Performance of Oil Palm Hybrids in Early Mature Phase in Upper Southern Region of Thailand

Somkid Damnoi[1/] Surakitti Srikul[2/] Suteera Thawornrat[3/] Sirinapha Khongcharoen[4/] Patcharin Tanya[4/] Peerasak Srinives[5/] Anake Limsrivilai[6/] Weeraphan Sridokchan[4/*]

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ABSTRACT

Eight hybrids of commercial oil palm seedlings, 4 from Thai and 4 from oversea sources, were transplanted into the experimental field in Ao Luek district, Krabi province, Thailand in 2013. Randomized complete block design (RCBD) was applied with 3 replications. Sixteen palms per plot were random sampling for the agronomic traits data. Growth characteristics were collected every 6 months from 12 to 60 months after transplant (MAT) while the yield data were collected from 31 to 66 MAT, covering a span of 3 years for yield harvesting. The Thai hybrid oil palm tends to have higher production of fresh fruit bunch (FFB) compared to hybrid oil palm from other countries. Hybrids of Deli × Yangambi-T and Deli × Tanzania-T exhibited statistically significant higher vegetative traits such as petiole cross-section, rachis length, and leaflet length when compared to other varieties, The two hybrids also demonstrated significantly higher yields, with maximum FFB values of 194.9 and 192.9 kg/palm, respectively in the 3rd year of harvesting. The hybrid with the highest kernel content was Deli × Tanzania-T with kernel to fruit ratio (KTF) and kernel to bunch ratio (KTB) values of 11.94% and 9.40% respectively. On the other hand, Deli × Yangambi-T showed the highest significant oil yield of 8.78 tons/ha/year at the age of 5 years after transplanting. This experiment demonstrates that certain improved hybrid oil palm varieties in Thailand have the potential for better growth, productivity, and superior components compared to imported hybrid varieties from oversea countries.

Keywords: adaptation, *Elaeis guineensis*, field trial, yield components

[1/] Field of Agricultural Research and Development, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand

[2/] Office of Senior Expert, Department of Agriculture, 50 Phahonyothin Road, Lat Yao, Chatuchak, Bangkok 10900, Thailand

[3/] Office of agriculture research and development region 7, Suratthani province. Tambon Tha Utae, Amphoe Kanchanadit, Suratthani province 84340, Thailand

[4/] Department of Agronomy, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand

[5/] Fellow, Academy of Science, The Royal Society of Thailand, Dusit, Bangkok 10300, Thailand

[6/] Goldentenera company limited 12/9 naplubpla Rd. tambol. Krabiyai Ampur. Muang Krabi province 81000, Thailand

*** Corresponding author: agrwps@ku.ac.th**

INTRODUCTION

Oil palm is the most efficient oil crop, with the highest oil yield per hectare, and long economic lifespan, having a life cycle over 25 years (Corley and Tinker, 2016). The advantages of it are edible crops (palm oil), oleo chemicals (consumption), and energy crops (biodiesel), which have various industrial markets to supporting. Therefore, Global oil palm harvesting areas has been increased from 3.6 million ha in 1961 to over 29 million ha in 2021, distributed across 43 countries (FAO, 2023). The palm oil industry in Thailand is rapidly growing, with a planted area expanding from 110,000 ha in 1988 to 965,398 ha in 2021, producing 3.4 million tons of palm oil (OAE, 2023 and USDA, 2023). Oil palm cultivation continues to expand in the southern of Thailand due to the appropriate climatic region. Research and development in oil palm breeding realized to improve oil palm variety that yield high and are adaptable to the Thailand environment. Utilizing oil palm breeding within the country offers benefits to farmers, such as reducing imports and lowering costs. Commercial seed production is based on D × P crosses, which produces the desired thin-shelled Tenera fruit. In Thailand, commercial oil palm planting material sold in the area can be classified into two groups based on the producers; 1) The commercial oil palm planting material that produced in Thailand, such as the Department of Agriculture (DOA), Univanich, Siam Elite, Golden Tenera, CPI Agro-Tech and PAO-RONG Company and 2) The imported commercial oil palm planting material from foreign countries such as ASD from Costa Rica, CIRAD from Benin, DAMI from Papua New Guinea, FELDA and Sime Darby from Malaysia. Currently, there is a lack of research comparing the growth and yield of commercial oil palm planting materials in these two groups in large field plots.

The evaluation of oil palm planting materials can help identifying the compatibility between varieties and environmental factors (Jing *et al*., 2015). The varieties with high bunch weight and oil content should be promoted to increase the palm oil productivity in Thailand. The objective of this study was to determine the high performance of oil palm planting materials in the early mature phase, focusing on growth and yield characteristics in the upper southern region of Thailand. Through cultivars testing, we can determine the compatibility between different cultivars and environmental factors. By promoting cultivars with high bunch weight and oil content, we can effectively increase palm oil productivity in Thailand.

MATERIALS AND METHODS

Oil palm planting materials

A total of 8 selected DxP Tenera derived from 8 different sources, including Deli dura and pisifera different sources, were evaluated in this study. The specific sources or producers are not disclosed due to economic reasons, and instead, the hybrids identified using codes. The selected DxP progenies were named as follows; Compact × Ghana-F, Deli × Compact-F, Deli × AV-

ROS-F, Deli × AVROS-T, Deli × Yangambi-T, Deli × La Me'-F, Deli × La Me'-T and Deli × Tanzania-T.

Vegetative traits

The trial was planted in June 2013 in Von Bundit Company Limited, AoLuk district, Krabi province. The Experimental design used was a randomized complete block design (RCBD) with 3 replications. Sixteen palms out of 80 per plot were randomly selected for data collection, in 9.0 × 9.0 × 9.0 m equilateral triangular patterns. Vegetative measurements were taken using non-destructive method twice a year from 12 to 60 months after transplanting (MAT). The first measurement was conducted in July 2014. The measurements and calculation of vegetative traits including frond production (FP, fronds), rachis length (RL, cm), petiole cross section (PCS, cm^2), Leaf area (LA, cm^2), Leaf area index (LAI), height (HT, m) and trunk diameter (DIA, m) were made according to the non-destructive methods suggested by Corley and Breure (1988).

Yield Production

Yield recordings on individual palm basis were taken for 12 month period, between January and December each year. The yield data were collected since 31 to 66 MAT, 3 years for yield harvesting in January 2016 to December 2018. Bunch analysis was determined using the 'bunch analysis' technique developed at Nigerian Institute for Oil Palm Research (NIFOR) (Blaak *et al*., 1963; Rao *et al*., 1983; Rao and Chang 2018). In this study bunch analysis was done at 5 years after transplanting. The oil yield (OY) is the result of calculating the bunch analysis (OTB) and fresh fruit bunch (FFB) of each oil palm variety. Analysis was made on individual data as well as data categorized based on the progenies and Pisifera groups of the planting materials. The analysis of variance (ANOVA), Duncan's Multiple Range Test (DMRT), and Least Significant Difference (LSD) were computed using the R statistical program version 4.1.2 (R Core Team, 2021).

RESULTS AND DISCUSSION

Vegetative traits

At 60 months after transplant (MAT), some vegetative growth traits such as total frond production (TF) ranged from 61.33 to 69.44 frond/palm, frond production (FP) ranged from 26.24 to 30.11 frond/palm/yr, leaflet width (LW) ranged from 4.07 to 4.41 cm, leaflet number (LN) ranged from 134.7 to 144.3 leaflets, leaf area (LA) ranged from 4.25 to 5.73 cm^2 and leaf area index (LAI) ranged from 4.05 to 5.67 (Table 1), these traits values showed no significant different in among of experimental oil palm hybrids. Additionally, it was observed that the LAI value among the 8 oil palm hybrids started to have narrower ranges as the palm fronds close to overlap. Arolu *et al*. (2017) suggestions LAI is the leaf area per unit ground surface area. In oil palm plantation, LAI is the product of number of palms/ha, the number of fronds/palm and their mean leaf area. Optimum LAI is obtained when the FFB yield/ha is highest and this varies from one location to another but in South-East Asia, it is taken to be from 5.5 to 6.0 in the mature phase of oil palm (Breure, 2010).

Deli × Tanzania-T has the significant highest petiole cross section (PCS) with measuring 23.86 cm^2. On the other hand, Compact × Ghana-F has the significant lowest PCS with 18.47 cm^2 Compact × Ghana-F and Deli × Compact-F have the significant lowest rachis length (RL) with 3.96 and 3.93 m respectively (Table 1). Deli Compact variety is breed by ASD company in Costa Rica and has the distinct characteristics of having short fronds and small canopy size, which emphasize increasing the number of oil palm trees per planting area. During the breeding process, the company used genetic material from the American oil palm species (scientific name: *Elaesis oleifera*), which has smaller size compared to *E. guineensis*, the common oil palm species (Barcelos *et. al*., 2015). Oil palm grower were advised to use a narrower planting distance of 8.0 × 8.0 × 8.0 m to increase the number of palms per hectare (170-180 palms/ha). (Alvarado and Escobar, 2017)

After 60 MAT, Deli × Yangambi-T showed trunk height (HT) at 0.92 m and Deli × Compact-F showed at 0.67 m there were no statistically significant differences from among of experimental oil palm variety (Table 1). The plant height characteristic of oil palm truck is undesirable for breeders because tall palms make it difficult to harvest the palm bunches. Additionally, there is a tendency for faster replanting due to the challenges of harvesting the palm fruit bunches in tall palms. Deli × LaMe'-F has the significant highest value of the diameter of palm trunk (DIAM), which is 0.82 m In contrast, other varieties have DIAM values ranging from approximately 0.71 to 0.77 m (Table 1).

Yield production

The yield of the 8 oil palm varieties was collected continuously for a period of 3 years of production. During the first year of harvesting, 31-42 MAT, the fresh fruit bunch (FFB) production had very low values ranging from 16 to 34 kg/palm. Deli × AVROS-T and Deli × Tanzania-T showed the significant highest of FFB at 34.93 and 34.79 kg/palm, respectively (Table 2). In the 2^{nd} year of harvesting, 43-54 MAT, Deli × Tanzania-T had the significant highest FFB of 134.9 kg/palm, meanwhile Deli × LaMe'-F had the lowest FFB of 79.87 kg/palm. In among experimental oil palm varieties did not show significant differences in FFB production in the 3^{rd} year of harvesting (55-66 MAT). However, there are three varieties that exhibit a higher trend in FFB yield compared to the others. These varieties are Deli × AVROS-F (168.1 kg/palm), Deli × Yangambi-T (194.9 kg/palm), and Deli × Tanzania-T (192.9 kg/palm) (Table 2). These values are higher than the SIRIM standard yield of 160 kg/palm/yr or 22.9 tons/ha. (Rao and Chang, 2018) Oil palm trees typically reach full FFB production capacity when they are growing longer than 7 years old (Corley and Tinker, 2016).

Table 1 Mean oil palm planting materials performance of vegetative traits in young mature phase (60 MAT)

Hybrids	TP (frond/ palm)	FP (frond/ palm/yr)	PCS (cm^2)	RL (m)	LL (cm)	LW (cm)	LN (leaflet)	HT (m)	LA (cm^2)	LAI	DIAM (m)
Compact × Ghana-F	66.52	27.82	18.47 b	3.96 b	78.76 c	4.21	134.7	0.72	4.25	4.05	0.71 c
Deli × Compact-F	65.92	28.76	20.51 ab	3.93 b	85.81 abc	4.41	134.9	0.67	4.72	4.46	0.77 b
Deli × AVROS-F	68.90	29.03	20.41 ab	4.42 a	92.14 ab	4.20	142.9	0.87	5.47	5.39	0.74 bc
Deli × AVROS-T	66.44	27.33	21.30 ab	4.42 a	84.41 bc	4.18	143.4	0.85	5.06	4.83	0.75 bc
Deli × Yangambi-T	69.44	30.11	22.81 a	4.54 a	94.08 a	4.30	144.3	0.92	5.73	5.67	0.76 b
Deli × LaMe-F	68.38	26.24	18.95 b	4.39 a	81.78 c	4.47	139.3	0.70	5.01	4.93	0.82 a
Deli × LaMe-T	61.33	26.77	20.51 ab	4.51 a	87.54 abc	4.07	142.9	0.72	5.07	4.45	0.75 bc
Deli × Tanzania-T	67.08	29.02	23.86 a	4.49 a	86.19 abc	4.30	137.4	0.74	4.96	4.76	0.75 bc
CV (%)	4.98	5.71	6.46	5.23	3.84	4.50	4.59	15.8	10.3	11.9	2.40

TP: total frond production, FP: frond production, PCS: petiole cross section, RL: rachis length, LL: leaflet length, LW: leaflet width, LN: leaflet number, HT: palm height, LA: leaf area, LAI: leaf area index, DIAM: diameter of palm trunk

Means in the same column followed by a common letter are not significantly different at the 5% level by DMRT

Table 2 Fresh fruit bunch (FFB, kg/palm) weight of the experimental oil palm varieties

Hybrids	FFB (year of production)			Average
	1st	2nd	3rd	3 years
Compact × Ghana-F	18.34 b	86.44 cd	150.5	85.10 bc
Deli × Compact-F	16.27 b	87.66 cd	150.8	84.91 bc
Deli × AVROS-F	26.63 ab	89.91 bcd	168.1	94.86 abc
Deli × LaMe'-F	21.61 ab	79.87 d	135.1	78.85 c
Deli × AVROS-T	34.93 a	107.5 a-d	151.4	97.93 abc
Deli × Yangambi-T	26.32 ab	120.2 ab	194.9	113.8 ab
Deli × LaMe'-T	29.09 ab	113.3 abc	153.4	98.60 abc
Deli × Tanzania-T	34.79 a	134.9 a	192.9	120.9 a
CV (%)	27.92	16.39	15.54	12.46

Means in the same column followed by a common letter are not significantly different at the 5 % level by DMRT

However, in this experiment, the oil palm trees were only 5 years old after transplant. This indicates that the all of oil palm varieties tested in this study are hybrid combinations with high potential for yielding significant FFB production in the southern region of Thailand. In term of the average FFB production (from 31-66 MAT), Deli × Tanzania-T showed the significant highest FFB of 120.9 kg/palm, meanwhile Deli × LaMe'-F had the lowest FFB of 78.85 kg/palm.

Deli × Tanzania-T hybrid had the highest values for accumulated FFB and average FFB. The Deli × Tanzania-T hybrid is a variety that has been improved and developed by a Thai government agency responsible for supporting oil palm farmers in Thailand. From the results of this experiment, it is evident that locally produced oil palm hybrids in Thailand have the potential to yield better results than imported hybrids from other countries. However, Deli × Tanzania-T and Deli × Yangambi-T shown the average FFB in the 3rd year harvesting (in early mature phase) higher the DOA (Thailand) and SIRIM standard of FFB in marginal area is >110 kg/palm. (Wongsri *et al*., 2019).

Bunch number (BNO) were no significant difference in among the experimental oil palm hybrids throughout this experiment except in the 2nd year of harvesting. Deli × LaMe'-T and Deli × Tanzania-T showed the significant highest of BNO in the 2nd year of harvesting of 21.98 and 21.71 bunches/palm, respectively (Table 3). The BNO in the 2nd and 3rd years of harvesting was around 15.97 – 21.98 bunches /palm/yr. Bunch number of oil palm is strong correlate to the number of the fronds. Oil palm typically produces only one inflorescence per frond. During the third-year harvest in this experiment, which corresponds to a 5-year-old oil palm, the average frond productivity (FP) ranges from approximately 26 to 30 frond/yr (Table 1).

Table 3 Bunch number (BN: bunches/palm/yr) of the experimental oil palm varieties

Hybrids	BN (year of production)			Average 3 years
	1st	2nd	3rd	
Compact × Ghana-F	11.43	19.82 ab	18.03	16.43
Deli × Compact-F	7.96	19.05 abc	16.04	14.35
Deli × AVROS-F	10.81	15.97 c	17.7	14.83
Deli × LaMe'-F	13.63	20.56 ab	17.67	17.29
Deli × AVROS-T	12.92	17.63 bc	16.94	15.83
Deli × Yangambi-T	10.88	19.52 abc	18.97	16.45
Deli × LaMe'-T	13.42	21.98 a	18.12	17.84
Deli × Tanzania-T	12.44	21.71 a	18.96	17.7
CV (%)	24.33	9.85	14.69	9.90

Means in the same column followed by a common letter are not significantly different at the 5 % level by DMRT

The average bunch weight (ABW) weight in the first three years showed an increase of 2.22, 5.31, and 9.10 kg/bunch in the 1st year, 2nd year, and 3rd year, respectively (Table 4). This increase in weight is expected as the oil palm trees in this experiment were still in the young mature stage, and the size and weight of the FFB continue to increase until reaching maturity at around 7 years after transplanting. The hybrid oil palm, Deli × Yangambi-T and Deli × Tanzania-T, exhibited the highest significant bunch weight, measuring 10.32 and 10.18 kg/bunch respectively, in the 3rd year of yield harvesting. This corresponds to the growth performance observed in leaf characteristics, where both hybrids displayed the longest rachis length, largest petiole cross section, and longest leaflet length. In addition, Popet *et al*., (2022) studied correlation and path analysis in commercial Tenera oil palms collected from southern Thailand and found that average bunch weight was positively and significantly correlated with leaf area (LA) and rachis length (RL) (r^2=0.63** and 0.56*, respectively).

Yield components and bunch analysis

Bunch analysis of 8 commercial oil palm varieties to determine the oil-to-bunch (OTB) percentage for calculating the oil yield (OY) of each hybrid revealed the following findings. The fruit-to-bunch ratio (FTB) showed statistically significant differences. Deli × Yangambi-T had the highest average FTB percentage, 78.62%. On the other hand, Deli × LaMe'-F, Deli× LaMe'-T, and Deli × AVROS-T had the lowest average FTB percentages, 72.16%, 71.28%, and 70.38% respectively (Table 5). The mean fruit weight (MFW) showed significant differences on among the experimental oil palm hybrids. The hybrids, Deli × Yangambi-T and Deli ×

Table 4 Average bunch weight (ABW, kg) of the experimental oil palm varieties

Hybrids	ABW (year of production)		
	1st	2nd	3rd
Compact × Ghana-F	1.60 b	4.35 ab	8.32 bc
Deli × Compact-F	2.11 ab	4.65 ab	9.40 ab
Deli × AVROS-F	2.47 ab	5.82 ab	9.53 ab
Deli × LaMe'-F	1.54 b	3.89 b	7.56 c
Deli × AVROS-T	2.70 a	6.24 a	9.09 abc
Deli × Yangambi-T	2.42 ab	6.22 a	10.32 a
Deli × LaMe'-T	2.10 ab	5.12 ab	8.43 bc
Deli × Tanzania-T	2.82 a	6.22 a	10.18 a
mean	2.22	5.31	9.10
CV (%)	13.36	13.96	9.09

Means in the same column followed by a common letter are not significantly different at the 5 % level by DMRT

AVROS-F had the highest mean fruit weight (MFW) of 17.70 and 17.36 g/fruit, respectively. On the other hand, Deli × Tanzania-T and Deli × LaMe'-F had MFW of 10.26 and 8.52 g/fruit, respectively (Table 5).

The fresh mesocarp to fruit ratio (MTF) showed significant differences on among the experimental oil palm crosses. Deli × AVROS-T, Deli × Yangambi-T, and Deli × AVROS-F had the highest average MTF percentages, 88.40%, 87.74%, and 87.33%, respectively. On the other hand, Deli × Tanzania-T and Deli × LaMe'-T had the lowest average MTF percentages, 77.31% and 75.82%, respectively. The kernel-to-fruit ratio (KTF) showed significant differences on among the experimental oil palm crosses. Deli × Tanzania-T had the highest average KTF percentage, 11.94%. On the other hand, Deli × AVROS-F, Deli × Yangambi-T, Deli × LaMe'-F, and Deli × AVROS-T had the lowest average KTF percentages, 6.24%, 6.07%, 5.94%, and 5.26%, respectively (Table 5).

The shell-to-fruit ratio (STF) showed statistically significant differences. Compact × Ghana-F had the highest average STF percentage, 8.70%. Following that, Deli × Tanzania-T, Deli × LaMe'-T, Deli × Compact-F, Deli × AVROS-T, and Deli × AVROS-F had average STF percentages of 8.31%, 8.11%, 7.98%, 4.80%, and 4.51%, respectively. On the other hand, Deli × Yangambi-T had the lowest average STF percentage of 4.31%. There were no statistically significant differences in the oil-to-dry mesocarp (OTDM), oil-to-wet mesocarp (OWM), and oil-to-bunch (OTB) percentages among the 8 oil palm varieties. The average values ranged

Table 5 Yield components and bunch analysis of oil palm hybrids in the third-year of harvesting (54-66 MAT)

Crosses	FTB (%)	MFW (g)	MTF (%)	KTF (%)	STF (%)	OTDM (%)	OTWM (%)	OTB (%)	KTB (%)	OY (t/ha/yr)
Compact × Ghana-F	74.96 ab	12.80 ab	80.82 ab	8.15 ab	8.70 a	72.08	44.26	28.72	5.72 bc	6.18 b
Deli × Compact-F	74.23 ab	12.94 ab	81.23 ab	8.42 ab	7.98 abc	75.13	48.77	26.91	5.56 bc	5.80 b
Deli × AVROS-F	74.92 ab	17.36 a	87.33 a	6.24 b	4.51 cd	73.39	52.71	31.38	4.08 cd	7.54 ab
Deli × AVROS-T	70.38 b	14.21 ab	88.40 a	5.26 b	4.80 bcd	74.43	48.95	28.63	3.43 d	6.20 b
Deli × Yangambi-T	78.62 a	17.70 a	87.74 a	6.07 b	4.31 d	74.69	47.65	31.50	4.71 cd	8.78 a
Deli × LaMe'-F	72.16 b	8.52 b	85.37 ab	5.94 b	7.12 a-d	74.26	44.89	31.82	3.36 d	6.15 b
Deli × LaMe'-T	71.28 b	11.18 ab	75.82 b	8.95 ab	8.11 ab	74.09	49.68	25.22	6.62 b	5.53 b
Deli × Tanzania-T	74.57 ab	10.26 b	77.31 b	11.94 a	8.31 ab	76.40	44.46	27.08	9.40 a	7.47 ab
CV (%)	4.63	19.42	6.13	23.93	27.04	3.04	11.89	13.79	18.40	16.10

FTB: fruit to bunch ratio, MFW: mean fruit weight, MTF: mesocarp to fruit ratio, KTF: kernel to fruit ratio, STF: shell to fruit ratio, OTDM: oil to dry mesocarp, OTWM: oil to wet mesocarp, OTB: oil to bunch ratio, KTB: kernel to bunch ratio, OY: oil yield

Means in the same column followed by a common letter are not significantly different at 5% level by DMRT from 72.08% to 76.40% for OTDM, 44.26% to 52.71% for OTWM, and 25.22% to 31.82% for OTB, respectively (Table 5).

The oil yield (OY) showed statistically significant differences. Deli × Yangambi-T had the highest average OY, at 8.78 ton/ha/yr. On the other hand, Deli × LaMe'-T, Deli × Compact-F, Deli × LaMe'-F, Compact × Ghana-F and Deli × AVROS-T had the lowest average OY values of 5.53, 5.80, 6.15, 6.18 and 6.20 ton/ha/yr, respectively (Table 5). The oil yield (OY) is the result of calculating the bunch analysis and fresh fruit bunch (FFB) of each oil palm genotype to select high-quality oil palm varieties. Junaidah *et al.* (2011) reported that the highest FFB yield, coupled with the highest oil-to-bunch ratio (% OTB), resulted in the highest oil yield. This is consistent with the findings that the commercial oil palm varieties Deli × Yangambi-T has the highest oil yield (OY) values of 8.78 ton/ha/yr (Table 5). It has the highest fresh fruit bunch (FFB) yield and average bunch weight (ABW) as 10.32 kg/bunch (Table 4). Although there were no statistically significant differences among the genotypes in terms of % OTB (27.08 - 31.50%), it was found that the Deli × Yangambi-T genotype exhibited distinct characteristics related to yield components such as MFW, FTB, and MTF, similar to the Deli × Tanzania-T genotype, which had the highest proportion of MTF (Table 5). The yield components of oil palm bunches in each variety analyzed in this study are significant and highly beneficial for selecting future oil palm breeding pairs. These data provide valuable insights and can be used to breed offspring with desired traits.

From the results of this experiment, it is evident that oil palm variety improved in Thailand and those with parental palm trees in Thailand (Surat Thani and Krabi provinces) have undergone adaptation to the local environment and have the potential to yield higher average bunch weight compared to imported oil palm varieties. This is observed even when considering hybrids with the same parental varieties, such as the Deli × LaMe'-F cross. The reason behind this could be attributed to the fact that the parental oil palm trees are grown in the upper southern region, adapting to the country's geography and climate, and passing on their genetic traits to the offspring. As a result, oil palm seedlings derived from parental varieties grown in the local region exhibit better growth and have the potential for higher yields compared to imported oil palm seedlings. This aligns with findings reported in other plant species (Beaton *et al.,* 1990; Tabatabaei *et al.,* 2012).

CONCLUSIONS

Among the total of 8 oil palm varieties, Deli × Yangambi-T and Deli × Tanzania-T exhibited vegetative characteristics such as petiole cross-section and leaflet length that were significantly higher than those of imported oil palm varieties. In terms of yield production, they also align with the growth characteristics mentioned earlier. Both Deli × Yangambi-T and Deli × Tanzania-T had trend higher fresh fruit bunch (FFB) values and average bunch weights (ABW) compared to foreign varieties. Although this experimental oil palm lives in early mature phase, it still produces a higher yield of FFB compared to the SIRIM standard at 160 kg/palm/yr.

In terms of yield components, it was found that the fruit to bunch ratio (FTB) and oil to bunch ratio (OTB) did not differ significantly among the oil palm varieties used in the experiment. However, the variety with the highest kernel content, which is a significant finding, is Deli × Tanzania-T, with kernel to fruit ratio (KTF) and kernel to bunch ratio (KTB). The oil derived from the kernel is considered to be of high quality and suitable for various industries, especially in the fields of medicine and cosmetics. On the other hand, Deli × Yangambi-T exhibits the highest significant oil yield (OY) of 8.78 tons/ha/yr at the age of 5 years after replanting. Improved genetically modified oil palm varieties developed in Thailand have shown better potential in leaf growth, yield production, and yield components compared to imported oil palm varieties. This could be attributed to the fact that the hybrid offspring of oil palm produced in Thailand have parent palm that are well-adapted and grown within the country, allowing them to better acclimate to the local environment. Furthermore, these improved genetic traits are passed on to future generations through breeding programs.

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