Comparison of Yield Components between Young Mature and Mature Phases of Five Tenera Oil Palm Varieties

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ABSTRACT

This study aimed to evaluate the yield performance of five Tenera varieties during the young mature and mature phases with the objective of identifying high-yield planting materials. The assessment was conducted at Golden Tenera Limited in Krabi, Thailand, using a randomized complete block design with three replicates. The oil palm trees were spaced 9.0 meters in a triangular pattern. This study spanned from 2009 to 2023, allowing for a comprehensive analysis of yield performance over a significant time period. The findings revealed that the mature phase, spanning from 6 to 11 years after planting, exhibited higher values for fresh fruit bunch (FFB) at 260.18 kg/palm/year and average bunch weight (ABW) at 16.62 kg/bunch/year. Conversely, the young mature phase, ranging from three to five years after planting, displayed a higher bunch number (BNO) of 25.20 bunches/palm/year. Among the 5 evaluated Tenera varieties, V4 demonstrated the highest values for FFB at 244.12 kg/palm/year and BNO at 22.90 bunches/palm/year. Furthermore, V4 consistently exhibited the highest FFB and BNO values in both young mature and mature phases. The findings of this study will improve the selection and cultivation of productive Tenera varieties, boosting their efficiency and productivity in palm oil plantations.

Keywords: fresh fruit bunch, bunch number, average bunch weight, production phase

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INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is the highest-yield and most profitable oil plant in the world. Palm and kernel oils dominate the international edible oil trade, with a production of approximately 88.60 million tonnes by 2023 (USDA, 2023). It is produced on approximately 28.91 million ha of plantations in 2021 (FAOSTAT, 2023). Originating in Africa, it has emerged as a pivotal cash crop in Southeast Asia (Corley and Tinker, 2016). Indonesia accounts for 59.12% of the production, followed by Malaysia (24.28%), Thailand (4.28%), and other countries (Colombia, Nigeria, and Papua New Guinea) making up the rest. The main markets are India, China, the European Union, and Pakistan, with other developing countries showing increasing interest (USDA, 2023). Thai oil palm production has expanded rapidly, the harvested area increased from 0.60 million ha in 2011 to 0.97 million ha in 2021, as demand for food and biodiesel is exploited (OAE, 2023). Regrettably, this expansion has resulted in deforestation, leading to adverse consequences such as air pollution caused by forest fires (Gingold *et al.*, 2012). To mitigate these environmental concerns, the use of high-yielding palm oil planting materials has emerged as an effective and sustainable approach, enabling the support of new land without resorting to deforestation (Rajanaidu *et al*., 2000; Arolu *et al.*, 2016). Therefore, breeding improved oil palm planting materials is crucial for increasing the oil yield and productivity of oil palms in Thailand.

The oil palm, with an average lifespan of twenty-five years, exhibits a productive phase lasting 21-23 years. This productive phase can be categorized into four distinct stages: 1) the immature phase, which spans up to 2-3 years after planting (YAP); 2) the young mature phase, occurring between 4-7 YAP; 3) the mature phase, observed from to 8-14 YAP; and 4) a phase of declining yields from 15-25 to YAP (Woittiez *et al.*, 2017). Fairhurst and Härdter (2003) demonstrated that young palms with 2-3 YAP had approximately 40 fronds, and the frond number decreases by 18-24 fronds in palms aged 4-6 YAP in mature palms. Corley and Gray (1976.) mentioned that frond production increased by 30-40 fronds at 2-4 YAP and 20-25 fronds per year were produced over 8 years. Hartley (1988) reported up to 35 fronds production at the oil palm age 3-4 YAP, then fronds produced decreased to 28 fronds at 6 YAP and 26 fronds at 20 YAP. He also said that the annual frond production in West Africa, Cameroun, Congo, and Sumatra were 18-27, 16-20, 18-26, and 20-24 fronds, respectively. In breeding programs, one of the key selection criteria for progeny is the attainment of high early fresh fruit bunch (FFB) yields during the young maturation period (Junaidah *et al*., 2011). Additionally, it is desirable for FFB yields to remain high during the maturation phase. This study aimed to assess the performance of five Tenera progenies obtained through crosses between Dura and Pisifera from various sources. The evaluation primarily focused on the young mature and mature phases with the objective of identifying high-yield planting materials.

MATERIALS AND METHOD

Oil palm varieties

Five Dura × Pisifera progenies derived from crosses between one Dura (D) selected from Deli Dura and Pisifera A with five Pisifera (P1-P5) chose from Deli Dura × Pisifera A for P1 and P2, Deli Dura × Pisifera B for P3 and P4, and Deli Dura × Pisifera C for P5, respectively. The traits evaluated for oil palm yield included fresh fruit bunch (FFB; kg/palm/year), bunch number (BNO; bunches/palm/year), and average bunch weight (ABW; kg/bunch/year).

Comparison of yield components between young mature and mature phases

Five crosses were planted in May 2009 at Golden Tenera Limited, Krabi, Thailand, in a randomized complete block design with three replications at 9.0 m triangular spacing, six palms per cross per replication, and 90 palms were individually studied. This experiment was conducted in the southern region of Thailand, specifically in Krabi province. Krabi province was selected due to its significant importance as the primary oil palm cultivation region in the country. Data collection for oil palm fruit bunches commenced 28 months after field planting, with subsequent operations conducted at regular intervals of 14 days, corresponding to two rounds per month. Harvesting activities and recording of FFB yields commenced in January 2012. Throughout the harvesting rounds, individual palms were assessed for bunch weight and number. Yield recordings were conducted over a 12 month period, spanning from January to December each year until December 2022. FFB represents the cumulative weight of the bunches and BNO refers to the total count of all bunches. Average bunch weight (ABW) was calculated as the ratio of FFB to BNO. The data on FFB, BNO, and ABW were employed to compare two periods: the young maturation period (3-5 years after planting; YAP) and the maturation period (6-11 YAP) for estimating the potential Tenera oil palm on yield traits following the tenera criteria of the Department of Agriculture (DOA) from Thailand (Wongsri *et al*., 2019), and the Standards and Industrial Research Institute of Malaysia (SIRIM), (Kushairi *et al.,* 2011) (Table1).

Table 1 The SIRIM and DOA standards for Tenera selection

Source	Tenera	Minimum standard
SIRIM	Fresh fruit bunch (FFB)	
	- Good yielding area	170 kg/palm/year
	- Marginal area	130 kg/palm/year
DOA	Fresh fruit bunch (FFB)	
	- highly suitable area	≥ 150 kg/palm/year
	- moderate suitable area	≥ 110 kg/palm/year

Source: Kushairi *et al*. (2011) and Wongsri *et al.* (2019)

Data Analysis

Each trait was analyzed using analysis of variance (ANOVA), and the mean values were compared using Duncan's new multiple range Test (DMRT) and the Least significant difference (LSD) using the R-stat program (R Core Team, 2022).

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) for fresh fruit bunch (FFB), bunch number (BNO), and average bunch weight (ABW) are presented in Table 2. The replication displayed non-significant differences in FFB, BNO, and ABW. Among the production phases, there were significant differences in FFB, BNO, and ABW. Among the varieties, FFB was significantly different, whereas BNO and ABW showed highly significant differences. The interaction between the production phases and varieties was highly significant for ABW but not for FFB and BNO. The coefficient of variation percentage is the percentage of the ratio of the standard deviation to the mean when the value is high, indicating that the estimate is less precise. Our experiment found that the CV percentage was low for FFB, BNO, and ABW, indicating a more precise estimation.

Table 2 Mean squares of yield components in Tenera oil palm

SOV	df	Fresh fruit bunch (FFB)	Bunch number (BNO)	Average bunch weight (ABW)
Replication	2	418	0.7	0.3
Productive phase	1	57,454**	607.6**	689.9**
Variety	4	1,720*	31.7**	6.4**
Productive phase: Variety	4	1,098	5.9	3.7**
Residuals	18	415	3.3	0.3
CV (%)		9.41	8.78	0.25

* significant difference at $p \leq 0.05$ and ** highly significant difference at $p \leq 0.01$

Table 3 presents the mean differences in fresh fruit bunch (FFB), bunch number (BNO), and average bunch weight (ABW). The grand means of FFB, BNO, and ABW based on production phases were 216.41 kg/palm/year, 20.70 bunches, and 11.83 kg, respectively (Table 4). The mature phase exhibited a higher mean for fresh fruit bunch (FFB) at 260.18 kg/palm/year and average bunch weight (ABW) at 16.62 kg/bunch/year. Conversely, the young mature phase displayed a higher bunch number (BNO) of 25.20 bunches/palm/year. These findings indicate that BNO surpasses that of the mature period during the young mature period, whereas FFB and ABW are higher during the mature phase. This observation was consistent with the results reported by Junaidah *et al.* (2011) and Rafii *et al.* 2013). The young mature phase had a higher BNO than the mature phase, whereas the FFB and ABW were low. As the young mature phase had more palm leaves produced annually than the mature phase, approximately 30-40 palm leaves affected the number of bunches, but the average bunch weight was low (Corley and Tinker, 2016).

Considering the DOA and SIRIM standards for improved Tenera oil palms found that V1-V5 were qualified on FFB, where the FFB was over 150 and 170 kg/palm/year, respectively (Table 1). The best Tenera on FFB and BNO was V4, followed by V3, V1, V2, and V5, whereas V5 was the largest bunch (Table 4). The Tenera oil palm V4 demonstrated the highest values for fresh fruit bunch (FFB) at 244.12 kg/palm/year and bunch number (BNO) at 22.90 bunches/palm/year. Based on these results, it can be inferred that the V4 variety was the most favorable and superior variety in this study (Table 4). The high FFB was attributed to high BNO and ABW; V4 had the highest FFB and BNO and failed to be the highest for ABW. This result indicates that the selection criteria were high FFB owing to high BNO and moderate ABW.

Table 3 Means of fresh fruit bunch (FFB), bunch number (BNO) and average bunch weight (ABW) with different productive phases

Productive phase	**FFB (kg/palm/yr)**	**BNO (bunches/palm/yr)**	**ABW (kg/bunch/yr)**
Young mature	172.65	25.20	7.03
Mature	260.18	16.20	16.62
F-test	**	**	**
mean	216.41	20.70	11.83

** highly significant difference at $p \leq 0.01$

Table 4 Means of fresh fruit bunch (FFB), bunch number (BNO), and average bunch weight (ABW) of 5 Tenera oil palm

Variety	**FFB (kg/palm/yr)**	**BNO (bunches/palm/yr)**	**ABW (kg/bunch/yr)**
V1	213.58 b	22.14 ab	10.92 c
V2	210.87 b	20.36 b	11.80 b
V3	215.53 b	21.12 ab	11.11 bc
V4	244.12 a	22.90 a	11.78 b
V5	197.98 b	16.97 c	13.53 a
F-test	*	**	**
mean	216.41	20.70	11.83

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

When examining the interaction between the productive phase and varieties, we found that FFB and BNO were not significantly different from the *p*-values of these traits (0.0673 and 0.1748, respectively). It showed that the mean of FFB and BNO appeared different to participate in but did not differ in their mean. The recommendation of this experiment was to conclude the sum square error and sum square of the interaction between the productive phase and varieties as the sum square error. The results are shown to be highly significant in the productive phase and for various factors. The results in Table 5 were useful when considering the varieties that responded to the young mature and mature phases. In the young mature phase, V4 gave FFB 202.62 kg/palm/year and BNO 27.49 bunches more than others, while V1 showed the BNO 27.78 bunches did not difference to V4 but FFB 185.71 kg/palm/year difference. V2, V3, and V5 displayed FFB and BNO ranges of 150.31-166.71 kg/palm/year and 21.44-25.24 bunches. The average bunch weight during the young mature phase ranged from 6.38-7.54 kg the contrasting bunch number was high because in the young mature phase oil palm frond formation approximately 30-40 fronds at 2-4 YAP (Corley and Gray, 1976). On the other hand, fronds production in the mature phase was 18-24 fronds, and it was found that the bunch number was not over 24 bunches, and the range of BN was 12.50-21.44 bunches. The results confirmed that the bunch number increased depending on frond production in each year, with 24 fronds generally found annually to produce male or female inflorescences at the mature phase; the bunch number did not exceed 24 bunches (Corley and Tinker, 2016; Hartley, 1988).

In our experiment, a distinction was made between the young maturation period (3-5 years after planting; YAP) and the subsequent maturation period (6-11 YAP), deviating from the previous categorization that characterized the young mature phase as spanning from to 4-7 YAP, with the mature phase encompassing the interval of 8-14 YAP (Woittiez *et al.,* 2017). Furthermore, Junaidah *et al.* (2011) classified the stages of maturation as consisting of the young maturation period (3-5 YAP) and the subsequent maturation period (6-8 YAP). The 3-5 YAP will show the amount of FFB and BN clearly a trend in response to screening and selecting some Tenera than separating at young mature 2-3 YAP (Fairhurst and Härdter, 2003) or 2-4 YAP (Corley and Gray, 1976) or 3-4 YAP (Hartley, 1988).

CONCLUSION

The mature phase demonstrated superior performance in terms of fresh fruit bunch (FFB) yield, with an average of 260.18 kg/palm/year, and average bunch weight (ABW) at 16.62 kg/bunch/year. Conversely, the young mature phase exhibited a higher bunch number (BNO) of 25.20 bunches/palm/year. Among the evaluated varieties, V4 was the most favorable and superior in terms of overall yield performance. These findings provide valuable insights into the

Table 5 Means of two productive stages (young mature and mature phase) and five Tenera varieties for fresh fruit bunch (FFB), bunch number (BNO) and average bunch weight (ABW)

Productive phase	Variety	FFB (kg/palm/yr)	BNO (bunches/palm/yr)	ABW (kg/bunch/yr)
Young mature	V1	185.71	27.78	6.95 ef
Young mature	V2	166.71	25.24	6.77 ef
Young mature	V3	150.31	24.04	6.38 f
Young mature	V4	202.62	27.49	7.54 e
Young mature	V5	157.91	21.44	7.54 e
Mature	V1	241.44	16.49	14.89 d
Mature	V2	255.02	15.49	16.84 b
Mature	V3	280.75	18.19	15.84 c
Mature	V4	285.61	18.31	16.02 bc
Mature	V5	238.06	12.50	19.53 a
F-test		ns	ns	**
mean		216.41	20.70	11.83

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

selection of varieties that are responsive to both the young mature and mature phases, aiding the identification of high-yield planting materials.

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