		11,499		9,079	
FER+AMF;T2	4,125	7.49**	16,767	7.61**	11,751	4.12**
FARMER : T3	2,812		11,499		9,079	
FER ; T1	4,107	0.29ns	16,657	0.39ns	11,728	0.09ns

Source: From the experimental research.

Remark: ns = There was no any statistical difference.

* = There was a difference at the significance level of 0.01 (t 0.01,9 = 3.25).

Discussion

From the results of testing the appropriate plant nutrient management technology for oil palm in Songkhla province, the test results were similar. The results were that fertilization according to the recommended 2 methods, fertilizing according to the leaf analysis and fertilizing according to the leaf analysis with 30grams of mycorrhizal bio-fertilizer/plant, provided the production of oil palm bunches and the economic return that were higher than the farmer's existing method. This was due to the fact that the recommended methods applied fertilizers according to the requirements of oil palm, by adding all the nutrients that palm oil needed in large or quite large quantities, put-

ting in the right quantity and at the right time [4]. This resulted in higher yields than the farmer's existing method. Farmers did not use fertilizers as recommended by the Department of Agriculture, causing the oil palm to not receive enough nutrients as required, resulting in low productivity. Most of the farmers applied low amounts of nitrogen and potassium fertilizers, while phosphorus was applied at rates close to the recommended method, which was a nutrient that palm oil required in large amounts [4]. For the soil, before experiment, there was an average of 57.15 percent of the root infestation of endemic mycorrhizal bacteria in oil palm roots. When applying mycorrhizal bio-fertilizer at the rate of 30g./plant in the Method 2 (fertilizing according to the leaf analysis with 30grams of mycorrhizal bio-fertilizer/plant), it did not increase mycorrhizal root infestation in oil palm roots, similar to the non-mycorrhizal bio-fertilization methods (Method 1, fertilizing according to the leaf analysis and Method 3, farmer's existing fertilization method). The average root infestation values of oil palm were 36.33-50.00 percent, indicating that the application of mycorrhizal biofertilizer at the rate of 30g./plant did not increase the percentage of mycorrhizal infestation in oil palm roots when compared with the results from t the non-mycorrhizal bio-fertilization methods. This was because in the original soil, there was already mycorrhiza living in the soil and oil palm roots. Therefore, the yield of oil palm bunch that was different between the recommended method and the farmer's method was caused by fertilizing according to the leaf analysis, not a result of mycorrhizal bio-fertilization [5].

Summary

a. Fertilizing according to leaf analysis is an appropriate plant nutrient management method for oil palm production in Songkhla Province. With this method, oil palm produces oil palm bunches and results in higher returns than the farmer's existing fertilization method. The yield is 46.05 percent higher, and the net income is 29.17 percent higher than the farmer's method, and it is cost-effective with a marginal rate of return (MRR) of 105.49 percent, which the additional cost of 100 baht is from the cost of fertilizing according to the leaf analysis which resulting in an increase in income of 205.49 baht.

b. The effect of the differences between the recommended methods and the farmer's method caused by the method of fertilizing according to the leaf analysis, not the method of fertilizing according to the leaf analysis with 30 grams of mycorrhizal bio-fertilizer/plant. This is due to the average 57.15 percent of the mycorrhizal mycosis in the oil palm roots that originally prohibited in the soil prior to the experiment. When the 30 grams of mycorrhizal bio-fertilizer/plant is applied into the soil, it does not increase the percentage of mycorrhizal root infestation, with a value of 36.33 percent.

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