The Planter, Kuala Lumpur, ***98*** *(1153): 257-268 (2022)*

Advancement in Oil Palm Planting Materials in the Future*

RAJANAIDU NOOKIAH
Academy of Sciences Malaysia, Menara Matrade, Tingkat 20, Sayap Barat, Jalan Sultan Haji Ahmad Shah, 50480 Kuala Lumpur, Malaysia

The development of shorter planting materials based on MPOB Nigerian population 12 and E.oleifera *x* E.guineensis *inter-specific hybrids is highlighted in this paper. The progeny test results of Nigerian Population 12 with selected Deli* duras *showed that the DxP oil yield ranges from 8.1-8.5 tonnes per hectare per year. The height increment of DxP is 33-39 cm per year. In comparison, the height increment of Deli x AVROS is about 60 cm per annum.*

In Colombia where DxP commercial plantations are devastated by bud rot disease, Cinepalma demonstrated that application of naphthalene acetic acid (NAA) increased the oil yield of inter-specific hybrids which are tolerant to the disease. It was demonstrated in commercial plantations that applying NAA can produce more than 40 tonnes fresh fruit bunch (FFB) per hectare per year, with an extraction rate of about 27 per cent giving >10 tonnes oleic oil per hectare.

The tissue culture labs in Kuala Lumpur-Kepong (KLK) and Asian Agri are also cloning their elite Deli duras *and* pisiferas *to create semi- and bi- seeds. Applied Agricultural Resources (AAR) is the largest semi-clonal seed producer in Malaysia, and produces about 8 million per year and sells the seeds at a premium.*

A number of plantation companies in Malaysia and Indonesia have initiated programmes to produce Ganoderma *tolerant planting material. Companies have adopted an integrated disease management (IDM) approach, covering land preparation, planting tolerant varieties, use bioagents, early detection, and removal of infected materials. Asian Agri AA TOPAZ GT variety, partially tolerant to* Ganoderma*, has an average oil yield potential of 9.2 tonnes crude palm oil (CPO) per hectare per year.*

Digitalisation refers to the process of integrating advanced digital technologies such as artificial intelligence (AI), big data, robotics, unmanned aerial vehicle (UAV), sensors, and communication networks, all connected through Internet of Things (IoT) into farm production system.

A major breakthrough was achieved by the oil palm Genome Programme at the Malaysian Palm Oil Board (MPOB), where the identification of the gene controlling Shell has made it possible to identify and differentiate dura, tenera *and* pisifera *at the nursery stage. This led to the first molecular diagnostic assay known as SureSawit™ SHELL, which the breeders can use to identify and isolate* dura, tenera *and* pisifera *seedlings from TxT and TxP breeding crosses. The kit can be used for identification of* dura *and* pisifera *contaminants in the nursery and more recently at the seed production facility.*

The planter has an important role to help realise the full potential of planting materials. The planter's role starts from receipt of germinated seeds to field planting. The planter is assigned to monitor ripeness standard, harvesting, loose fruit collection and managing of workers, all of which are major tasks to ensure productivity.

Climate change is real and we have to confront drought and floods more frequently. In order to minimise the impact of drought, it is advisable to plant planting materials with high bunch number. MPOB has collected oil palm germplasm in the dry areas of Nigeria. This germplasm has attributes such as high

* Edited version of the paper presented at the 15th ISP National Seminar 2022 Book, "Addressing Challenges in Plantation Management", from 14-15 March 2022 at Royale Chulan Kuala Lumpur.

bunch number, low bunch weight and high chlorophyll content in the leaves. These traits are useful to develop drought tolerant planting materials.

***Keywords**: MPOB Nigerian Population 12, interspecific hybrids, tissue culture ramets,* Ganoderma *tolerant, digitalisation, oil palm genome, climate change.*

Current oil palm planting materials are conventional DxP, semi- and bi-clonal seeds and tissue culture clonal materials. In Central/ South America, inter-specific hybrids are planted at commercial level. The interspecific hybrids are tolerant to bud- rot which is caused by *Phytophthora palmivora*. Fortunately, this disease has not reached South East Asia. The past two years (2021-2022) have been a very challenging period to the oil palm industry. The spread of Covid-19 impacted oil palm operational activities. The supply of foreign workers from Indonesia, Bangladesh and India has been disrupted. This had cascading effect on harvesting, yield recording, pollination of parental palms, bunch analysis, seed production activities etc. The impact of climate change has brought devastating floods during this period and further affected plantation activities. Obviously, it is a challenging time for the oil palm breeders to assess the performance of their breeding materials.

The major planting material used by the oil palm industry is *dura* crossed to *pisifera* (DxP). The DxP or the resulting *tenera* fruit form yields 30 per cent more oil compared to DxD based planting materials. Introduction of the DxP hybrid seeds signaled first wave of yield improvement. As expected, there was a huge demand for DxP seeds, but there was a shortfall due to limited number of *pisifera* palms available in South East Asia at that time. As such, the far-east oil palm plantations started to import *pisifera* pollen to produce DxP seeds. Fortunately for Malaysia, there was an African *pisifera* palm, 27^B, at the Department of Agriculture (DOA), Serdang and it was no surprise that DOA became the main supplier of pollen to the seed producers in Malaysia.

Initially, Belgian Congo INEAC was the main centre for oil palm research located at Yangambi. The well-known Yangambi pollen is derived from the famous Djongo palm in Congo. Later oil palm breeding research shifted to the West African Institute for Oil Palm Research (WAIFOR)/Nigerian Institute for Oil Palm Research (NIFOR) in Nigeria and IRHO/CIRAD in Ivory Coast and Benin. The civil war in Belgian Congo completely destroyed the oil palm research infra-structure but the vast germplasm accumulated by Belgians formed an important resource to develop outstanding *pisifera* palms such as SP540, AVROS and Yangambi. Subsequently, the French (IRHO) developed La Me *pisifera*s in Ivory Coast, while the English *via* Pamol in Cameroon established the Ekona *pisifera* and in Nigeria the Calabar *pisifera*s. In Malaysia, Guthries imported *pisifera* pollen from Congo and made crosses to Deli *duras* to obtain *tenera* palms, which were selfed to develop URT/URP *pisifera*s. Companies such as AAR developed hybrid *pisifera*s by crossing Dumpy E206, 27^B, Yangambi/AVROS. Felda Global Ventures (FGV) produces 3-way cross by mating Deli *dura* x Nigerian MPOB *dura* and the hybrid *duras* were later crossed to ML 161 (Yangambi) *pisifera* to produce 3-way DxP planting materials. The *pisifera* palms mentioned above currently form the core of all oil palm breeding programmes in the world. The Deli *duras* derived from the four Bogor palms planted in 1848 are still the major source of female parents for commercial seed production (Rajanaidu *et al.*, 2013).

The status of the Malaysian oil palm industry is given in *Table 1*. Details of planted area, crude palm oil (CPO) production, fresh fruit bunch (FFB) yield and oil extraction rate (OER) are listed. The FFB yield, CPO yield per hectare and OER of three major plantation companies, FGV, IOI, and United Plantations (UP) are highlighted in *Table 2*.

DEVELOPMENT OF SHORTER PLANTING MATERIALS

Harvesting accounts for nearly 30 per cent of

TABLE 1
STATUS OF OIL PALM INDUSTRY IN MALAYSIA 2020-2021

Parameters	*2020*	*2021*	*% difference (+ or -)*
Planted area (million ha)	5.74	5.81	-2.2
CPO production (mn T)	18.2	19.14	-5.3
FFB yield (t/ha)	15.47	16.73	-7.5
Oil extraction rate (%)	20.01	19.92	+0.5
Planted area in Malaysia by category (2021)			
Total	5.74 million ha		
Private, government/state estates	4.20 million ha (73.2%)		
Organised smallholders	0.67 million ha (11.7%)		
Independent smallholders	0.86 million ha (15.1%)		

Source: MPOB (2022)

TABLE 2
YIELD PROFILE OF SELECTED PLANTATION COMPANIES IN MALAYSIA

Company and factors	*2018*	*2019*	*2020*	*2021*
FGV				
FFB yield (tonnes/ha)	16.9	19.4		
OER (%)	20.49	20.78		
Oil/ha (tonnes/ha)	3.46	4.03		
IOI				
FFB yield (tonnes/ha)		23.0	21.2	20.8
OER (%)		21.4	21.8	21.4
Oil/ha (tonnes/ha)		4.92	4.62	4.45
UP				
FFB yield (tonnes/ha)	26.20	25.88	26.65	
OER (%)	21.80	22.02	22.24	
Oil/ha (tonnes/ha)	5.71	5.70	5.93	

Source : Companies' websites

the production cost in oil palm. To assist harvesting, the Malaysian Palm Oil Board (MPOB) looked for slow growth trait in its germplasm collection, which was successfully identified in MPOB's Nigerian Population 12, which is of short stature with height increment of 22 cm per year. Using Population 12, MPOB developed shorter planting material, namely PS1.1, details of which are outlined below.

The other source for dwarf genes in oil palm is *E.oleifera*. The introgression of *oleifera* dwarf genes into *E.guineensis* to produce OxG inter-specific hybrids described is also further discussed in this section.

MPOB (PS 1.1)

MPOB has developed PS1.1 planting materials involving Deli *duras* with larger fruits (>15 g) as shown in *Table 3*. These Deli *duras* were crossed to Nigerian Population 12 *pisiferas* collected in places as shown in *Figure 1*. The Population 12 was sampled in East Central State in Nigeria. The height increment of these *pisiferas*/*teneras* is 20-27 cm per annum (*Table 4*) compared to AVROS at 40-60 cm per annum. The progeny testing results of Nigerian Population 12 *pisiferas* is given in *Table 5*. The oil yield is 8.1-8.5 tonnes per hectare per year (*Figure 2*) and the height increment is 33-39 cm per year (*Figure 3*). During the coronavirus pandemic, there was a major disruption of labour supply in Malaysia, which highlighted the issues related to harvesting. Wider use of MPOB PS1.1 planting material, will make it easier to harvest the shorter oil palm trees and facilitate the adoption of automation in commercial fields (Rajanaidu *et al.*, 2017). The Nigerian Population 12 progenies also show low lipase activity compared to current DxP material. It provides an opportunity to lengthen harvesting round from 10-15 days to 30 without sacrificing oil quality.

INTER-SPECIFIC HYBRIDS

Renewed interest in the *E.oleifera* was brought about by the bud rot disease in Central and South America and its devastating impact on *E.guineensis* plantations. MPOB collected *Elaeis oleifera* germplasm in Honduras, Nicaragua, Costa Rica, Panama, Colombia, Suriname and Brazil (ex-Department of

TABLE 3
SELECTED DELI *DURA* PALMS IN TRIAL 0.338 FOR HIGH OIL YIELD

Palm no.	*Average FFB yield (1998-2003)*		*Oil yield*		*Oil/bunch*
	kg/p/yr	*t/ha/yr*	*kg/p/yr*	*t/ha/yr*	*%*
451	231.78	34.30	60.38	8.94	26.05
360	192.70	28.52	51.03	7.55	26.48
45	198.04	29.31	49.39	7.31	24.94
215	205.14	30.36	47.78	7.07	23.29
190	202.74	30.01	46.04	6.81	22.71
330	210.98	31.23	44.12	6.53	20.91
382	194.66	28.81	42.81	6.34	21.99
157	195.96	29.00	42.78	6.33	21.83
277	211.76	31.34	41.95	6.21	19.81

Figure 1 Map of Nigeria indicating Nigerian sampling sites

TABLE 4
PERFORMANCE OF PROGENIES OF MPOB-NIGERIAN POPULATION 12 IN TRIAL 0.337
(PLANTED IN 1994)

Progeny	*Pedigree*	*FFB (kg/p/yr)*	*O/B (%)*	*HTI (cm/yr)*
PK1040	12.06 x 12.06	166.43	24.49	20
PK1105	12.01 x 12.01	147.73	22.98	22
PK1151	12.04 x 12.04	167.15	25.37	22
PK1201	12.04 x 12.04	138.23	24.27	27
PK1211	12.04 x 12.04	165.48	23.98	22
PK1228	12.04 x 12.06	167.19	25.59	27
D x P	E206 x AVROS	110.22	26.48	35

Note:
FFB - fresh fruit bunch, O/B - oil to bunch, HTI - height increment

Agriculture, Malaysia). Recently, collections were also gathered from Ecuador (Taisha) and Peru (Pastaza). *E.oleiferas* possess a number of desirable traits for oil palm breeding, such as higher unsaturated oil, slower height increment and tolerance to bud rot caused by *Phytophthora palmivora* (Martinez, 2009).

The inter-specific hybrids between *E.oleifera* and *E.guineensis* are another source for dwarf genes to produce shorter planting materials. Initially, plant breeders assembled and studied *oleiferas* in Central

TABLE 5
PERFORMANCE OF PS1.1 DxP

Pisifera x Dura (Tenera)	*FFB (t/h/y)*	*BNO*	*ABW (kg)*	*MFW (g)*	*M/F (%)*	*K/F (%)*	*O/DM (%)*	*O/B (%)*	*OY (t/ha)*	*TEP (t/ha)*	*FP*	*HTI (cm/y)*
0.338/10 x 0.337/622	221.0	14.8	13.7	11.1	84.9	5.0	81.3	31.3	9.9	10.5	28.7	38
0.338/391 x 0.337/622	227.5	14.9	15.6	13.4	86.9	4.0	82.0	30.9	8.4	8.8	26.6	30
0.338/89 x 0.337/622	219.8	14.4	14.9	12.9	84.3	4.5	81.4	30.7	8.3	8.7	24.9	38
0.338/89 x 0.337/622	233.1	15.3	14.2	12.0	85.2	5.4	81.2	28.5	8.4	9.0	26.3	32
0.338/89 x 0.337/554	256.8	15.9	16.5	14.4	81.4	6.9	81.6	28.2	7.8	8.5	25.5	29
0.338/391 x 0.337/554	252.6	14.7	18.1	16.1	83.8	6.2	81.5	28.5	8.1	8.7	25.0	28
0.280/65 x 0.337/622	278.2	15.1	16.5	10.5	83.3	5.8	80.8	28.3	8.1	8.8	27.8	33
0.212/272 x 0.174/211 (control)	203.0	12.4	16.2	15.3	79.6	7.2	81.5	29.1	7.3	8.0	29.9	46

Note:
FFB - fresh fruit bunch, BNO - bunch number, ABW - average bunch weight, MFW - mean fruit weight, M/F - mesocarp to fruit, K/F - kernel to fruit, O/DM - oil to dry mesocarp, O/B - oil to bunch, OY - oil yield, TEP - total economic product, FP - frond production, HTI - height increment

America (Nicaragua, Honduras, Costa Rica, Panama, Colombia). The hybrids based on *guineensis* and Central American *oleiferas* had attractive oil quality but oil to bunch is very low compared to commercial DxP planting materials.

New *oleifera* populations were discovered in Brazil (Coari, Manaus Manicore), Ecuador (Taisha), and Peru (Pastaza). These *oleiferas* have been progeny tested with AVROS, La Me and Yangambi *pisiferas*, and the resulting inter-specific hybrid FFB yield and oil/bunch are acceptable, especially with assisted pollination. These hybrids also exhibit reduced height increment and low free fatty acid.

For the past 20 years, the commercial company Palmar del Rio (PDR) has been collecting *E.oleifera* in Ecuador and evaluating them in the form of interspecific OxG hybrids for FFB and oil yield. The Ecuadorian *oleifera*

Figure 2 PS1.1 - Cross-section of fruits

Figure 3 Height comparison - left is PS1.1 palm and on the right is control

population showed resistance to South American Bud Rot (PC), slow vertical growth (5 to 7 cm/year), long bunch stalk, uniform anthesis, almost free from bunch spathes. These traits are rather unique to Taisha populations, making the population the most promising for OxG hybrid production (Julian Barba, 2010).Their average FFB production is 25 tonnes per hectare per year and oil content extracted in the laboratory for certain families has reached 24 per cent, with oil high in oleic acid. A significant proportion of *E. oleifera*, population collected from Pastaza (Peru) had better oil content than the Taisha. Nevertheless, there are certain disadvantages associated with interspecific OxG hybrids, among which include:

Low extraction rate at mill (18.5- 21%),
Requires assisted pollination,
Some crosses have androgyny inflorescences, and
Low pollen production and germination.

Recent publications from Colombian Oil Palm Research Center (Cinepalma) highlighted the use of naphthalene acetic acid (NAA) to realise potentially higher oil yield in inter-specific hybrids. The 1200 mg per L NAA treatments consistently showed the most outstanding results in terms of bunch formation, bunch component characteristics and oil yield. Romero *et al*. (2021) have shown commercial plantations can produce more than 40 tonnes per hectare per year FFB (with 27% OER) resulting in more than 10 tonnes per hectare per year of high oleic palm oil. The research was conducted on five to six-year-old inter-specific OxG hybrids, cultivar "Coari x La Me".

Studies at Unipalma had shown that the OER can reach up to 28 per cent by applying a mixture of Pollen + NAA + Talc, and the FFB yield realised could be 35 tonnes per hectare. It is possible to use drones to apply NAA mixture on inflorescence at anthesis, and interestingly Taisha based hybrids lack prominent bracts to interfere with pollination by drones. Ochoa *et al.* (2021) suggests to apply NAA at low dose with pollen for inflorescences at anthesis and high doses of NAA for inflorescences at post anthesis.

Cloning and semi-clonal seeds

With the advent of the tissue culture technology, it is possible to clone elite *tenera*, Deli- *dura* and *pisifera* palms to produce clones, as well as semi- and bi-clonal seeds. Most breeding companies have started cloning their elite *dura*s, and *pisifera*s based on progeny test results obtained from DxP/DxT crosses. At present the large plantation companies such as IOI, KLK, PT SMART, Asian Agri have their own tissue culture laboratories and produce clonal plantlets for their own needs. The FFB produced in their plantations are processed in their mills and the companies benefit from higher OER obtained compared to DxP seedlings.

The tissue culture technique is an extremely useful tool to clone elite Deli *dura* and *pisifera* palms identified based on progeny testing, which has made it possible to produce semi- and bi-clonal seeds. Currently, AAR is the major semi-clonal seed producer in Malaysia. UP and Asian Agri have cloned elite Deli *duras* and *pisiferas* to produce bi-clonal seeds. It will be helpful for a national agency like MPOB to assist oil palm breeders in Malaysia to clone their parental palms in order to scale up the production of semi- and bi-clonal seeds.

The production of DxP, semi-clonal and clonal ramets in Malaysia is listed in *Table 6a*. FGV is the top DxP seed producer in Malaysia (21.3 million) and AAR is the leading producer

TABLE 6a
DXP, SEMI-CLONAL AND CLONAL PRODUCTION IN MALAYSIA (2021)

Company	*DxP/Semi-*	*Clones*	*Price*
FGV	21.3 million	345,000	
Sime Darby Plantation	8 million		Calyx RM 3.60
AAR	8 million (Semi-)	600,000	Semi-D RM 3.20
United Plantations	4 million		
IOI	4 million	1,000,000	

Source: Pers. com. with the respective companies

of semi- D seeds (8 million) and IOI is the top producer of clonal materials. The gross DxP seed production in Malaysia is 50 million in 2021 (*Table 6b*) .

TABLE 6b
SEED PRODUCTION IN MALAYSIA

Year	*Production (million)*
2019	41.1
2020	39.2
2021	50.0

Source: MPOB (2022)

Ganoderma tolerant planting materials

Ganoderma is a major disease in South East Asia (Indonesia, Malaysia) and Papua New Guinea (PNG). At the recent ISOPB (International Society for Oil Palm Breeders) Seminar which focused on *Ganoderma*, wide scale screening of oil palm progenies in Indonesia for tolerance to *Ganoderma* was highlighted. Indonesian companies such as Socfindo, Asian Agri, and PT SMART have released partially *Ganoderma* tolerant DxP planting material. It is important for the planters to monitor the progress of *Ganoderma* tolerant planting material.

The strategy applied by IOPRI (Indonesian Oil Palm Research Institute) to develop partially *Ganoderma* tolerant material has the following steps: identification of resistant germplasm, pedigree analysis, crossing plan, nursery test, DNA profiling and multi-location field testing in endemic areas. Generally African TxT/P crosses had higher resistance level to *Ganoderma* compared to Deli *duras*.

Field observation at MPOB had shown that Deli *dura* selfs are more susceptible to *Ganoderma* compared to inter-crosses, which has important implications on the strategy used to breed oil palm mother palms for seed production.

Asian Agri Group has adopted an active integrated disease management (IDM) plan that covers land preparation, planting of tolerant varieties, use of bioagents, early detection, and removal of infected palms. Based on screening of 408 DxP test crosses involving 215 *duras*, and 50 *pisiferas*, there was significant differences in disease incidence amongst progenies, *duras*, *pisiferas* and their interactions. Asian Agri carried out extensive screening of 2 205 progenies and identified 18 DxP crosses that form AA TOPAZ GT, *Ganoderma* tolerant variety. The average yield potential of this variety is 9.2 tonnes CPO per hectare.

Socfindo and Palm Elit also focused on

breeding for *Ganoderma* tolerant planting materials and released such materials in 2013. The strategy applied was observing infection levels in progeny trials, parental and seed gardens. The materials identified were subsequently used in NCM11 crossing programme between group A (*dura* parents), group B (*pisifera* parents), where certain lines of *dura* Dabou and Deli Socfin were found to confer resistance to *Ganoderma*. In group B, *pisifera* parents La Me A and La Me B transmitted resistance.

CIRAD genomic loci conferred resistance to *Ganoderma* in selected populations. An oil palm mapping population was created with large genetic diversity made up of palms from the heterotic groups A and B, according to RRS (reciprocal recurrent selection) scheme. The progenies derived from heterotic groups were evaluated in pre-nursery trials. A 70K SNP array was developed by CIRAD to increase the marker density on the reference microsatellite based linkage map. Later a pedigree-based approach was used for quantitative resistance locus (QRL). This approach provides important information for breeders to develop planting materials resistant to *Ganoderma via* marker assisted selection.

UP, in a paper describing Cultural Practices and *Ganoderma* Disease Management, provided important perspectives on managing the disease by carrying out activities such as surgery, flooding, palm base mounting, trenching and root bole excavation, which have been executed with varying degrees of success. Nevertheless, it is useful to have accurate, cost-effective early detection method, and disease resistant planting materials to delay onset of the disease.

The details of the papers mentioned are given in the closing remarks in the Proceedings of ISOPB International Seminar on *Breeding for* Ganoderma *Tolerance in Oil Palm* (2019).

QUALITY CONTROL

Digitalisation

In the nineteen eighties and nineties, precision agriculture (PA) integrated remote sensing and satellite data with machine language (ML) models to optimise yields and reduce production costs. Now, agriculture digitalisation (AD) has replaced PA, where it refers to the process of integrating advanced digital technologies such as artificial intelligence (AI), big data, robotics, unmanned aerial vehicles (UAV), sensors, and communication networks, all connected through Internet of Things (IoT) into farm production system.

Cloud storage facilities, mobile phones/ tablets and the availability of WIFI, facilitates real time data capture of individual palms labelled with QR code. The QR code is embedded with trial number, palm number, progeny number and fruit form. The FFB yield and vegetative data are captured in the field and transmitted to cloud storage. The management team can monitor the progress of yield recording in real time. In the case of bunch analysis (BA), bunch harvested is labelled, and transported to bunch laboratory. All the variables for BA are captured by smart mobile and the data is transmitted to cloud for storage, update and analysis.

With the digitalisation of procedures and processes in oil palm breeding, the productivity improves with efficiency, as it minimise paper work, reduces errors and need to check raw data. Digitalisation has changed the way data collection is carried out, information is extracted, interpreted all of which improves decision-making capability.

MPOB SawitNow™ is such a tool which includes in its main features Real-time Analytics

Dashboard, Programme and Trial Management, Interactive Palm Lineage Visualisation, and Breeding Materials Selection.

Molecular tools

A major breakthrough was achieved by the Oil Palm Genome Programme at MPOB, where the identification of the gene controlling Shell has made it possible to identify and differentiate *dura*, *tenera* and *pisifera* at the nursery stage. The discovery led to the first molecular diagnostic assay known as SureSawit™ SHELL, which the breeders can use to identify and isolate *dura*, *tenera* and *pisifera* seedlings arising from TxT and TxP breeding crosses. The SureSawit Kit, also makes it possible to check the purity crosses/seeds before field planting and even as early as the seed production stage. It appears that *dura*/*pisifera* contamination is still a problem in some sectors of the oil palm industry, and the diagnostic kit can be used as quality control tool in commercial seed production to overcome the problem.

The development of high yielding oil palm planting materials takes nearly 10-20 years. It involves extensive evaluation of DxD, TxT, TxP parental crosses and progeny testing of selected parents as DxP/DxT crosses. As such, it is important to maintain the highest standards when making and evaluating these crosses, which can be achieved by using the diagnostic assays developed. This is because recent studies indicate the quality control of the pollination procedure and elimination of *dura* parental palms with rudimentary anthers are critical to minimise *dura* contamination in DxP planting materials.

Planters role

The planter has an equally important role to help realise the full yield potential of the planting materials. The planter's role starts from receipt of oil palm germinated seeds, and continues at the pre-nursery, main nursery to field planting. Appropriate culling in prenursery (15%), main nursery (10%), watering, fertiliser application, weed control, nursery pest and disease control, transplanting from prenursery to main nursery and field planting are among the many tasks that need to be executed well to realise the palms' full potential. In addition, harvesting, fertiliser application, weed control, planting cover plants, monitoring ripeness standard and loose fruit collection, managing workers and transport of crop are some of the additional tasks assigned to planters. During the recent pandemic there was a major disruption of labour supply, and this affected operations such as harvesting bunches in trial plots, yield recording, bunch analysis and seed germination.

CLIMATE CHANGE

Moving forward, in the medium- to long-term, climate change, i.e. fluctuations in weather pattern such as drought and floods is an issue that has to be actively addressed by the industry. Recognising suitable planting materials for climate change will be a challenge to breeders and planters, especially since weather patterns can be difficult to predict with high accuracy. Various global climate models indicate Malaysia could experience temperature changes from 0.7 to 2.6 degrees celsius and rainfall changes ranging from -30 per cent to +30 per cent. It is obvious that the recent floods have affected oil palm plantations' operations.

MPOB has collected oil palm germplasm from various ecological niches. The oil palm populations from the dry areas of Northern Nigeria have attributes such as high bunch number, low bunch weight and higher content of chlorophyll per unit leaf area. These are suitable populations to use for breeding for drought tolerant planting materials.

CONCLUSION

It is the joint responsibility of oil palm breeders to produce the best planting materials and planters to best manage these palms to realise the yield potential of oil palm, which currently is at 9-10 tonnes per hectare. It has been estimated that genetic component of the planting material contributes 50 per cent and the management (planters) the other 50 per cent in the expression of yield, indicating both components are equally important, if maximum productivity is to be achieved.

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