The Planter, Kuala Lumpur, ***95*** *(1116): 157-168 (2019)*

Impact of Ceased Manuring on Oil Palm Yield

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Malaysian palm oil production contributes significantly to the local economy as well as providing many job opportunities. Yield records of crude palm oil (CPO) over the last 7 years (2012-2018) hovered at less than 20 million tonnes per year. The main reason resulting in such dismal performances was due to the inability of plantations to achieve their expected yields. This was mainly due to:(i) inadequacy of harvesters; (ii) climatic influence particularly during significantly lower rainfall periods i.e. El Nino in 2015/16 and; (iii) fertiliser input strategies during low CPO prices. Past experiments revealed that the cessation of fertilisers can result in yields dropping over 40 per cent which translates to about 14.5 tonnes per hectare per year. In another fertiliser experiment of 15 years, high yields of over 30 tonnes per hectare per year is not sustainable without proper fertiliser inputs. Therefore, impact of fertiliser cessation in relation to palm age and inherent soil fertility on oil palm yields will be discussed in this paper.

Keywords: *Cease manuring, yield, oil palm.*

Malaysia's crude palm oil (CPO) production increased significantly, almost 3.1 times, from over 6 million tonnes in 1990 to over 19.2 million tonnes in 2013. However, national yield has been stagnant in the subsequent years, hovering below 20 million tonnes (*Figure 1*). Oil yield per hectare dropped from 2013's level by almost 11 per cent (or 0.42 tonnes/ha/yr), from 3.85 tonnes per hectare per year to 3.42 tonnes per hectare per year in the year 2018 (*Table 1*) despite the introduction of newer planting materials with higher oil yield traits to the industry. The reported production performance of fresh fruit bunch (FFB) and CPO per hectare have been decreasing since 2013 and markedly in the last 5 years (MPOB, 2019).

Oil palm exhibits rapid vegetative growth before attaining peak canopy dry weight at around 10 to 12 years after planting (YAP). Likewise, FFB yield peaked between 8 and 10 YAP (*Figure 2*). FFB yields in commercial fields generally decline approximately 16 years after planting due to increasing difficulties in harvesting and maintaining optimal number of fronds for better harvesting efficiency (Goh *et al.*, 1994; Chew & Goh, 2003).

Various causes have been identified and deliberated at national level forums on achieving optimal yields. The commonly deliberated impactful factors causing yield stagnation are:

(i) inadequacy of harvesters in the plantation industry,
(ii) adverse climate during lower rainfall periods i.e. El Nino in 2015/16 (Amirul *et al.*, 2016), and
(iii) effects of reduced fertiliser inputs or total cessation of fertiliser applications during lower CPO prices.

Manuring cessation at 2 to 4 years before replanting is a common practice in the oil palm industry (Mohd Nazeeb *et al.*, 1993). However, fertiliser applications had also been reduced in most plantations due to recent low CPO prices, even for fields not dated for replanting.

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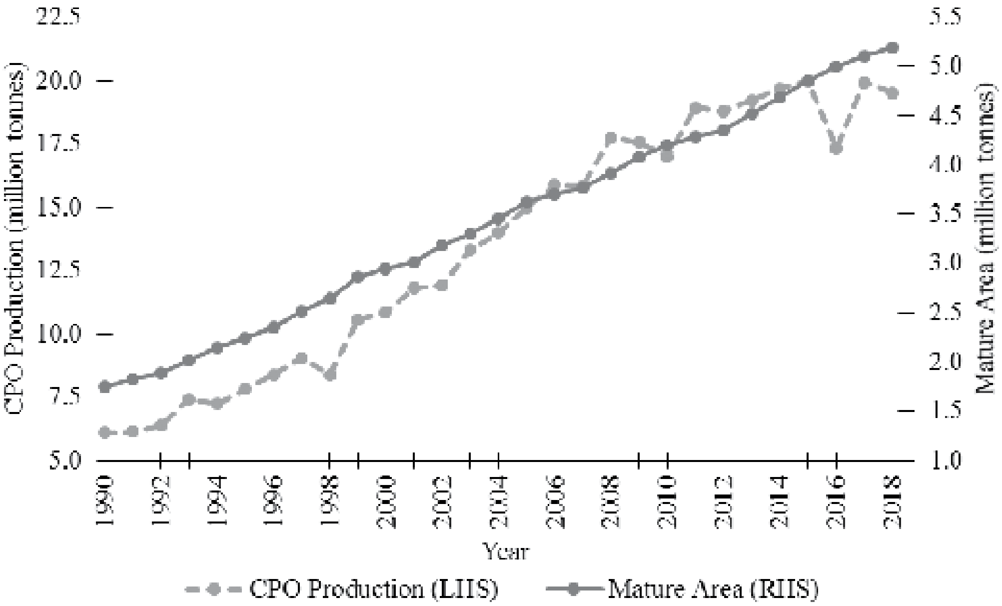


Figure 1 Comparison between Malaysian CPO production (million tonnes) and mature areas (ha) (1990 to 2018)

TABLE 1
MALAYSIAN FFB AND OIL YIELD PERFORMANCE (2008-2018)

Year	*FFB Yield* (tonnes/ha/yr)	*Oil yield* (tonnes/ha/yr)	*OER (%)*
2008	20.18	4.08	20.21
2009	19.20	3.93	20.49
2010	18.03	3.69	20.45
2011	19.69	4.01	20.35
2012	18.89	3.84	20.35
2013	19.02	3.85	20.25
2014	18.63	3.84	20.62
2015	18.48	3.78	20.46
2016	15.91	3.22	20.23
2017	17.90	3.53	19.72
2018	17.15	3.42	19.95
CAGR* 2008-2018	-1.61	-1.74	-0.13

Source: MPOB (Malaysian Palm Oil Board) (2019)

*Compound Annual Growth Rate (%)

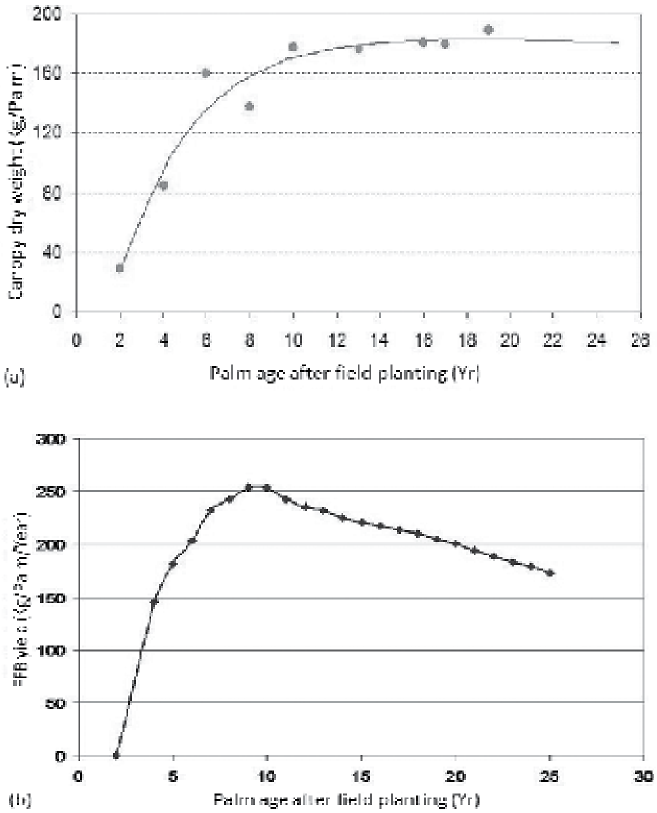


Figure 2 Vegetative growth (a) and yield profile (b) of well grown oil palm on inland soil in Malaysia
Chew & Goh (2003)

Therefore, studies showing impact of manuring cessation had been reviewed to evaluate the present industry's challenges and its effect on oil palm production components.

FERTILISER PRICES TREND 1990 TO 2018

Fertiliser prices had increased significantly, almost two to three times more over a 29 years period (1990-2018) as compared to the mean price of 1990-1994. In contrast, improvement of CPO prices to some extent were supported by the depreciation of the Malaysian Ringgit. The long-term trend of fertiliser prices from 1990-2018 of urea, muriate of potash (MOP) and rock phosphate (RP) and their relationships to CPO prices are shown in *Table 2*.

Implication of prices of fertiliser and CPO on oil palm industry

Malaysian fertiliser usage in oil palm 2012-2018

The oil palm acreage in Malaysia was at 5.85 million hectares in the year 2018 which exhibited an increase of 0.77 million hectares (15.2%) compared with 5.08 million hectares in 2012. Despite the increase in oil palm planted area, fertiliser usage had been reducing since

TABLE 2
PRICES FOR FERTILISER, CPO AND CURRENCY EXCHANGE RATE FROM 1990 TO 2018

Period	*Urea*	*RP*	*MOP*	*CPO Price (RM/tonne)*	*CPO Price (USD/tonne)*	*Currency (RM/USD)*
	(USD/tonne)					
1990-1994	116	38	106	925	386	2.4
1995-1999	126	40	118	1 578	562	2.8
2000-2004	121	41	118	1 300	380	3.4
2005-2009	299	125	347	2 091	662	3.2
2010-2014	357	151	384	2 730	941	2.9
2015-2018	235	106	248	2 417	686	3.5
	Growth rate (%) of mean values by 5-year period over mean of 1990-1994					
1995-1999	8	6	11	71	46	17
2000-2004	4	7	11	40	-1	43
2005-2009	157	227	226	126	72	32
2010-2014	207	296	260	195	144	21
2015-2018	102	177	133	161	78	47

Note: RP=Rock phosphate; MOP=Muriate of potash
GEM (Global Economic Monitor) Commodities; MPOB (2019)

2015 (*Table 3*), partly due to lower CPO prices (Leong, 2018). Fertiliser inputs in 2018 continued to be lower than the mean of 2013-2014 by 6.5 per cent. Interestingly, the oil yield per hectare in 2018 had also reduced significantly by 0.5 tonnes per hectare per year (~11%) to 3.42 tonnes per hectare per year as compared with 3.85 tonnes per hectare per year which was the mean of 2013-2014 (*Table 1*). This scenario of fertiliser application reduction in general since 2015 and subsequent reduced crop production suggests a close relationship between the two (*Table 3*).

Viability of oil palm industry in relation to prices of fertiliser and CPO

Fertiliser cessation trial studies by Sidhu *et al.* (2004, 2009 and 2014) were used as references to simulate overall yield trend in the coming years without proper manuring programmes. The study was based on 15 years of yield data with a high yield of over 30 tonnes per hectare per year during prime age. Total applied fertilisers to sustain the high yield was at 8.33 kg per palm per year which comprises of urea (2.5 kg/palm/yr), RP (2.33 kg/palm/yr) and MOP (3.5 kg/palm/yr). A simple calculation based on percentage of fertiliser cost over CPO price was computed. Results from historical data from 1990-2018 revealed that fertiliser expenses (material cost only) constituted an average of 10 per cent over CPO prices (*Figure 3*). At times of higher CPO prices, e.g. during 1994-1999, average fertiliser cost was only 7 per cent of CPO price. Thus, this particularly high CPO price time frame resulted in a most profitable period due to higher margins of profit. In contrast, fertiliser cost over CPO prices averaged at 13 per cent during 2008-2013 as the former increased. In short, increase of fertiliser prices and fertiliser cost will certainly affect the profitability of the oil

TABLE 3
MALAYSIAN FERTILISER APPLICATION AND GROWTH RATE IN OIL PALM INDUSTRY (2013-2018)

Year	N-Source	P-Source	K-Source	Total	CPO Price (RM/tonne)
	(million tonnes)				
2013	2.07	1.18	2.20	5.45	2 371
2014	2.09	1.28	2.11	5.49	2 384
2013-14 Avg.	2.08	1.23	2.16	5.47	2 378
2015	1.92	1.17	1.91	5.00	2 154
2016	2.00	1.17	1.91	5.08	2 653
2017	2.03	1.22	2.01	5.26	2 783
2018*	1.99	1.17	1.95	5.11	2 235
	Growth rate (YoY%) over mean of 2013 and 2014				
2015	-7.8	-4.6	-11.4	-8.5	-9.4
2016	-4.0	-4.9	-11.5	-7.2	11.6
2017	-2.3	-1.2	-6.9	-3.9	17.1
2018*	-4.2	-4.8	-9.7	-6.5	-6.0

Note: Amount of fertiliser by nutrient type is based on total amount applied in Malaysian agriculture industry for the year 2018 where 75% of the area is from oil palm plantations

Leong (2018); MPOB (2019)

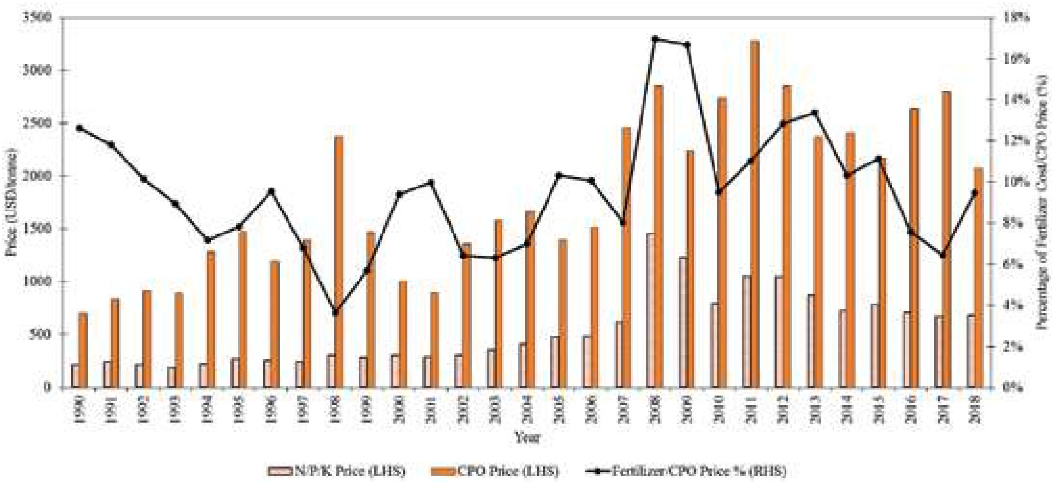


Figure 3 Comparison between fertiliser cost (USD/tonne) and CPO price (USD/tonne) (1990 to 2018)

GEM Commodities; MPOB (2019)

palm business. Therefore, continued effort to refine palm nutritional requirements is essential for the oil palm industry to be a profitable plantation business.

IMPACT OF MANURING CESSATION ON OIL PALM YIELD

Optimal rate of fertiliser input in oil palm had been assessed in various soils to maintain high FFB yields in the range between 25 tonnes per hectare per year and 44 tonnes per hectare per year (Goh *et al*., 2009). These were assessed from trials carried out during 1970s, 1980s and 1990s and across a wide range of soils and climatic regions (*Table 4*). Oil palm planted on soils with low inherent soil fertility such as inland soils and riverine soils without fertilisers (control plots) can produce FFB yields of 20-23 tonnes per hectare per year which is lower than manured oil palm by 13.0 to 14.5 tonnes per hectare per year (36% to 42%) as shown in *Table 5*. On the contrary, oil palm planted on soils with higher inherent fertility such as those on coastal soils yielded 26 tonnes per hectare per year without manuring which is only 4.6 tonnes per hectare per year (15%) lower compared with manured oil palm. In fact, oil palm planted on riverine soils exhibited highest yields at 43 tonnes per hectare per year (*Table 4*, period of 1980s-90s) with manuring and yield of palms without manuring exhibited significantly lower productivity by 20 tonnes per hectare per year (47%). Therefore, optimum application of fertiliser is necessary to support oil palm growth and high yields.

Yield trends over 15 years during ascending and prime stage

Long-term trials conducted in a period of 15 years as reported by Sidhu *et al*. (2004, 2009 and 2014) were used to demonstrate the impact of manuring cessation on oil palm yield during ascending and prime yielding stage. The experiment was designed in a 2^3 factorial NPK trial and was laid down in 1999 on 4-year-old (1995 planting) DxP oil palm planted on loamy sand (Typic Dystrudepts) in Riau Province, Indonesia.

Palm yield response over 10 years from ascending to prime yielding stage phase I, under zero manuring (T0)

Palms with zero manuring (T0) recorded lower yields over the years and more distinctly after 3 years of harvesting with mean yields dropping significantly during the ascending phase [1 to 5 years after harvesting (YAH)] by almost 8.7 tonnes per hectare per year (73%) at 11.9 tonnes per hectare per year as compared with palms with continuous manuring (TC) at 20.6 tonnes per hectare (*Figure 4*). Prolonged absence of fertilisers resulted in further yield deterioration during prime yielding stage I (6 to 10 YAH) which only recorded an average of 8.6 tonnes per hectare per year or yields dropping by almost 250 per cent as compared with palms yielding 30.2 tonnes per hectare per year with continuous manuring during the same period (*Figure 4*).

During the ascending yielding phase, palms without manuring displayed noticeably lower bunch numbers and bunch weight. The gap widened visibly after 3 YAH compared with manured palms. Palms without manuring during the ascending phase (1-5 YAH) recorded reduction in bunch number and bunch weight by 20 per cent and 39 per cent respectively, compared with palms in TC plots. Under normal fertilised conditions, oil palm in general will express significant increase in FFB and bunch weight during the prime yielding stage (6-10 YAH). Nevertheless, palms without manuring (T0) recorded significantly lower bunch number

TABLE 4
COMPARISON OF FFB YIELD RESPONSE (TONNES/HA/YR) BETWEEN OIL PALM PLOT APPLIED WITH MAXIMUM AMOUNT OF FERTILISER AND WITHOUT FERTILISER (CONTROL)

Trial period	*Site*	*Soils*	*Maximum*	*Control*
1970s – 80s	Inland	Bungor	31.8	8.6
		Rengam	27.7 – 32.5	11.2 – 18.2
		Serdang	32.3	12.0
		Durian	25.6 – 36.8	13.0 – 23.0
		Munchong	29.9 – 34.6	11.6 – 24.4
		Batu Anam	25.5 – 33.0	17.3 – 28.1
		Malacca	27.9 – 29.3	22.9–25.9
		Kumansi	31.2	23.6
		Batang	33.8	28.9
	Coastal	Carey	27.8 – 31.9	18.5 – 25.8
		Selangor	35.1 – 36.1	30.0 – 34.0
		Sedu	31.2	22.8
		Briah	23.7 – 31.1	18.3 – 27.4
	Riverine	Akob	26.2	20
		Sogomana	29.0	24.8
		Lumisir	30.3	26.4
		Koyah	32.7	21.1
		Inanam	20.8	16.7
		Buran	33.7	29.1
1980s – 90s	Inland	Rengam	34.4 – 38.5	12.1– 23.8
		Munchong	35.2	22.8
		Batang (lat)	39.7	21.2
		Kumansi	37.9 – 45.8	18.9 – 25.7
		Sahabat	38.8	24.6
	Coastal	Carey	28.8	27.1
		Briah	30.3	25.7
	Riverine	Inanam	44.1	19.9
		Buran	41.5	25.4

Kee and Goh (2006), Foong *et al*. (1996)

and bunch weight by 47 per cent and 146 per cent respectively, in comparison to palms in the TC plot.

Re-introducing of manuring programme (TR) to neglected palms at the prime 1 phase clearly revealed that it took almost 4 years to narrow the yield gap. However, a yield difference at an average of 4.4 tonnes per hectare per year (or 17%) during the prime 1 phase was observed as compared with TC plot which retained higher average yield at 30.2 tonnes per hectare per year. The higher yield derived from TC was mainly contributed by heavier bunch weight; an additional 2.9 kg per bunch or an increase of 17 per cent as compared with palms from TR plot.

TABLE 5
SUMMARY OF TREATMENT AND FFB VARIANCE IN DIFFERENT SOIL TYPES

Soil type	*Treatment*		*Variance*	
	Maximum	*Control*	*Tonnes/ha/yr*	*%*
	(tonnes/ha/yr)			
Inland	34.9	20.4	14.5	42
Coastal	30.3	25.7	4.6	15
Riverine	35.8	22.8	13.0	36

Note: Summarised from *Table 4*

The large increase in the number of harvested bunches is likely due to the reduction in abortion rate of female inflorescences which normally occurs 9 to 10 months prior to bunch ripening (Corley & Tinker, 2016). Significant increase in yield and bunch number were also reported by Warriar and Piggot (1973), approximately 10 months after manuring recommencement in a similar rehabilitation trial. This effect was attributed almost entirely to a reduction in pre-anthesis female inflorescence abortion and not due to change in sex-ratio, which normally occurs about 24 months prior to bunch ripening (Breure, 2003).

Chiu and Siow (2005) also reported other rehabilitation trial established on depleted soils in West Kalimantan. The yields of previously 'neglected' and 'semi-neglected' blocks still lagged behind the 'normal' block by an average of 27 per cent and 16 per cent respectively, even after 6 years of fertiliser application. Yields of these neglected blocks never caught up with the normal block even in subsequent years. It also appeared that the neglected palms required higher nutrient inputs than normal palms to cater for both growth and deficiency demand (Corley & Tinker, 2016). The neglected palms would have to recover its biomass in preparation for the effect of applied fertiliser on yield (*Figure 5*).

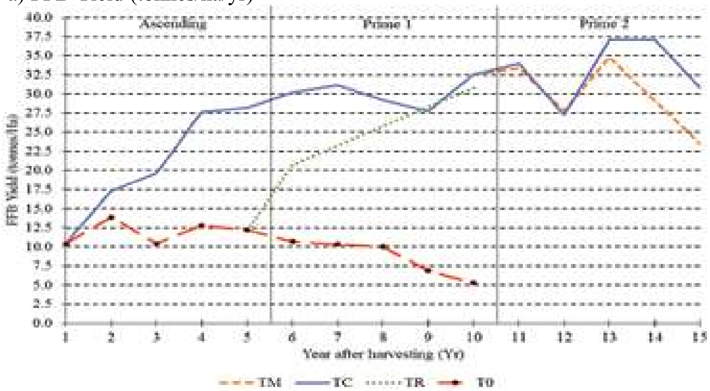
Impact of ceased manuring on oil palm yield during prime yielding stage phase 2

Palms with high production at prime yielding stage 2 (11-14 YAH) required reasonable fertiliser inputs (TC) to sustain over 33 tonnes per hectare per year. However, when palms were later deprived of fertiliser inputs (N, P and K fertilisers withdrawn), yield reduction started to be noted after 3 years and were more conspicuous from the fifth year where yield suffered an almost 7 tonnes per hectare per year drop or 31 per cent as compared to TC (*Figure 4a*). Such practice to cease fertiliser applications over 5 years have resulted in an average loss of 3.5 tonnes per hectare per year or 12 per cent lower than the palms from TC plot yielding at 33.2 tonnes per hectare. Impact of fertiliser cessation in this case (TM) resulted in lower bunch number and bunch weight by 3.7 per cent and 7.8 per cent, respectively, as compared with palms from TC (*Figure 4*).

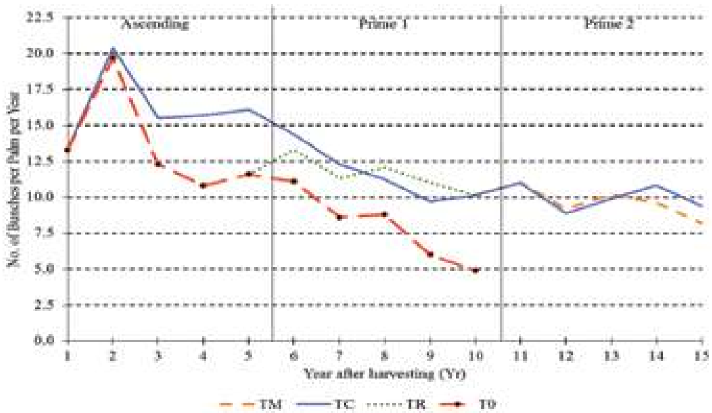
Optimising fertiliser rate as a mitigation measure during low CPO price

In view of the present scenario of low crude palm oil prices, sensible and effective strategies to reduce fertiliser rates are essential to bring down the production cost as well as maintaining profitability. Plantation managers and especially

a) FFB Yield (tonnes/ha/yr)



b) Number of bunches per palm per year



c) Average bunch weight

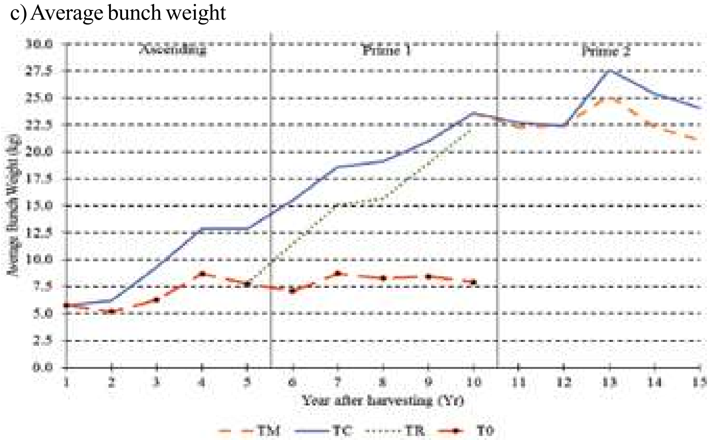


Figure 4 Impact of fertiliser cessation on oil palm yield parameters at various growth stages

Note: TM=Manuring halted at 10 YAH; TC=Continuous manuring; TR=Resume manuring at 5 YAH; T0=No manuring

Sidhu *et al.* (2004, 2009 and 2014)

(a)

(b)

Figure 5 Comparison of growth between mature palms: (a) with manuring and (b) without manuring

agronomists should have a detailed understanding on palm age, nutritional status and inherent soil fertility which affects minimum yield, yield reduction and/or growth during fertiliser cessation or resumption; in other words, understanding palm responses to fertilisers at that given site. Goh *et al.* (2009) suggested a time lapse of approximately a year before linear decline in FFB yield was observed.

Good understanding of the general principles governing mineral nutrition of the oil palm (Corley & Tinker, 2016; Goh & Hardter, 2003) and methods to maximise fertiliser use efficiency (Goh *et al*., 1999; Goh *et al*., 2003) are key in coming up with strategies to optimise fertiliser usage in this situation. Reducing fertilisers or totally withdrawing them for economic reasons should always be a last resort because some yield loss will ultimately happen and the economic optimum is usually not achieved. The main factors that can influence the degree of fertiliser reduction or cessation for minimal impact on FFB yield are types of nutrient, cost of fertiliser, inherent soil fertility/ nutrient, climatic zone and palm age (Goh *et al.*, 2009).

Under tight cash flow or low profitability, the risk preference approach is probably the best option. Adoption of Good Agricultural Practices (GAP) such as frond retention in young prime palms (4 to 9 years after planting) would promote growth and yield (*Figure 6*). However, Low and Goh (1973) reported that manipulation of the fertiliser rates was not likely to produce the desired effect due to the time-lag between fertiliser application and the subsequent yield response. Moreover, it would also further complicate present supply to price prediction models. Therefore, various appropriate approaches with a slight reduction of fertiliser rate without causing significant yield reduction are preferred e.g. site specific fertiliser application using nutrient maps derived *via* geostatistic analysis (Lee & Salihuddin, 2013; Goh *et al.,* 2009; Lee & Foong, 2002; Tang *et al.,* 1999; Teo, *et al.,* 1998).

CONCLUSION

Oil palm require reasonable judicious fertiliser inputs and best management practices to sustain high yields. Palms without proper fertiliser input and to some extent under 'neglected' or without fertiliser inputs during prime yielding stage may experience yield loss up to 40 per cent or about 14 tonnes per hectare

(a) (b)

Figure 6 Comparison between young mature palms: (a) without frond retention and (b) with frond retention

per year. Therefore, strategy to reduce fertiliser inputs during low CPO prices must be properly addressed in order to remain profitable.

ACKNOWLEDGEMENT

The authors wish to thank the management of FGV Holdings Berhad for permission to publish this paper.

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