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Harvesting Practices for Maximum Yield in Oil Palm: Results from a Re-Assessment at IJM Plantations, Sabah

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ABSTRACT

Recoverable yield of fresh fruit bunches (FFB), palm oil (PO, or oil) and palm kernel (PK, or kernel) are determined during harvesting. After harvest, losses occur as harvested FFB lose weight with time and loose fruits (LF) of harvested bunches are not all collected; and oil quality starts to deteriorate as free fatty acid (FFA) content rises. The quantum of loss and the degree of oil quality deterioration depend on the efficiency of harvesting practices which must balance maximum oil yield and acceptable oil quality. Harvesting involves teams of workers visiting blocks of palms at regular intervals to cut and recover ripe bunches. Field managers determine the minimum ripeness standard and manage the harvesting interval, the combination of both factors determines the overall ripeness composition of the harvested crop. In practice, the minimum ripeness standard (MRS) may be difficult to enforce but with adequate resources the harvesting interval (HI) can be controlled. Bunch analysis (BA) shows that oil content of harvested bunches vary greatly, with a poor relation to the number of LF per bunch, thus a low MRS can be implemented without much impact on the potential oil extraction rate (OER) of the harvested crop. High FFB yield is a prerequisite for high oil yield but not necessarily high OER; on the other hand, high OER does not necessarily mean high oil yield. The definition of 'under-ripe' bunches used in crop grading should be consistent with field practice, i.e. *the adopted MRS, to avoid mismatch between plantations and mills.*

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ABSTRAK

Hasil yang diperolehi dari buah tandan segar (BTS), minyak sawit (PO, atau minyak) dan isirong sawit (PK, atau isirong) ditentukan oleh penuaian. Semasa penuaian, kerugian boleh berlaku apabila berat BTS yang dituai akan berkurangan dengan peredaran masa dan tidak semua buah relai (LF) dikumpulkan; dan kualiti minyak mula merosot apabila kandungan asid bebas lemak (FFA) meningkat. Kuantum kerugian dan tahap kemerosotan kualiti minyak bergantung pada kecekapan amalan penuaian yang mesti mengimbangi antara memaksimumkan hasil minyak dan kualiti minyak yang boleh diterima. Penuaian melibatkan sekumpulan pekerja yang memasuki ladang mengikut jadual yang ditetapkan untuk memotong dan menuai tandan masak. Pengurus ladang menentukan piawai minimum kematangan tandan (MRS) dan kekerapan menuai, gabungan kedua-dua faktor tersebut menentukan komposisi kematangan keseluruhan tandan yang dituai. Kebiasaannya, piawai minimum kematangan tandan mungkin sukar untuk dikuatkuasakan tetapi dengan sumber yang mencukupi, selangan tuaian (HI) boleh dikawal. Analisis tandan (BA) menunjukkan bahawa kandungan minyak amat berbeza antara tandan yang dituai, serta perkaitan yang lemah dengan bilangan buah relai setiap tandan. Oleh itu, MRS yang rendah boleh diamalkan tanpa memberi kesan yang ketara terhadap potensi kadar perahan minyak (OER). Hasil BTS tinggi diperlukan untuk mengeluarkan hasil minyak yang tinggi tetapi tidak semestinya dapat memperolehi OER yang tinggi; sebaliknya, kadar OER yang tinggi tidak bermakna hasil minyak yang tinggi. Takrif tandan 'kurang-masak' yang digunakan dalam *penggredan tandan perlu selaras dengan amalan ladang, iaitu penggunaan MRS, untuk mengelakkan ketidaksetaraan antara ladang dan kilang.*

Keywords: oil palm FFB yield, oil quality, harvesting practices, bunch analysis, oil extraction rate.

INTRODUCTION

Since the early days of the oil palm industry, planters as well as researchers have studied the process of ripening and oil synthesis in oil palm fruits and bunches in relation to harvesting practices (Rajaratnam and Williams, 1970; Ng and Southworth, 1973; Rajanaidu *et. al*., 1985; Azis *et al*., 1993; Gan *et al*., 1995; Rajanaidu *et al*., 1998; Sharma *et al*., 1999; Corley and Law, 2001).

This knowledge has helped planters and millers devise appropriate management and operating schemes for harvesting and milling to maximise the yield of fresh fruit bunches (FFB), palm oil (PO, or oil) and palm kernels (PK, or kernel). The most objective and practical way to assess the maturity or ripeness of a bunch (*i.e*., when it is ready to be harvested) is by the number of loose fruits (LF) detached from it. Field managers will determine the minimum ripeness standard (MRS, *i.e*. the condition of a bunch making acceptable to harvest) in terms of the number of LF per bunch. Fruit detachment usually starts *ca.* 150 days after a bunch was pollinated. PK content is maximised well before fruits start detaching from a bunch, so pollination rather than ripeness determines potential PK yield before harvest. After harvest, losses of LF reduce the potential to the recovered PK yield.

Oil content in each individual fruit in a bunch is maximised before the abscission process is triggered, eventually causing the fruit to detach completely from a bunch. It follows therefore that the oil content of a bunch is maximised only after every fruit has abscised. Quality of the oil starts to deteriorate in abscised fruits, with an increase in the level of free fatty acids (FFA) in the oil. A balance is therefore needed between maximising oil yield and maintaining acceptable oil quality in managing the harvesting of bunches.

To achieve this in a plantation, harvesting is organised with teams of harvesters visiting blocks of palms at regular intervals [*i.e.* harvesting interval (HI), which is the number of days between successive harvests in a given area or block] to recover the available crop based on the pre-determined MRS; and a collection and transport system is organised to quickly deliver the harvested crop to the mill so that processing can start before oil quality deteriorates beyond specified commercial limits (for FFA, not more than 5%).

The recoverable yield of FFB, PO and PK is determined during harvesting. The quantum of crop loss and the degree of oil quality deterioration are dependent on the efficiency of harvesting and crop recovery practices.

The palm oil industry in Malaysia has faced an increasing problem with the supply of plantation workers since the 1980s, resulting in increasing difficulties in field operations including harvesting. Since then in Malaysia as a whole, FFB yields have stagnated and oil extraction rate (OER) in mills have fallen. Planters and millers remain under constant pressure to achieve production and productivity targets that may be out of date and no longer realistic. Our aim here is to present the harvesting practices that we consider will deliver high yield and product quality. While the focus is mainly on estate practices, it is also meant to provide the interested miller a good idea of the situation in the plantation, so that both planters and millers can have a common understanding of the factors needed for maximising yield and product quality in oil palm production.

MATERIALS AND METHODS

IJM Plantations (IJMP) established its Quality, Training & Research Centre (QTRC) at Sijas Estate in 2001. The area where the QTRC is located was planted with oil palms in 1992, and 290 palms are located inside the fence of the QTRC. A harvesting study was initiated using these 290 palms in 2001 to determine whether the crop ripeness targets set for IJMP estate managers were achievable with the adopted minimum ripeness standard (MRS) of one LF before cutting. The study area was split into two parts, with one part harvested on a harvest interval (HI) of 10 days, and the other on a HI of 15 days. The study continued until mid-2006, but for the purpose of this article, we present only the data for January to December 2002.

Harvesting was done as close as practically possible to the target HI in each plot. During harvesting, the number of LF on the ground was first counted before the bunch was cut and then placed in a rattan basket used to hold the bunch during weighing. In the case of palms with more than one bunch suitable for cutting (based on the MRS of one LF), the LF before cutting was allocated to each bunch and kept separately. Each harvested bunch was classified according to ripeness categories as defined by the Malaysian Palm Oil Board (MPOB).

From February 2002, bunch analysis (BA) was initiated to determine bunch and fruit components and oil and kernel contents. Up to June 2002, each palm was sampled only once for BA. From July 2002, all harvested bunches were sampled for analysis except when more than one bunch was harvested on the same occasion from a palm, in which case none would be sampled so that there would be no error in the allocation of LF between the bunches. Thus, 1561 bunches (out of a total harvest of 3848 bunches) were sampled from 283 palms (out of the total 290 palms), *i.e.* an average of 5.5 bunches were analysed per sampled palm.

Bunches sampled for analysis were placed in gunny sacks and transported to the bunch analysis laboratory located within the QTRC on the day of harvesting. Spikelet sampling was carried out according to the Pamol method (Rao *et al.*, 1983). Fruit sampling was also carried out according to the Pamol method (Rao *et al.*, 1983), with a standard number of 30 fruits sampled. The composition of the 30-fruit sample was based on the relative proportions of pollinated and parthenocarpic fruits, and within each of those groups, inner and outer fruits. Extraction was by the cold extraction method (Rao *et al.*, 1983).

RESULTS AND DISCUSSION

In the 12 months of 2002, estimated FFB yield was 33.7 t ha^{-1} with the 10-day HI, 6.6% higher than the yield (31.6 t ha^{-1}) with the 15-day HI (*Table 1*), from both higher bunch number and bunch weight. The 'loss' in yield with the higher HI is invisible for it would not have been recorded in the normal course of events as the "lost" FFB would not have reached the mill weighbridge at all.

The FFB yield recorded for the estate blocks (*i.e.* blocks 12 and 13) within which the QTRC is located was 30.5 t ha^{-1}, *i.e.* 6.7% lower than the average mean yield (32.7 t ha^{-1}) of the study plots (*Table 1*), apparently due to lower bunch number. It would have been likely that there was also loss of LF in the estate blocks, but this was not evident from the average bunch weight (*Table 1*).

The lower yield in the estate blocks occurred during the peak yield month of September 2002 (*Figure 1*). The highest HI (18 days) in the estate blocks occurred during the first harvest in September, which indicates the importance of maintaining a low HI during the peak crop period.

The average oil per bunch (OB, or oil content) of bunches from the palms harvested every 10 days was 25.6% (uncorrected BA value, *Table 2*), marginally below the average of 25.7% of bunches harvested every 15 days. This small difference in oil content was observed despite a large difference in LF number and overall more 'ripe' crop with the higher HI (*Table 2*). As the FFB yield with the 10-day HI was much larger (+6.7% higher than 15-day HI, *Table 1*) than the small disadvantage in OB (only -0.7% lower than 15-day HI, *Table 2*), the recovered potential oil yield (8.6 t ha^{-1}) with the 10-day HI was higher than with the 15-day HI (8.1 t ha^{-1}) (*Table 2*).

Overall, there was 61% more LF per bunch with the 15-day HI, estimated at 2.4 t ha^{-1}. This is likely an underestimate as the average fruit weight from BA data was used in the estimation; actual LF weight may be 50% higher. Not all the LF will be recovered, thus the oil yield advantage of the

TABLE 1. EFFECT AN INCREASE IN HARVESTING INTERVAL FROM 10 TO 15 DAYS ON FRESH FRUIT BUNCHES (FFB) TIELD AND ITS COMPONENTS

Treatment	FFB yield (kg $palm^{-1}$)	Bunches ($palm^{-1}$)	Mean bunch weight (kg)	FFB yield (t ha^{-1})
10 Days HI[2] plot	247.5	13.5	18.3	33.7
15 Days HI[2] plot	232.4	13.0	17.9	31.6
Average QTRC[3]	240.1	13.3	18.1	32.7
Blocks 12 & 13 SJS[4]	212.4[5]	11.5[5]	18.4	30.5

Note: [1] FFB yield/per hectare for 10 and 15 days HI plots, extrapolated from yield $palm^{-1}$ by assuming a stand of 136 palms ha^{-1}; for estate blocks from actual estate records; [2] Harvesting interval (number of days between successive harvests); [3] Average for the 2 plots in the QTRC area; [4] Average for the commercial estate blocks were the QTRC is located in Sijas Estate; [5] Estimated using actual stand ha^{-1} (average of blocks 12 and 13=144 palm ha^{-1}) and planted area.

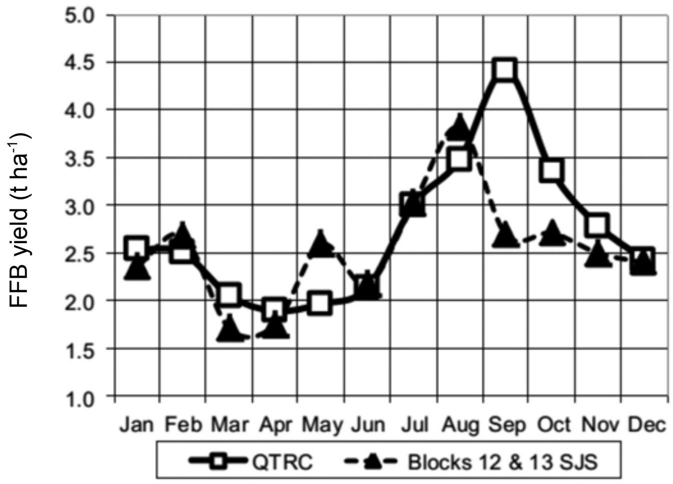

Figure 1. Monthly fresh fruit bunches (FFB) yield for year 2001 in harvesting study plots quality and research centre (QTRC) and Sijas Estate blocks 12 and 13.

TABLE 2. OIL CONTENT, OIL YIELD, RIPENESS COMPOSITION AND LOOSE FRUIT QUANTITY IN THE HARVESTING STUDY AT QTRC

Treatment	Oil/bunch (%)[2]	Oil yield (t ha^{-1})	Ripeness categories[4]			LF per bunch	LF per ha (t)[5]
			Under-ripe	Ripe	Over-ripe		
10 Days HI[1] plot	25.55	8.6	15	84	-	96	1.50
15 Days HI plot	25.73	8.1	11	88	2	155	2.40
Average QTRC[6]	25.61	8.3	13	86	1	125	2.00

Note: 1 – Harvesting interval (number of days between successive harvests); 2 – uncorrected bunch analysis (BA) values; no. of palms sampled – 147 of 147 (for 10 days HI); 136 of 143 (for 15 days HI); No. of bunches analysed – 929 (for 10 days HI); 632 (for 15 days HI); 3 – estimated from FFB yield (*Table 1*) and oil per bunch; 4 – definitions follow the Fresh Fruit Bunch (FFB) Grading Manual of the Malaysian Palm Oil Board (MPOB); Unripe= no detached or loose fruits (LF), Under-ripe = 1-9 LF, Ripe = 10 or more LF, Over-ripe = 50%-90% fruits detached; 5 – estimated using average fruit weight (from BA data) and no. of bunches per palm, converted to per hectare using assumed 136 palms ha^{-1}; 6 – average for the two plots in the QTRC area.

shorter HI will be larger in practice. Any delays in collection of LF will also lead to increased FFA content in the oil produced (*Figure 2*). With more LF, higher losses of LF are also likely at all stages of the journey between the estate and the mill. The loss from LF in terms of oil will be disproportionately higher.

Based on BA data, the relationship between bunch oil content and numbers of LF per bunch is a very weak one with a coefficient of determination (R^2) of only 0.005 (*Figure 3*). For bunches that have already started abscising, the variation in OB at any given number of LF per bunch is so great that the idea of 'higher OB with more LF-per-bunch' is essentially meaningless. Thus in commercial practice, bunches may be considered ripe for harvest as soon as abscission starts. This is important in the field to minimise overall LF numbers (*Table 2*), therefore minimising potential losses of LF, and to allow better harvesting productivity.

The results in *Table 2* show that with a harvesting system using a MRS of one LF before cutting, it is impossible to avoid having 'under-ripe' bunches in the harvest. This is because the definition of 'under-ripe' remains as 'less than ten LF', while 'ripe' is defined as 'ten LF or more'. Logically though, the definition of 'under-ripe' and 'ripe' must follow the MRS, thus if the MRS is already accepted as one LF, it follows that the 'ripe' definition should become 'one LF or more', and the entire 'under -ripe' category should disappear. If FFB grading at the mills remain the same, therefore there is a mismatch in definitions (between field operations and mills) that always leads to recriminations.

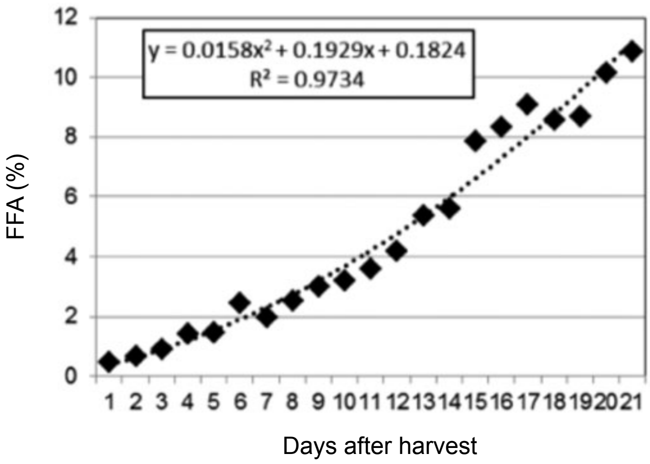

Figure 2. Increase in free fatty acid (FFA) content after harvesting.

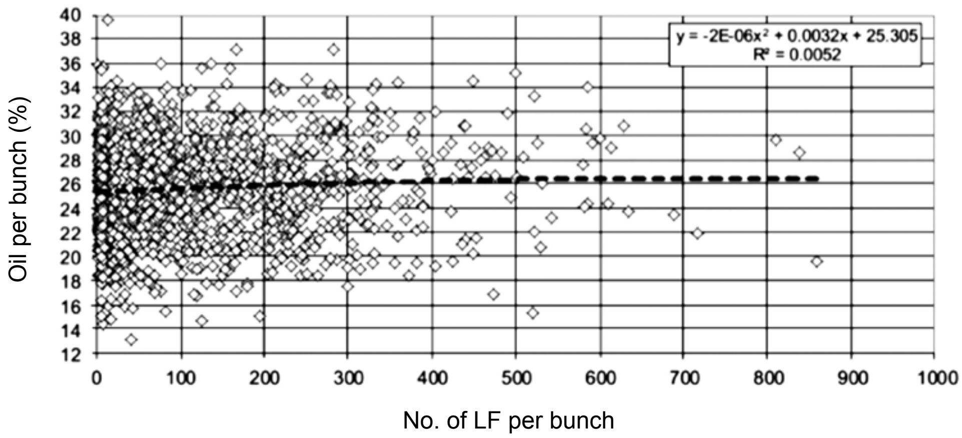

Figure 3. Relationship between oil per bunch (%) and number of loose fruits per bunch in harvesting study at (QTRC).

CONCLUSION

Higher FFB yield is achieved with a 10-day HI compared to a 15-day HI. Oil yield is also higher with the 10-day HI because the reduction in oil content due to lower ripeness (*i.e.* less LF) of the harvested bunches is very small. In effect, a high FFB yield is essential for high oil yield, but not necessarily high OER. Conversely, a higher OER does not necessarily mean a high oil yield. In theory, plantation management can manipulate both the MRS and the HI. In practice, the MRS is difficult to enforce, especially if a high MRS (*e.g.* five or ten LF before cutting) is desired. BA results however show that a high MRS is unnecessary for high oil content, so quality management in harvesting should focus on minimising 'unripe' rather than 'under-ripe' bunches. The definition of 'under-ripe' used in mills for crop grading should be consistent with actual field practice, *i.e.* it should be related to the adopted MRS, so that there is no mismatch in definition between planters and millers.

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