Estimating Oil Content of Commercially Harvested Oil Palm Fresh Fruit Bunches – A Step towards Increasing Palm Oil Yields

C R Donough*; J Cock*; T Oberthür*; K Indrasuara**; Rahmadsyah#; Gatot, A R† and T Dolong‡‡

ABSTRACT

Oil palm growers are able to assign fresh fruit bunch (FFB) yields to individual blocks, and thus are able to manage their plantation (or smallholding) to optimise FFB yield. However, currently it is not possible to attribute oil extraction rate (OER), hence oil yield, in a similar way, because mills process FFB from many sources, deriving a common OER for all the FFB that is processed rather than for individual sources. OER depends on the intrinsic qualities of the FFB being milled, which is likely to differ from one batch of FFB to another, hence assessment of milling performance is better based on extraction efficiency rather than OER per se. The South-east Asia Programme of the International Plant Nutrition Institute (IPNI SEA) recently showed that practices aimed at maximising FFB yield may not necessarily maximise OER. The bunch analysis (BA) method adapted by IPNI SEA for assessing oil content of FFB from commercial-scale harvesting in Indonesia can be implemented by plantations without much difficulty. BA and harvest audit data together allow growers to compute their Field Oil Recovery Efficiency (FORE), an assessment of the effectiveness of field practices on crop recovery and oil content. Pre-milling estimates of oil content (EOC) in harvested FFB allows mills to better measure their process performance based on their Mill Oil Recovery Efficiency (MORE). Knowledge of EOC will allow mills to pay growers for the oil content of their crop, providing further motivation to growers to improve FORE. These recovery efficiency measures allow a more holistic analysis of the overall oil recovery process involving the growers and the mills, likely leading to reduced friction and better overall performance.

ABSTRAK

Penanam sawit boleh menguruskan ladang mereka untuk mendapatkan hasil buah tandan segar (BTS) yang optimum dari setiap blok. Walau bagaimanapun, setakat ini tidak mungkin untuk menghubungkaitkan kadar perahan minyak (OER) dengan hasil minyak kerana kilang memproses BTS yang diperoleh daripada pelbagai sumber. Oleh itu, OER yang diperoleh adalah untuk semua BTS yang diproses, bukan daripada sumber individu. OER bergantung pada sifat intrinsik BTS yang diproses, yang berbeza antara kumpulan BTS. Oleh itu, penilaian prestasi pengilangan adalah lebih baik berdasarkan kecekapan pengekstrakan daripada OER per se. Baru-baru ini South-east Asia Program of the International Plant Nutrition Institute (IPNI SEA) mendapati bahawa kaedah untuk memaksimumkan hasil BTS tidak semestinya dapat memaksimumkan OER. Analisis tandan (BA) adalah kaedah yang digunakan oleh IPNI SEA untuk menilai kandungan minyak BTS dari penjualan berskala komersial di Indonesia boleh dilaksanakan di ladang tanpa banyak halangan. Penanam sawit boleh menggunakan BA bersama data audit tuaian untuk mengira Kecekapan Pemulihan Minyak di Ladang (FORE) iaitu penilaian terhadap keberkesanan amalan ladang bagi pemulihan tunaman dan kandungan minyak. Anggaran kandungan minyak (EOC) dalam BTS pada peringkat pra-pengilangan membolehkan kilang untuk mengukur presiasi mereka dengan lebih baik berdasarkan Kecekapan Pemulihan Minyak Kilang (MORE). Dengan mengetahui EOC, kilang akan membayar penanam sawit...
Wood processing loss normally reported at about 10% of the process (Adzmi et al., 2012), with the total processing loss normally reported at about 10% (Wood et al., 1987; Adzmi et al., 2012).

The South-east Asia Programme of the International Plant Nutrition Institute (IPNI SEA) recently showed that field best management practices (BMP) that maximise FFB yield do not necessarily maximise OER even though estimated oil yield with BMP is higher (based on standard conversion of bunch analysis (BA) oil content values to mill OER) (Oberthür et al., 2012). In this article, we show how the methodologies adapted by IPNI SEA for assessing FFB from commercial-scale harvesting can be used to estimate oil recovery efficiency for the oil production process from the field to the mill.

**MATERIALS AND METHODS**

Data from three out of six IPNI SEA BMP project sites in Indonesia (one site in Sumatra, two sites in Kalimantan) (Oberthür et al., 2012) was used for this analysis. At each site, five pairs of commercial blocks had been evaluated for four years, where each pair of similar blocks included one where BMP (for maximising FFB yield) was implemented, and another reference (REF) block was managed using standard estate practices (Donough et al., 2010).

The final year’s FFB yield data from the 15 BMP blocks was considered for this article. Harvesting in these 15 BMP blocks was carried out with a short (seven-day) harvesting interval (HI) coupled with a low minimum ripeness standard (MRS), usually one loose fruit (LF), before harvest.

Harvest audits were carried out on at least one harvesting occasion per month to obtain estimates of: (a) the number of LF uncollected per bunch, (b) the percentage of unharvested palms, and (c) the percentage of unripe bunches in the harvested crop. Audits were done one day after harvesting for (a) and (b), and on the day of harvesting for (c). Estimates of (a) and (b) were based on a sample of minimum 12 palm rows (approximately 10% of the total number of rows in each block), and a minimum of 50 harvested bunches (based on fresh cuts on the palms examined). For (c), assessment was done on harvested bunches already placed on the roadside crop collection platforms, with at least five platforms sampled, and at least 50 bunches examined.

A modified bunch BA procedure (described by Oberthür et al., 2012) was used to estimate oil content (OC) of harvested FFB before any harvest losses occurred. Only ripe bunches, defined as a bunch with at least 1 LF, were analysed including all their LF, giving an estimate of the OC of ripe FFB. The bunches were sampled as described by Oberthür et al. (2012) to obtain a representative sample of each occasion of harvesting. The mean OC value of the sample of harvested ripe bunches was then taken as the OC value (before any losses) for the total weight of FFB of the entire harvest on that occasion. Between December 2009 and June 2011, over 4300 ripe bunches were analysed.

**Keywords:** palm oil yield, oil content, oil recovery.

**INTRODUCTION**

In the palm oil production system, fresh fruit bunches (FFB) are harvested from the plantations (or estates, or smallholdings), then quickly delivered to palm oil mills where the final products of the crop viz. crude palm oil (CPO, or oil) and palm kernels (PK, or kernel) are extracted. In general, the industry pays scant attention to kernel, and yield intensification efforts have focused on the oil. Intensifying oil yield depends on: (a) increasing the FFB yield; (b) increasing the oil content of the FFB; and (c) extracting more of the oil from the FFB, i.e. improving the extraction efficiency rather than the oil extraction rate (OER) per se.

FFB received at the mills is graded for ripeness and other criteria that may affect the milling process and OER, but the current practice does not involve estimating potential OER of the FFB delivered. The mills process FFB of unknown oil contents from many sources, then estimate the OER based on the amount of oil they produce. Thus, while FFB yield can be attributed to specific blocks (or even estates); they are assigned indiscriminately using the average OER of the mill which received FFB. The bunches were sampled as described by Oberthür et al. (2012) to obtain a representative sample of the OC of ripe bunches at each site. Between December 2009 and June 2011, over 4300 ripe bunches were analysed.

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RESULTS AND DISCUSSION

Recorded FFB yield averaged 28.8 t ha\(^{-1}\) (Table 1) for the three sites. Harvest losses occurred even with the strict BMP harvesting regime, through uncollected LF and unharvested palms. Using data from harvest audits and BA, the quantum of lost FFB can be estimated. Adding these estimated crop losses to the actual recorded yield gives an approximation of the potential FFB available for harvest. This permits the FFB recovery efficiency to be calculated as an objective measure of the effectiveness of crop recovery in the plantation. The highest FFB yield did not give the highest FFB recovery efficiency (Table 1).

The crop losses can also be expressed in terms of oil using BA data (Table 2). In addition, the effect of crop quality (i.e. ripeness) was also accounted for by assuming a lower oil content for unripe bunches (assumed 30% less than ripe bunch OC, based on Wood et al. 1987). The estimated potential oil (EPO, Table 2), calculated using the potential FFB yield (Table 1) and ripe bunches OC, is before any harvest losses and assumes all harvested bunches were ripe. The estimated recovered oil (ERO, Table 2) in the harvested FFB is obtained after deducting the estimated oil losses (from lost and unripe fruits/bunches). The field oil recovery efficiency (FORE, Table 2) measures the effectiveness of crop recovery in the plantation in terms of oil, and an estimate of the pre-milling oil content (EOC, Table 2) of the harvested FFB is obtained.

The pre-milling EOC is sometimes referred to as potential OER (Wood et al., 1987; Chew et al., 1999; Corley and Tinker, 2003). Wood et al. (1987) had shown that there is a reasonable relationship between EOC (determined using BA) of bunches sampled from commercial harvests and mill OER from batch milling trials especially when carefully monitored. The EOC therefore provides an estimate of the maximum amount of oil that the mill can achieve from milling the FFB harvested.

In the milling process, the total weight of oil produced from a given weight of bunches gives the actual OER. It depends on both the intrinsic properties of the FFB received for processing and the mill processes. The difference between the actual OER and EOC represents the losses of oil during milling. The mill oil recovery efficiency (MORE) is the ratio of actual oil produced to the oil contained in the FFB recovered from the field, i.e. the ERO (Table 2).

Combining BA and harvest audit data allows plantations to estimate the ERO and assess the efficiency of their crop recovery process. With known estimates for ERO of the FFB sources contributing to a palm oil mill, better assessment of milling performance becomes possible based on the MORE rather than evaluations based purely on actual OER.

The BA data generated from the IPNI SEA projects also provides insights into the variation in EOC in FFB from individual blocks. In these observations on commercial blocks there was no consistent, strong relationship

### TABLE 1. ANNUAL FRESH FRUIT BUNCH (FFB) YIELD AND RECOVERY EFFICIENCY AT THREE SITES IN INDONESIA

<table>
<thead>
<tr>
<th></th>
<th>Site A</th>
<th>Site B</th>
<th>Site C</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual annual FFB yield (kg ha(^{-1}))(^{1})</td>
<td>28 800</td>
<td>25 100</td>
<td>32 500</td>
<td>28 800</td>
</tr>
<tr>
<td>Actual annual no. of bunches (ha(^{-1}))(^{2})</td>
<td>1 396</td>
<td>1 362</td>
<td>2 072</td>
<td>1 610</td>
</tr>
<tr>
<td>Estimated uncollected LF weight (kg ha(^{-1}))(^{3})</td>
<td>68</td>
<td>44</td>
<td>82</td>
<td>65</td>
</tr>
<tr>
<td>Estimated FFB weight of unharvested palms (kg ha(^{-1}))(^{4})</td>
<td>176</td>
<td>78</td>
<td>418</td>
<td>224</td>
</tr>
<tr>
<td>Potential annual FFB yield (kg ha(^{-1}))(^{5})</td>
<td>29 044</td>
<td>25 222</td>
<td>33 000</td>
<td>29 089</td>
</tr>
<tr>
<td>FFB recovery efficiency (%)(^{6})</td>
<td>99.2</td>
<td>99.5</td>
<td>98.5</td>
<td>99.0</td>
</tr>
</tbody>
</table>

Note: \(^{1}\) Based on actual production records; \(^{2}\) loose fruit; \(^{3}\) derived from harvest audit data [No. of uncollected loose fruit (LF) per bunch] and bunch analysis (BA) data (average weight per LF); \(^{4}\) derived from harvest audit data (% of unharvested palms), block records (actual No. of palms per hectare), and assumed bunch No. per palm and average bunch weight same as harvested palms; \(^{5}\) actual FFB yield plus estimated weights of uncollected LF and FFB of unharvested palms; \(^{6}\) actual FFB yield as a % of potential FFB yield.
between OC of individual bunches and the number of LF per bunch: there was a weak positive correlation. The variation in OC was so great that we question the notion that a higher number of LF per bunch is a pre-requisite for higher OC. Excessive focus on increasing actual OER by increasing the MRS (i.e. more LF in the field) may be counter-productive, leading to lower FFB yields as a result of increased crop losses in the field, and ultimately lower oil yields. This has important implications for the industry which is facing severe labour shortages. By reducing the MRS, the labour efficiency of harvesting operations and FORE can be improved.

On the milling side, if the currently accepted standards for actual OER can be eschewed, this may also be seen as a positive development as the FFB being received for processing becomes less variable in terms of ripeness (albeit averaging at a lower level), thus easing process controls and possibly reducing process losses, leading to better MORE.

Thus, the industry may need to revise FFB ripeness or maturity grading definitions to become consistent with rigorous field observations rather than unproductive arguments between mills and plantations due to a ‘definition gap’. In the plantation, harvest audits can focus on LF recovery and unripe bunches, i.e. those without any LF.

The BA procedure adopted by IPNI SEA can be done by any estate using very basic facilities. Only one of the IPNI SEA project sites had an existing Research Unit with BA facilities and experienced staff. At the other sites, BA teams were formed and trained in the IPNI SEA BA procedure, and facilities for BA were established by modifying existing buildings (such as a vacant staff house).

**CONCLUSION**

BA can be carried out by plantations without the need to establish sophisticated laboratories. BA of FFB from individual blocks can provide growers with information on the oil yield of individual blocks.

BA coupled with harvest audit data can provide estimates of the effects of variation in crop and harvesting management practices on potential oil (EPO) and recoverable oil (ERO), and allows assessments of the oil recovery efficiency in the field (FORE).

EOC of the FFB arriving at the mills will provide a more realistic means of evaluating mill performance in terms of oil recovery efficiency (MORE). Clear estimates of the EOC of incoming FFB will permit valuations and payments based on product contents to growers, thereby encouraging them to further improve FORE. A virtuous cycle of estimating potential product contents of individual FFB deliveries and using the information to improve crop recovery in the plantation may thus start.

A more holistic analysis of the two components (plantation and mill) in the overall oil recovery process based on the performance measures above will reduce friction between the two and foster better overall achievement.
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