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Evaluation of Two Fruit Typing Methods and Their Use in Assessing the Purity of Commercially Planted Topaz DxP Oil Palm Replants

MANJIT SIDHU, ABDUL AZIZ, ZULKASTA SINURAYA, ANG BOON BENG, SUCIPTO, RIZKI AKBAR, TAN KIM SENG, YOPY DEDYWIRYANTO, TAN JOON SHEONG, YOHANNES SAMOSIR AND MUKESH SHARMA

Asian Agri Group R&D Centre, Bahilang Estate, Tebing Tinggi, North Sumatra, Indonesia

A high level of dura *contamination can significantly reduce oil yield and oil extraction ratio (OER). Recent surveys carried out in oil palm nurseries, independent estates and the commercial sector in Malaysia by the Malaysian Palm Oil Board (MPOB), indicates that* dura *contamination remains a serious concern. Although no recent survey data is available from Indonesia, field visits to medium and smaller estates suggests a similar problem also exists there.*

Although genetic tools are now available for fruit typing, a simple, quick and practical survey method is still required, especially during due diligence visits to brownfield plantations up for acquisition, where quick decision making is required. This paper reports on the results of an investigation comparing the accuracy of two survey methods, namely individual palm survey (IPS) versus *harvester platform survey (HPS) and the use of both methods to assess the purity of Topaz D x P seedlings planted in progeny trials and in commercial second generation replants in Asian Agri estates in Indonesia.*

Results of the investigation conducted in three fields with varying levels of dura *contamination [low, medium, high], showed that inspecting harvested fresh fruit bunches (FFB) on 20 per cent of roadside harvesters platforms (HPS) was just as reliable as fruit typing individual palms (IPS) in the field. No significant differences were recorded between the two methods. At medium to low contamination levels, HPS tended to slightly over estimate contamination levels but differences were small and within acceptable range. As HPS is based on inspecting ripe and harvested FFB, it excludes counting of* pisifera *palms which are female sterile and bunches abort before maturity. Nevertheless, numbers of the latter in commercial fields were found to be low or negligible. The HPS method was also easier to conduct, faster and less labour intensive than IPS. However, if an individual palm survey was required, inspection at 5 to 10 per cent intensity was just as accurate as 100 per cent palm inspection.*

*IPS was used to assess the purity of new Topaz D x P progenies planted in 18 breeding trials established from 2003 to 2010. Out of the 28 772 palms individually inspected, only five palms were non-*tenera *[0.02%] and were detected in only four out of the 18 trials.*

The HPS was comprehensive, covering three provinces and a total of 14 estates which had undergone replanting from 2006 – 2016. Approximately 4 800 hectares were randomly surveyed encompassing 161 field blocks and 2 677 harvesters platforms (20 per cent). Out of over 25 000 FFB fruit typed, only 33 FFB (0.13 per cent) were found to be of dura *type. Such low levels of non-*tenera *contamination in both the progeny trials and commercial fields are a testament to the excellent quality control measures implemented by Asian Agri R & D's seed pollination unit and a guarantee on the purity of Topaz D x P seed.*

Keywords *: Contamination ,* dura*, D x P, oil palm, Topaz.*

One important prerequisite (amongst others) for high yields is the quality and purity of the planting materials to be used. In the latter case, a high level of contamination (e.g. by *dura* palms) can significantly reduce oil yield and oil extraction ratios (OER), as fresh fruit bunches (FFB) from *dura* (DxD) palms generally contain 23-35 per cent less oil than *tenera* (DxP) bunches of the same weight (Rao *et al.*, 1994; Corley & Law, 2001).

In Malaysia, in-house surveys and published reports have provided a reliable indication on the extent of *dura* contamination in oil plam seed planted over the last 30 years. Although *dura* contamination was evident even before the introduction of the pollinating weevil, *Elaeidobius kamerunicus*, into Malaysia, it only became serious after the weevil's release in 1981 (Rao *et al.*, 1994). Since then, high levels of contamination with *dura* palms have been reported from commercial plantings of DxP material from virtually all the major Malaysian seed producers, especially those planted between 1984 and 1990 (Donough & Law, 1995; Rajanaidu *et al.*, 1995). Contamination levels ranging from 1 to 60 per cent have been quoted and it is estimated that during this period (1984-1990) over 700 000 hectares in Malaysia could have been affected by *dura* contamination. Even with an average contamination of only 10 per cent, an area equivalent to 70 000 hectares could be planted with *dura* palms (Rajanaidu *et al.*, 1995). Chan and Lee (1994) report that since 1987, seed production agencies have tightened their controlled pollination procedures and reports of *dura* contamination in later plantings (1991 onwards) have been below 5 per cent. However, more recent surveys done in both independent plantations and nurseries as well as commercial sectors throughout Peninsular Malaysia, Sabah and Sarawak with shell DNA tests, indicates the problem still exists. Average non-*tenera* contamination rates were found to be 10-12 per cent (Leslie *et al.*, 2016; Lakey *et al.*, 2017).

The level of *dura* contamination in Indonesia remains uncertain as published reports on the subject matter are scarce. Nevertheless, issues and concerns regarding the common use of illegitimate seed by smallholders has been reported in the local press and seminars (Samosir *et al.*, 2019). Visits by the authors to oil palm plantings and mills in most of the provinces of Sumatera suggests that the problem also exists in Indonesia. Results from a comprehensive fruit typing survey conducted in 2002 covering over 74 000 hectares of generation one non-Topaz mature oil palm (1976-1998) and sampling over 235 000 fresh fruit bunches in Sumatera confirmed earlier observations (Sidhu *et al.*, 2002). Unlike Malaysia, the Indonesian survey noted no clear trend between *dura* levels and palms planted during pre or post weevil periods. However, a notable decline in seed purity was recorded between 1988 and 1998 when expansion of the oil palm hectarage in Indonesia was most rapid and at its height (Mamat & Chandramohan, 1996). The survey also recorded disparity in seed purity between the four seed sources evaluated. Highest contamination levels came from one of the two external local sources, although the better of the two, provided seed with purity on par with overseas sources (Sidhu *et al.*, 2002).

Seed purity remains a pertinent issue in view of the recent push by both the Malaysian and Indonesian governments to improve livelihoods of farmers by replanting less productive older palms with elite high yielding planting materials. Likewise, the level of non-*tenera* contamination would also be a major concern to companies whose expansion programmes include acquisition of plantations. As such, the importance of purchasing oil palm seeds from certified seed producers and surveying oil palm estates for non-*tenera* contamination prior to purchase, cannot be overemphasised.

For certified seed producers, Lakey *et al.* (2017) have proposed a two stage testing protocol. In stage one, 10 per cent of each batch of 1 000 pre-nursery seedlings undergoes SHELL DNA testing. If non-*tenera* contamination is less than or equal to 2 per cent, then no further testing is required and the remaining 90 per cent is classified as a low contamination, high performing batch. However, if non-*tenera* contamination exceeded 2 per cent, then the remaining 90 per cent of the seedlings in that batch should be comprehensively tested (second stage) to identify and remove all non-*tenera* palms. By doing so, national contamination rates will drop from 10-12 per cent to significantly below 2 per cent (Lakey *et al.*, 2017).

Although the SHELL DNA test kit can also be used for field planted palms, a quicker more direct fruit typing method may be warranted especially if immediate information on non-*tenera* contamination is required during due diligence visits for existing brownfield plantation acquisitions. This paper reports on the results of an investigation comparing the accuracy of two field fruit typing survey methods and using both to assess the purity of Topaz DxP progenies planted in breeding trials and commercially planted Topaz DxP oil palm in Asian Agri estates.

METHODOLOGY

Comparative accuracy of two fruit typing survey methods

An investigation was conducted to compare the accuracy of two fruit typing survey methods i.e. Individual Palm Survey (IPS) *versus* Harvester Platform Survey (HPS). The survey was done in three fields planted in1997 and 1998 with high (>30 per cent), medium (5-30%) and low (<5%) levels of non-*tenera* contamination. Planting material was from an external Indonesian seed producer.

Individual palm survey

This method involved inspecting fresh fruit bunches (FFB) on individual palms in all three selected fields at five census intensities shown in *Table 1*.

From each palm inspected, a single FFB with a minimum of two normal fruits were sampled for fruit typing purposes.

Harvester platform survey

This method involved inspecting harvested FFB placed on roadside platforms in the same three

TABLE 1
CENSUS INTENSITY OF INDIVIDUAL PALM SURVEY

Sampling intensity (%)	*Census method*
100	Inspection of every palm in every row
50	Inspection of every palm in alternate rows
25	Inspection of every palm in every fourth row
10	Inspection of every palm in every tenth row
5	Inspection of every palm in every twentieth row

fields. Twenty percent (one in every five) of all harvesters platforms in each field were sampled. A maximum of ten FFB were sampled in each selected platform. As harvested FFB are normally arranged in rows on the platform, the method outlined in *Appendix 1* was adopted for selection of bunches to be sampled. If the platform contained fewer than ten bunches, all bunches were sampled.

Duncan's multiple range test (DMRT) was carried out to determine statistical differences between the two survey methods and between the different census intensities of IPS.

Fruit typing criteria

For both survey methods, sampled FFB was classified into either of three fruit types categories i.e. *dura* (*Figure 1*), *pisifera* (*Figure 2*) or *tenera* (*Figure 3*) based on diagnostic characters as described by Turner and Gillbanks (1974) and summarised below :

Fruit type	*Diagnostic characters*
Dura (*Figure 1*)	i. Presence of a thick shell more than 2 mm width. ii. Absence of a concentric ring of dark mesocarp fibres surrounding shell/ kernel.
Pisifera (*Figure 2*)	i. Very small kernel. ii. Absence of a shell enclosing kernel. iii. Presence of concentric ring of dark mesocarp fibres surrounding kernel.
Tenera (*Figure 3*)	i. Presence of a thin shell less than 2 mm width. ii. Presence of a concentric ring of dark mesocarp fibres surrounding shell/ kernel.

From each FFB, a minimum of two normal fruits were cut cross-sectionally for fruit typing purposes.

Figure 1 Dura *fruitlet*

Figure 2 Pisifera *fruitlet*

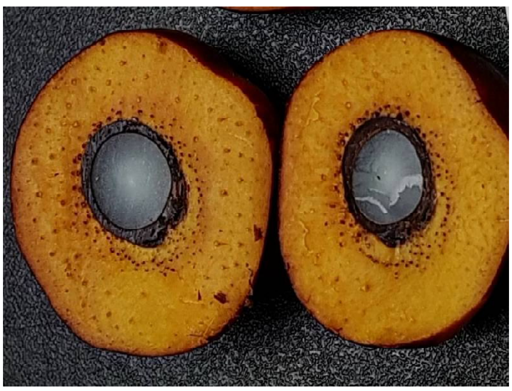

Figure 3 Tenera *fruitlet*

Topaz Oil Palm Research Station (OPRS) progeny trials survey

To gauge the quality of Topaz Oil Palm Research Station's controlled pollination programme, IPS was carried out in 18 progeny trials planted from 2003-2010. All 28 772 palms were sampled and categorised using fruit typing criteria described earlier.

Commercial field survey

Asian Agri commenced its cocoa to oil palm replanting in 2006 followed by rubber to oil palm and oil palm to oil palm replanting from 2010 onwards using Topaz DxP progenies.

A commercial field survey was undertaken in 2016 and 2019 to determine the level of purity of the commercially produced Topaz DxP seed.

The survey was carried out in all replantings from 2006 to 2016, encompassing 20 per cent of the total planted area in three provinces (North Sumatra, Riau, Jambi) in Indonesia. The HPS methodology was used with 20 per cent sampling of all harvester's platforms in each selected block/field.

RESULTS AND DISCUSSION

Comparative accuracy of two fruit typing survey methods

Results of the investigation are summarised in *Table 2.*

No significant differences in *dura* contamination levels were recorded between HPS and IPS methods. At medium (5-30%) to low levels (<5%) of the latter, HPS tended to slightly over estimate *dura* contamination but the variation (1.7-2.2 percentage points) was highly acceptable. In a number of cases, it was suspected that the over estimation was a result of two or more bunches being harvested from the same palm, especially during peak cropping periods. An additional drawback of HPS is that it cannot estimate the level of *pisifera* contamination, as the latter variety is often female-sterile and bunches abort before maturity (Tuner & Gillbanks, 1974). However, based on results of IPS, *pisifera* palm populations were generally very low (0.1-1.5%) and unlikely to contribute significantly to overall non-*tenera* contamination levels (*Table 2*).

As the HPS was conducted on roadsides, it was easier to carry out, faster and less labour intensive than IPS. The latter method can be tedious to implement especially on hilly terrain without terraces or in fields where access was difficult due to poor field upkeep and agricultural standards (a common feature in estates put up for sale).

In the case of the IPS method, no significant differences in *dura* levels were noted between the different sampling intensities evaluated. Palm inspection at 5 to 10 per cent sampling intensity was found to be as reliable as 100 per cent.

Progeny trials

Results of the IPS conducted in the 18 progeny trials established from 2003 to 2010 are summarised in *Table 3*.

Out of the 28 772 palms inspected, only five palms were non-*tenera* (0.02%) and were detected only in four out of the 18 trials. Such low levels of contamination are a testament to the excellent quality control measures implemented by the R&D pollination unit.

Commercial fields

The HPS survey was comprehensive, covering three provinces and a total of 14 estates which had undergone replanting from 2006-2016. Approximately 4 800 hectares encompassing

TABLE 2
COMPARATIVE EFFICACY OF TWO SURVEY METHODS FOR NON-*TENERA* CONTAMINATION

Field number	*Area (Ha)*	*Year of planting*	*Total palms*	*No.of palms inspected*	*IPS[1] survey intensity (%)*	*Number of palms detected*							
						Dura	%	Tenera	%	Pisifera	%	*Others[3]*	%
B3	34.8	1998	5073	5 073	100	2 648	52.2 a*	2145	42.3	1	0	279	5.5
				2 540	50	1304	51.3 a	1091	43.0	1	0	144	5.7
				1 291	25	645	50.0 a	577	44.7	1	0	68	5.3
				528	10	282	53.4 a	220	41.7	0	0	26	4.9
				265	5	142	53.6 a	111	41.9	0	0	12	4.5
				-	HPS[2]	-	52.2 a	-	-	-	-	-	-
F15	30.7	1997	4159	4 159	100	877	21.1 a	2921	70.2	60	1.5	301	7.2
				2 081	50	433	20.8 a	1460	70.2	24	1.2	164	7.8
				1 058	25	242	22.9 a	722	68.2	3	0.3	91	8.6
				442	10	94	21.3 a	316	71.5	1	0.2	31	7.0
				242	5	45	18.6 a	176	72.7	1	0.4	20	8.3
				-	HPS[2]	-	23.3 a	-	-	-	-	-	-
G4	34.3	1998	4831	4 831	100	128	2.7 a	4195	86.8	12	0.2	469	10.3
				2 479	50	78	3.2 a	2140	86.3	7	0.3	254	10.2
				1 286	25	56	4.4 a	1116	86.8	2	0.1	112	8.7
				503	10	10	2.0 a	450	89.5	0	0	43	8.5
				282	5	9	3.2 a	249	88.3	0	0	24	8.5
					HPS[2]	-	4.4 a	-	-	-	-	-	-

[1] Individual palm survey
[2] *Dura* survey based on inspecting harvested ffb placed on harvesting platforms
[3] Non-bearing palms (including abnormal palms)
* Values of *dura* contamination with similar alphabets are not statiscally different

TABLE 3
RESULTS OF FRUIT TYPING SURVEY IN TOPAZ DXP PROGENY TRIALS ESTABLISHED FROM 2003-2010

Progeny trial number	*Year of planting*	*Number of palms sampled*	*Total number of palms*			*Non*-tenera *palms (%)*
			Tenera	Dura	Pisifera	
2	2003	1 601	1 599	2	0	0.13
7	2004	802	802	0	0	0
8	2006	1 131	1 131	0	0	0
9	2006	1 038	1 038	0	0	0
13	2006	603	603	0	0	0
14	2007	1 281	1 281	0	0	0
15	2007	1 322	1 322	0	0	0
16	2007	1 300	1 299	1	0	0.08
18	2007	1 205	1 205	0	0	0
19	2008	2 079	2 079	0	0	0
20	2008	2 956	2 956	0	0	0
21	2008	1 668	1 668	0	0	0
22	2008	1 359	1 359	0	0	0
26	2008	1 921	1 921	0	0	0
27	2008	2 485	2 485	0	0	0
29	2008	1 880	1 880	0	0	0
30	2009	2 344	2 343	1	0	0.04
31	2010	1 797	1 796	1	0	0.06
Total	2003-2010	28 772	28 767	5	0	0.02

161 blocks of mature oil palms were surveyed and more than 25 000 FFB sampled from 2 677 harvesters' platforms (20%) were fruit typed.

Out of the total number of 25 409 FFB sampled, only 33 FFB (0.13%) were found to be of *dura* type. Of the three provinces, *dura* contamination was highest in Jambi (0.47%) and lowest in Riau (0.09%). North Sumatra estates were intermediate, averaging 0.11 per cent (*Table 4*).

The extent of *dura* contamination in relation to year of oil palm replanting is summarised in *Table 5*. Highest *dura* contamination was recorded in the 2013 (0.55%) and 2014 (0.44%) replants. On the other hand, very low levels of contamination ranging from 0.08-0.16 per cent were recorded in the 2009, 2011, 2012, 2015 and 2016 replants. Replanting undertaken in 2006, 2007, 2008 and 2010 was free of contamination.

The levels of *dura* contamination recorded in the second generation Topaz DxP oil palm replants were significantly lower than those recorded in the first generation non-Topaz plantings whose seed was outsourced from other local and overseas producers. In an extensive survey covering 74 753 hectares and sampling over 235 701 FFB, Sidhu *et al.* (2002) recorded an average contamination level of

TABLE 4
RESULTS OF FRUIT TYPING SURVEY IN TOPAZ DXP OIL PALM PLANTINGS IN NORTH SUMATRA, RIAU AND JAMBI PROVINCES

Year of planting	*Total number of blocks*	*Total number of blocks sampled*	*%*	*Total number of HP*[1]	*Total number of HP sampled*	*%*	*Total number of FFB*[2] *sampled*	*Number of FFB bunches*		Dura *contamintaion (%)*
								Tenera	Dura	
North Sumatra										
2006	8	4	50	308	63	20	574	574	0	0
2007	11	3	27	192	39	20	390	390	0	0
2008	89	17	19	1 450	293	20	2 185	2 185	0	0
2009	45	7	16	732	148	20	1 230	1 228	2	0.16
2010	110	14	13	860	177	21	1 556	1 556	0	0
2011	132	10	8	790	152	19	1 224	1 222	2	0.16
2012	106	9	9	560	105	19	980	979	1	0.10
2013	60	9	15	423	100	24	1 253	1 246	7	0.55
2014	30	10	33	354	90	25	900	896	4	0.44
2015	23	15	65	934	214	23	2 140	2 139	1	0.05
2016	26	15	58	1 252	267	21	2 673	2 673	0	0
2006-2016	640	113	18	7 255	1 648	23	15 105	15 088	17	0.11
Riau										
2010	22	4	18	168	32	19	263	263	0	0
2011	44	7	16	236	46	20	582	582	0	0
2012	50	7	14	272	56	21	509	508	1	0.20
2015	16	10	63	1 240	273	22	2 730	2 727	3	0.11
2016	19	10	53	2 104	453	22	4 530	4 526	4	0.09
2010-2016	151	38	25	4 020	860	21	8 614	8 606	8	0.09
Jambi										
2016	17	10	59	976	169	17	1 690	1 682	8	0.47
2016	17	10	59	976	169	17	1 690	1 682	8	0.47

[1] HP = harvester's platform
[2] FFB = Fresh fruit bunches

TABLE 5
RESULTS OF FRUIT TYPING SURVEY IN TOPAZ DXP OIL PALM PLANTINGS FROM 2006-2016 IN AAS ESTATES IN NORTH SUMATRA, RIAU AND JAMBI PROVINCES

Year of planting	*Total number of blocks*	*Total number of blocks sampled*	*%*	*Total number of HP*[1]	*Total number of HP sampled*	*%*	*Total number of FFB*[2] *sampled*	*Number of FFB bunches*		Dura *contamintaion (%)*
								Tenera	Dura	
2006	8	4	50	308	63	20	574	574	0	0
2007	11	3	27	192	39	20	390	390	0	0
2008	89	17	19	1 450	293	20	2 185	2 185	0	0
2009	45	7	16	732	148	20	1 230	1 228	2	0.16
2010	132	18	14	1 028	209	20	1 819	1 819	0	0
2011	176	17	10	1 026	198	19	1 806	1 804	2	0.11
2012	156	16	10	832	161	19	1 489	1 487	2	0.13
2013	60	9	15	423	100	24	1 253	1 246	7	0.55
2014	30	10	33	354	90	25	900	896	4	0.44
2015	39	25	64	2,174	487	22	4 870	4 866	4	0.08
2016	62	35	56	4,332	889	21	8 893	8 881	12	0.13
2006-2016	808	161	20	12 851	2 677	21	25 409	25 376	33	0.13

[1] HP = Harvester's platform
[2] FFB = Fresh fruit bunches

5.2 per cent. However, *dura* levels in individual estates ranged from 0 to 28 per cent and was as high as 66 per cent in a few individual fields. Only three out of the 45 estates surveyed were *dura* free.

CONCLUSION

The comparative investigation between two fruit typing methods showed that HPS was sufficient for obtaining a reliable estimate on the extent of *dura* contamination in a mature oil palm planting. It clearly demonstrated that as a method for fruit typing, inspecting harvested FFB placed on 20 per cent of roadside platforms was a valid substitute to fruit typing individual field palms. It was also easier to conduct, faster and less labour intensive than the IPS method. However , if an individual palm survey was required, then census conducted at 5 to 10 per cent intensity was just as reliable.

The results of the comprehensive surveys carried out in both Topaz DxP progeny trials and commercial field plantings, is a testament of the good quality control procedures practiced by Asian Agri's seed production unit and a guarantee on the purity of Topaz DxP planting materials, which have been made available to the oil palm industry since 2004. The average *dura* contamination levels of 0.13 per cent in commercial plantings was much lower than the maximum levels of 2 per cent and 5 per cent currently being proposed by Indonesian and Malaysian authorities respectively (Lakey *et al.*, 2017).

The excellent quality control achieved by reliable and genuine seed producers thus questions the need to impose mandatory seed testing *via* molecular technology, as proposed by some. The majority of seed producers are aware that the problem does not lie at source but with unscrupulous, illegitimate seed suppliers and nursery operators, who supply spurious and adulterated planting materials to the unsuspecting smallholders and farmers. Apart from increasing the cost to seed producers (which will be passed down to the buyers), mandatory testing at the seed production centres will not be able to safeguard seed purity once it leaves a seed producer's door, along the long route to the buyers farms. Encouraging small farmers to buy directly from seed producers, mobile marketing of seed and pre-nursery seedlings direct to the latter, establishing regional nursery outlets managed by the seed producers themselves and launching of educative campaigns on social, electronic and print media may be a more effective alternative to mandatory seed testing (Samosir *et al.*, 2019). Likewise, enchanced commitment and action is also required by both the Malaysian and Indonesian government authorities to combat the problem of spurious and illegitimate planting materials, which is the main cause of high levels of non-*tenera* contamination in the plantation industry. Blocking of illegitimate websites selling spurious seed and taking legal action against unlicensed nursery operators are just some of the proposals put forward by the seed producers to local government bodies (Samosir *et al.*, 2019).

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REFERENCES

CHAN, K.W. and LEE, K.H. 1994. A concern facing the oil palm industry. In: *Proceedings of National*

Seminar on Palm Oil Extraction Rate:Problems and Issues. (Darus, A. and Jalani B.S., eds), Kuala Lumpur 1993. Kuala Lumpur: Palm Oil Research Institute of Malaysia. 1-16.

CORLEY, R.H.V. and LAW I.H. 2001. Ripening, harvesting and oil extraction. *The Planter* **77** (906): 507-524.

DONOUGH C.R. and LAW I.H. 1995. Breeding and selection for seed production at Pamol Plantations Sdn Bhd and early performance of Pamol DxP. *The Planter* **71** (836):513-530.

LESLIE, C.L., ENG-TI, L and MELINA, O.A 2016. Non-tenera contamination and the economic impact of shell genetic testing in the Malaysian independent oil palm industry. *Frontiers in Plant Science* Vol.**7**:13pp.

LAKEY, N.D., ORDWAY, J.M., JIANG, N. and SMITH S.W. 2017. Increasing oil palm industry profit, Malaysian gross national income and government tax revenue with breakthrough DNA tests. *The Planter* **93** (1093): 273-279.

MAMAT, S. and CHANDRAMOHAN, D. 1996. Status and prospects of the oil palm industry in selected countries. Paper presented at the Seminar on Sourcing of Oil Palm Planting Materials for Local and Overseas Joint-Venture, 1996. Kuala Lumpur. Asgard Information Services. 1-10.

RAJANAIDU, N., JALANI, B. S., CHEAH, S.C. and AHMAD KUSHAIRI, D. 1995. Oil palm breeding: Current issues and future developments. In: *Proceedings of the PORIM International Palm Oil Congress 'Update and Vision'* (Jalani *et al.*, eds). Kuala Lumpur 1993. Kuala Lumpur: Palm Oil Research Institute of Malaysia. 9-23.

RAO, V., JALANI, B.A. and RAJANAIDU, N. 1994. Effect of dura contamination on oil extraction rates. In: *Proceedings of National Seminar on Palm Oil Extraction Rate : Problems and Issues* (Darus, A. and Jalani B.S., eds.). Kuala Lumpur 1993. Kuala Lumpur: Palm Oil Research Institute of Malaysia. 58-60.

SAMOSIR, Y., SIDHU, M.S. and ANG, B.B. 2019. Change planting material. Presentation at the National Seminar on Smallholder Oil Palm Replanting, Jakarta, 10-11 July 2019.

SIDHU, M.S., CHEONG, K.K., MOK, C.K., SURIANTO, AZIZ, A., SINURAYA, Z. and HENDRA, S. 2002. Dura contamination in some oil palm estates in Sumatera, Indonesia. Asian Agri Group Special Project Report. Restricted Circulation, 19 pp.

TUNER, P.D. and GILLBANKS, R.A. 1974. *Oil Palm Cultivation and Management*. First edn. 672 pp. Kuala Lumpur: The Incorporated Society of Planters.

APPENDIX 1

HARVESTER PLATFORM SURVEY (HPS)

Survey location	:	Fresh fruit bunches (FFB) on harvester platform (HP) along collection roads
Sampling intensity	:	20 per cent (1:5 HP)
Sampling procedure	:	(i) when HP has ≤10 FFB, all FFB should be sampled (ii) when HP has 11-20 FFB, one FFB from each pair of FFB should be sampled until a minimum of 10 FFB are sampled (iii) when HP has > 20 FFB, the following sampling protocal is advised : ▪ 5 rows of FFB : sample 2 FFB/row ▪ 6-10 rows of FFB : sample 2 FFB/row from rows 1,3,5,7,9 ▪ 11-15 rows of FFB : sample 2 FFB/row from rows 1,4,7,10,13 (iv) From each FFB, select 2 attached fruitlets and cut them cross-sectionally to confirm fruit type as per *Figures 1-3*