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Research Article
Technical Efficiency of Oil Palm Production under a Large Agricultural Plot Scheme in Thailand

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Abstract

Background and Objective: Thai government launched a Large Agricultural Plot Scheme (LAPS) in 2005 in order to enhance the effectiveness of the extension programme. The objective of this research was to compare the technical efficiency (TE) of oil palm production and factors influencing the TE of oil palm production between member and non-member farmers under the LAPS in Bang Saphan Noi district, Prachuap Khiri Khan Province, Thailand. **Methodology:** The data were collected from January-June, 2017 from 57 LAPS member farmers and 63 non-LAPS member farmers. This paper estimated technical inefficiency by using a stochastic production frontier model and Tobit regression to investigate the factors influencing the TE. **Results:** The results revealed that the TE of oil palm production of the LAPS member farmers was ranked 12-99%, whereas that of the non-LAPS member farmers was ranked 14-99%. The TE mean of LAPS member farmers was 0.63, while the TE mean of non-LAPS member farmers was 0.52. The years of experience on oil palm plantations and age were crucial factors that contributed to the TE of LAPS member farmers and TE of non-LAPS member farmers, respectively. **Conclusion:** The TE mean of LAPS member farmers was higher than that of non-LAPS member farmers knowledge and experience sharing between old and young generations who are eager to work in oil palm production should also be a concern.

Key words: Technical efficiency, oil palm, product efficiency, agricultural scheme, LAPS

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Like other developing countries, palm oil production in Thailand has been increasingly promoted as a major crop for rural livelihoods[1,2]. During the past decades, oil palm cultivations in the country has tripled[3,4].The oil palm is crucial to Thailand's economy and it ranked as the third largest producer of palm oil in the world out of 42 oil palm countries, including Indonesia and Malaysia[5]. The current management of oil palms in Thailand does not consider efficiency and productivity but focuses on volume, even though the efficiency and productivity of the oil palm sector are important for Thailand-as a main manufacturer and exporter of palm oil[6,7]. In addition, oil palm countries have faced high production costs and low productivity, as well as a lack of efficient management and policy[8,9].

To help oil palm farmers at the policy level, the Thai government set up a road-map for development according to the 2015-2026 oil palm and palm oil strategy by setting goals for increasing oil palm products to respond to the demands of domestic consumption, alternative energy and export requirements that comprises three main elements: (1) The expansion of plantation areas, (2) An increase in products to increase the products per rais and (3) An increase in the oil percentage from oil palm fruits[10]. Moreover, to enhance the effectiveness of small farmers, in 2015, the Ministry of Agriculture and Cooperatives launched a Large Agricultural Plot Scheme (LAPS) policy, allowing small farmers to consolidate and combine production areas into one large plot. Oil palm plantations in the LAPS were emphasized by (1) Reducing production costs by encouraging farmers to use organic and chemical fertilizers based on soil analysis and production factor purchasing, (2) Improving the quality of products by certifying their quality according to standards including selecting good varieties, (3) Increasing yields by using good varieties or appropriate and suitable fertilizers. Under the LAPS, a government officer provides and shares supply-demand information among member farmers. This scheme is intended to enhance the effectiveness of the extension programme and the TE of smallholder oil palm productions.

Two years after the government launched the LAPS, no study has been performed on the oil palm production efficiency of farmers participating in this scheme. Efficiency is an important factor for productivity growth, especially in developing agricultural economics[11,12]. Technical efficiency (TE) indicates the ability of a farmer to produce a maximum output given a set of inputs and technology[13], that is, a producer's ability to obtain the highest possible output from a given quantity of inputs[14,15]. To enhance oil palm production efficiency, TE increases the ability of farmers to measure methods of increasing their production by employing fewer necessary resources. TE analysis is also useful for measuring the production efficiency of different methods oil palm production. Hasnah *et al.*[16] studied the performance of small holders in a Nucleus Estate and Smallholder scheme of oil palm production in West Sumatra by measuring their TE. Alwarritzi *et al.*[17] analyzed TE among oil palm smallholder farmers in Indonesia. Regarding the study of TE in Thailand, Krasaerchat[18] measured the operation results of oil palm plantations by using anon-parametric method and analysis of efficiency on utilizing production factors of oil palm production in Surat Thani province, Juntawong[19]. Nevertheless, gaps in the literature remain regarding the investigation of the TE of oil palm productions under government schemes.

At the country level, oil palms under LAPS reached 113,779.79 rai, with 8,725 member farmers. The oil palms in Prachuap Khiri Khan Province, in Southern Thailand, represent one targeted area for the LAPS. In this province, oil palms are planted in vast areas because of the appropriateness of the soil condition, especially in Bang Saphan Noi district where the largest areas of oil palm plantations are located[20] and cover 50,492 rai, that is, 42.94% of all oil palm plantation areas in the province[21]. Additionally, oil palms are economic plants for a new alternative source of energy. In summary, oil palm plantations are grown among small-scale farms and represent a major livelihood and source of food security for rural households in Bang Saphan Noi district. However, the average production in this area is relatively low (i.e., 2.13 t per rai) compared with the average yields of Thailand (i.e., 3.22 t) and the government has implemented a policy to increase yields to 3.50 t by 2026. As a result, this province was selected as one of the oil palm plantation areas under LAPS.

At the time of this study, there are 57-member farmers with a total plantation area of 1,158 rai under the LAPS in Prachuap Khiri Khan Province. The proportion of farmers participating in the LAPS is small, representing only at 2.08% of the total palm oil farmers in the province[22]. Consequently, this research aimed to conduct a comparative study between member and non-member farmers of the LAPS. Interestingly, less consideration was allocated to investigating the TE of the oil palm production of farmers under the LAPS in Prachuap Khiri Khan Province, Thailand. Due to the small number of oil palm farmers participating in the LAPS, this study aimed to estimate the TE of 2 groups: LAPS members and non-LAPS members. This study aims to contribute to the ongoing oil palm LAPS with regards to improving resource use efficiency. In addition, this study investigated those determinants that affect technical inefficiency in oil palm production to formulate a proper policy that can increase oil palm production efficiency. The results and recommendations gained from this study are beneficial for pertinent organizations and agencies to improve the efficiency of oil palm production for farmers.

MATERIALS AND METHODS

The study area: Bang Saphan Noi district, in the southern part of Prachuap Khiri Khan Province, Thailand, was selected as the study area. Oil palm farmers in this province, are mostly small-sized farmers, with plantation areas less than 20 rais. In 2016, this area was selected to participate in the LAPS[22]. This district is famous for being the first oil palm plantation complex in Thailand using technology in the production process of biodiesel and olefin oil production for domestic consumption[23]. The oil palm is important for the livelihood of small-sized farmers in this area. Improving production efficiency improves their livelihood.

Population and sample size: The population of this study was 57 oil palm farmers who are members in the LAPS[22] and 63 non-LAPS members in five sub-districts of Bang Saphan Noi district, Prachuap Khiri Khan Province.

Data collection: Primary data were collected from January-June, 2017. Structured questionnaires were administered and oral interviews were conducted with selected oil palm farmers. The purposive sample technique was applied for random sampling. The questionnaire comprised three parts. The first part consisted of the characteristics of member oil palm farmer sunder the LAPS and non-member farmers. The second part addressed the costs and returns on oil palm production. The third part presents the comments from the participants in the LAPS.

Data analysis: A descriptive statistical analysis was employed to describe the socioeconomic characteristics of oil palm farmers, namely, frequency, mean and percentage. A chi-square was applied to compare characteristics between LAPS member and non-LAPS member farmers. An estimate of TE by using a Cobb-Douglas production function, which provides an adequate representation of production technology, is also used in this research. This function is widely used in the analysis of agricultural efficiency in developing and developed countries[7,24-28]. This research uses the Cobb-Douglas form of the stochastic frontier production model with a log-log functional form and the estimation of the specific model is given in Eq. 1 as follows:

$$\text{In}Y = b_0+b_1\text{In}X_{1i}+b_2\text{In}X_{2i}+b_3\text{In}X_{3i}+b_4\text{In}X_{4i}+(V_i-U_i) \quad (1)$$

Where:

Y	=	Yield (t/rai)
X_{1i}	=	Farm size (rai)
X_{2i}	=	Number of oil palms (tree/rai)
X_{3i}	=	Fertilizer (t/rai)
X_{4i}	=	Number of Household labourers (hour)
I_1	=	Sample of LAPS member farmers 1,2,3,⋯,57
I_2	=	Sample of non-LAPS member farmers 1,2,3,⋯,63
V_i	=	Random errors caused by uncontrollable factors
U_i	=	Randomness inefficiency
bi	=	Coefficients to be estimated

Determinants of oil palm TE w as estimated by using the Tobit regression model. Tobit analysis accounts for the censoring and allows the estimation of the impact of independent variables on the uncensored variable[29]. Tobit regression coefficients are presented as the following equation[30,31]:

$$Y_i = \beta_0+\beta_1x_i+...+\beta_kx_{ki}+\varepsilon_i \quad (2)$$

Where:

x_{1i}, x_{2i}, x_{ki}	=	Independent variable 1 to k
$\beta_0+\beta_1+\beta_2..., \beta_k$	=	Unrecognized regression coefficient
E_i	=	Random error
i	=	1, n

According to the literature, factors that may influence the TE of farmers by their age and level of education, use of hired rather than family labourers, gender composition of family labour[16,32], the utilization of extension services as investigated by Bravo-Ureta and Pinheiro[25] and Hasnah *et al.*[16] and advice from extension, gender composition of family labour and education were investigated by Hasnah *et al.*[16]. These studies have mainly focused on four of these factors: gender, the age of household head, the education of household head and years of experience on oil palm plantations, which were included in Eq. 2.

RESULTS AND DISCUSSION

Socioeconomic characteristics of farmers: Table 1 shows the comparison of mean differences between LAPS members and non-LAPS members. The results revealed

Table 1: Characteristics of oil palm farmers under the LAPS and non-LAPS member farmers

	LAPS member (N = 57)		Non-LAPS member (n = 63)			
Characteristics	Frequency	Percentage	Frequency	Percentage	χ^2	p-value
Gender						
Male	29	50.9	36	57.1	0.473	0.492
Female	28	49.1	27	42.9		
Age						
<31 years	1	1.8	-	-		
31-40 years	1	1.8	12	19.0		
41-50 years	7	12.3	12	19.0	45.824	0.356
51-60 years	23	40.4	24	38.1		
>60 years	25	43.9	15	23.8		
Years of education						
3 years	25	43.9	39	61.9		
6 years	10	17.5	13	20.6		
9 years	4	7.0	3	4.8	7.792	0.168
12 years	9	15.8	5	7.9		
14 years	5	8.8	1	1.6		
16 years	4	7.0	2	3.2		
Year of experience in oil palm plantations						
<10 years	7	12.3	6	9.5	38.586	.030**
10-20 years	45	78.9	47	74.6		
>20 years	5	8.8	10	15.9		
land holding size						
<20 rai	25	43.9	45	71.4		
20-50 rai	28	49.1	16	25.4	29.125	0.819
>50 rai	4	7.0	2	3.2		
Oil palm tree age						
<10 years	6	10.5	6	9.5		
10-20 years	48	84.2	49	77.8	37.094	0.016**
>20 years	3	5.3	8	12.7		
Number of oil palm						
<100 trees	-	-	5	7.9		
100-500 trees	38	66.7	49	77.8	48.599	0.608
>500 trees	19	33.3	9	14.3		

**Significant at ($p \leq 0.05$)

Table 2: Descriptive statistics of the variables of technical efficiency variable

		LAPS member				Non-LAPS member			
Variables	Unit	Mean	Standard deviation	Minimum	Maximum	Mean	Standard deviation	Minimum	Maximum
Yield	ton	33.67	56756.35	1.00	427.44	19.49	23003.91	1.50	150.00
Farm size	rai	23.54	22.34	3.00	150.00	19.37	15.37	3.00	75.00
Number of oil palm	tree	623.26	658.61	70.00	4000.00	470.44	432.39	60.00	2603.00
Fertilizer	ton	2.08	1881.40	0.15	8.55	1.42	1582.61	0.080	6.55
Household labor	hour	808.54	697.11	40.00	2935.47	709.89	818.78	61.33	4872.00

statistically significant differences at the 0.01 level in five aspects. Years of experience on oil palm plantations and oil palm tree age were statistically and significantly different at the 0.05 level. The majority of LAPS (78.9%) and non-LAPS (74.6%) member farmers had 10-20 and 20 years of experience on oil palm plantations, respectively and the difference was statistically significant at the 0.05 level. By contrast, gender, age and education of household head had no statistically significant difference.

The findings also exposed that the oil palm age range of LAPS (84.2%) and non-LAPS (77.8%) member farmers was 10-20 years and the difference was statistically significant at the 0.05 level. Alwarritzi *et al.*[17] asserted that yield-peak periods of oil palm were between 9-19 years and decreased after 20 years. By contrast, landholding size and the number of oil palms did not present a statistically significant difference.

In Table 2, the average yields of member farmers under the LAPS were 33.67 t from January-June, 2017. The average farm size was 23.54 rai and the average number of oil palms was 623.26 trees. The amount of aggregated fertilizer was on average 2.08 t, including chemical fertilizer, organic fertilizer and dolomite. Additionally, 808.54 h were required for labour

Table 3: Maximum Likelihood Estimates (MLE) of frontier production

Variables	Parameters	LAPS member		Non-LAPS member	
		Coefficient	t-value	Coefficient	t-value
Production function					
Constant	0	2.32	16.81***	0.42	6.65***
In (Farm size) (rai)	1	0.26	2.38*	-0.13	-0.48
In (number of oil palm) (tree)	2	0.39	4.37**	0.44	2.45*
In(Fertilizer) (kg)	3	0.11	1.32	0.21	2.13*
In (Household labor) (h)	4	0.66	12.03***	0.39	3.72**
Variance parameters					
Sigma-squared	2	0.62	9.22***	0.89	2.79**
Gamma	γ	0.99	1741.00	0.99	13.79
Log-likelihood		-27.17	-42.95***		

Significant at ($p\leq 0.01$), **Significant at ($p\leq 0.05$), *Significant at ($p\leq 0.10$)

input (i.e., hired and household labourers) to operate oil palm farms. The total study day was accumulated from total activities, namely, fertilizing, weeding, trimming leaves, harvesting and transporting.

Regarding non-member farmers, the average yields were 19.49 t from January-June, 2017. The average farm size was 19.37 rai and the average number of oil palms was 470.44 trees. The amount of aggregated chemical fertilizer was 1.42 t. On average, 709.89 h were required for labour input (i.e., hired and household labourers) to operate oil palm farms. The total study day was accumulated from total activities, namely, fertilizing, weeding, trimming leaves, harvesting and transporting. Chandio *et al.*[33] indicated that the maximum likelihood estimation (MLE) indicated that credit, farm size, fertilizer and household labour significantly influenced rice productivity in Sindh, Pakistan. Good fertilization management was the key contributor to high productivity and efficiency in oil palm plantations[34,35].

Maximum-likelihood estimates of the Cobb-Douglas production function: Table 3 presents the MLEs of the Cobb-Douglas stochastic frontier production model. The result revealed that, for LAPS members, the coefficients of household labourers, the number of oil palm trees and farm size were at the 1, 5 and 10% levels of significance, with the values of 0.66, 0.39 and 0.26, respectively. These results indicated that the oil palm yields of LAPS members can be explained by 66% of household labourers, 39% of the number of oil palm trees and 26% of the farm size. Notably, the coefficient of fertilizer was not significant with the value of 0.11, indicating that oil palm yields can be explained by 11% fertilizer only.

Similarly, for non-LAPS members, the coefficients of the number of oil palm trees, household labourers and fertilizer were at the 5 and 10% levels of significance, with the values of 0.44, 0.39 and 0.21, respectively, which indicated that the oil

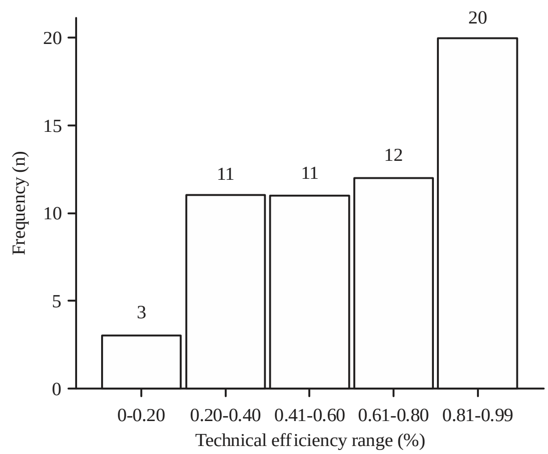

Fig. 1: Distribution of technical efficiency in oil palm farmers LAPS member

palm yields of non-LAPS members can be explained by 44% of the number of oil palm trees, 39% of household labourers and 21% of fertilizer. However, the coefficient of farm size was not significant with a value of -0.13, indicating that oil palm yields can be explained by -13% of farm size only. The estimated value of gamma (γ) was 0.99, which demonstrated that 99% of oil palm yields among farmers were due to the differences in TE. In addition, the estimate of σ was 0.62, which was significantly different from zero, indicating a good fit.

Technical efficiency: Figure 1 and 2 shows the distribution of the TE results from the oil palm LAPS and non-LAPS members, respectively. Estimates of TE among LAPS members varied between 12 and 99%. The average TE level was 63% with a standard deviation of 0.26. This mean index signified that oil palm farmers under the LAPS produced on average 63% of the outputs of best-practice farmers for the same levels of inputs used. Regarding non-LAPS member farmers, the estimate of TE varied between 14 and 99%. The average TE level was 52% with a standard deviation of 0.22. This mean

Table 4: Factors affecting the technical efficiency of oil palm farmers

	LAPS member			Non-LAPS member		
Variables	Coefficient	Standard-error	p-value	Coefficient	Standard-error	p-value
Constant	0.171	0.317	0.592	0.102	0.257	0.693
In gender	0.016	0.073	0.821	0.046	0.063	0.469
In age (years)	0.002	0.004	0.637	0.006	0.003	0.090*
In education of household head	0.036	0.022	0.108	0.042	0.029	0.154
In year of experience in oil palm plantation (years)	0.014	0.007	0.042**	-0.004	0.006	0.510
Pseudo R^2	0.5695		0.6325			
Log likelihood	-2.6269		-0.9997			

**Significant at ($p \leq 0.05$),*Significant at ($p \leq 0.1$)

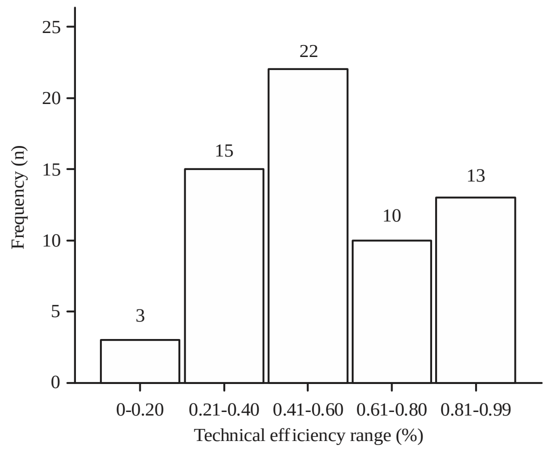

Fig. 2: Distribution of technical efficiency in oil palm non-LAPS member

index signified that non-LAPS oil palm farmers produced on average only 52% of the outputs of best-practice farmers for the same levels of inputs used. The result indicated that the majority of LAPS member farmers had greater TE at 0.8 (35.1%), whereas the majority of non-LAPS member farmers had a TE between 0.41-0.6 (34.9%). Also, the mean TE of LAPS member farmers (0.63) was higher than that of non-LAPS member farmers (0.52). This phenomenon was because oil palm LAPS member farmers applied chemical and organic fertilizer and dolomite for soil improvement, whereas non-LAPS members applied only chemical fertilizer in their oil palm production because soil is a fundamental resource for the growth of crops[2]. In addition, the utilization of organic wastes as bio fertilizer increased crop productivity[36].

Factors affecting technical efficiency: Table 4 displays the results of the Tobit regression function for the TE of oil palm member sunder the LAPS and non-member farmers in Bang Saphan Noi district, Prachuap Khiri Khan Province. The TE scores were regressed against gender, the age of farmers, the education of household heads and years of experience in oil palm plantations. The results of LAPS members showed that years of experience in oil palm plantations significantly related at the 5% level to the technical efficiency scores. By contrast, gender, the age of farmers and the education of household head were not significant. This finding went against the study of Alwarritzi *et al.*[17], which asserted that the education level of the farmers might improve oil palm productivity. However, the result revealed that years of experience on oil palm plantation affected TE. This phenomenon may be because farmers who participated in the LAPS gained experience from the training that enhanced their knowledge of oil palm plantations and they also had an opportunity to share their indigenous knowledge with government staff to discover the optimum level of productivity. The majority of LAPS members (78.9%) had 10-20 years of experience on oil palm plantations. This result confirmed the statement of Harvey *et al.*[37], that experience may lead farmers to adopt more sustainable practices and better management on their plantation.

The results of non-LAPS members, by contrast, demonstrated that the age of farmers significantly related at the 10% level to the TE scores. Additionally, gender, education of household heads and years of experience on oil palm plantations were not significant because non-LAPS farmers who were older were likely to be able to plant oil palm orchards more efficiently than those participating in the LAPS. The majority of non-LAPS member farmers were 60 years old and this had an impact on oil palm production efficiency. This finding correspond with the study of Alwarritzi *et al.*[17], who maintained that the age of farmers had a positive sign with inefficiency and was significant at 5%. In addition, younger farmers were observed to be more technically efficient than older ones because the character of younger farmers was to be more active in current agricultural activities and willing to improve their farming knowledge, which was in accordance with the finding of Coelli and Battese[32].

CONCLUSION

The LAPS for oil palm plantations in Thailand aimed to help small farmers reduce production costs, improve the quality of products and increase yields. This research attempted to compare the technical efficiency (TE) of oil palm production between farmers who were and were not under the LAPS in Bang Saphan Noi district, Prachuap Khiri Khan Province, Thailand, which covers 1.02% of the country. However, a very small proportion of farmers are participating in the LAPS.

The results demonstrated that the mean TE of LAPS member farmers (0.63) was higher than that of non-LAPS member farmers (0.52). LAPS members obtained technical assistance from formal institutions on farming practices from government staff who were managers of the LAPS and learnt how to improve the soil to increase their oil palm productivity, which indicated that member farmers had opportunities to obtain technical assistance for oil palm plantations to reduce production costs, increase productivity, and improve the quality of the product.

Regarding this study, the years of experience of LAPS member farmers in oil palms is an important factor that contributes to TE, whereas the age of farmers is an important factor for non-LAPS member farmers that contributes to TE. Consequently, policy makers should include knowledge and experience sharing between old and young generations who have interest in working in oil palm production. Furthermore, a new generation of oil plantation management should be encouraged.

SIGNIFICANCE STATEMENTS

This research investigated technical efficiency of oil palm production between member and non-member farmers of the Large Agricultural Plot Scheme (LAPS) policy in Thailand. The study indicated that the TE mean of LAPS member farmers (0.63) was higher than that of non-LAPS member farmers (0.52). Using the Tobit regression model, this study offered suggestions on how to improve technical efficiency for oil palm farmer. Consequently, relevant stakeholders and policy makers are able to plan interventions that will assist farmers as well as initial measures to enhance and elevate the effectiveness of extension programmes.

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