REVIEW ARTICLE

Global perspective of germplasm and breeding for seed production in oil palm

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ABSTRACT

Palm oil derived from oil palm plays a vital role in the edible oil sector apart from innumerable industrial uses and downstream products. Oil palm is grown in about 43 countries. The production of palm oil has been estimated to increase by 2.63 % to 75.51 million tons during 2019-20 from the total cultivated area of 21.33 million hectares. Globally, the oil palm industry is developing at a faster rate. The increase in area under oil palm and the replanting programme had also increased the demand for quality planting materials. Elite germplasm base with inherent economic traits are essential for breeding for seed production. Globally, Indonesia and Malaysia are major players in oil palm research and development. Breeding stocks and superior planting materials of Indonesian Oil Palm Research Institute (IOPRI) are widely adopted by oil palm industry. Asian Agri (AA) group and Golden Agri Resources (GAR) are of the major seed producers from private side in Indonesia. The public sector Malaysian Palm Oil Board (MPOB) has released 14 PS (Planting Series) to the industry. The seed production and supply to large and smallholders in Malaysia are undertaken through agencies approved by Malaysian Palm Oil Board. Agricultural Services and Development (ASD) is a private organisation in Costa Rica involved in oil palm R&D and distributing oil palm seeds and clones in all the regions of tropical America, Asia and Africa. Palmelite, France has been supplying CIRAD® planting materials worldwide. CIRAD commercial seeds are produced by its long-standing partners in Benin (CRA-PP), Ivory Coast (CNRA), Cameroon (CEREPAH), Indonesia, Colombia, Ecuador and Thailand. In case of Africa, out of twenty countries, only six countries namely Nigeria, Cameroon, Cote de Ivory, Ghana, Congo and Benin are having capability to produce large scale quality planting materials. The 'Thodupuzha-dura' and 'NIFOR -pisiferas' are the base breeding material extensively utilized for Indian oil palm industry and semi wild and elite germplasm from Cameroon, Tanzania, Zambia and Guinea Bissau, Senegal, Sierra Leone and other resources are being utilized to develop genetic stocks and hybrids. India has potential area of 1,933,250 hectares in 18 states. India imports bulk of its demand of planting materials from abroad. There are three options of commercial planting materials (advanced D×P seeds, clonal/semi clonal and O×G hybrids) are available for the oil palm growers. Few of the important sources of planting materials which are commercially available worldwide are 1. ASD Costa Rica 2. Palmeite-CIRAD®, 3. Sime Darby Plantation, 4. AAR, Malaysia, 5. FGV-Felda, 6. Sawit Kinabalu Seeds, 7. IOI, Malaysia, 8. Asian Agri, Indonesia 9. PT Dami Mas Sejahtera, Indonesia. In Malaysia, Oil palm D×P seed production reached 131 million in 2013. ASD Costa Rica has marketed 30 million seeds of compact hybrids. It is reported that out of 200 million seeds of worldwide market of oil palm seeds, around 30 to 50 million seeds are supplied per year from Palm elite. It is suggested to study the hybrid/clone performance in the local conditions before taking decision on order for planting materials.

Key words: oil palm, seed production, germplasm, breeding

INTRODUCTION

Oil seeds and vegetable oil emanate direct impact on world economy as their uses are extensively diversified for food and non-food industries. Oil palm, *Elaeis guineensis* J. entered into the global vegetable oil pool with its two types of oils *viz*. palm oil and palm kernel oil in a small way in sixties had emerged as the second largest vegetable oil source during nineties next to soya bean and occupied the first place after 2000. Oil palm is grown in about 43 countries (http:// theoilpalm.org/ about/), but the biggest plantations are in Indonesia and Malaysia. The developing countries and emerging countries such as Brazil, Peru and Central and Western Africa are promoting oil palm cultivation as a major contributor to poverty alleviation in view of increasing demand and shrinking arable cultivable land available. Globally, the oil palm industry is developing at a faster rate. Several West Africa countries have formulated national programs to encourage both national and foreign investments in establishing new oil palm plantations. There are 26 countries figured in the list of World Palm Oil Producers published by USDA (USDA, 2019) and their latest area, Fresh Fruit Bunch (FFB) production and average productivity and palm oil production (FAOSTAT, 2019) has been estimated. Out of 203.83 million tons of vegetable oil production, 73.53 million tons is palm oil in 2018-19. The production of palm oil has been estimated to increase by 2.63 % to 75.51 million tons during 2019-20 from the actual cultivated area of 21.33 million ha. Indonesia produces 43 million tons followed by Malaysia which account for 21 million tons of palm oil. Malaysia and Indonesia hold 85% of the total production (57 % from Indonesia and 43% from Malaysia). India has large area (about 0.33 million ha) of oil palm under irrigated conditions. India's share in production, consumption and world edible oil import during previous year (2017-18) were 7, 12 and 20 % respectively (USDA, 2018). The demand for edible oil in India has been increasing year by year which is about 6% per year, whereas countries edible oil production is increasing at the rate of 2 percent per year only. Around 60 % of India's domestic demand is met through import from abroad and three fourth of the import is palm oil. This increase in area under Oil Palm and the replanting programme had also increased the demand for quality planting materials (Renjini and Girish Jha, 2019). Many West African countries and countries in other parts of Africa are planning to have area expansion for oil palm industry. The oil palm industry is developing at a faster rate in Indonesia and few other countries like Philippines, Thailand and India are also making considerable progress. The developing countries and emerging countries such as Brazil, Peru and Central and Western Africa are promoting oil palm cultivation as a major contributor in view of increasing demand and shrinking arable cultivable land available (USDA-FAS, 2011). The production of oil palm clonal and bi-clonal seeds provides additional avenue as source of planting material. Costa Rica and CIRAD network of African countries are other important seed producers. This implies that highly productive planting materials of varieties adapted to these diverse growing conditions are to be supplied worldwide to the growers. In order to develop the best planting materials in the medium and long term, the main strength in any breeding program is to have the greatest genetic diversity possible. This is especially important in a long cycle crop like oil palm. The choice of planting material is also important to ensure the production of high yield with good oil quality for economic sustainability to oil palm industry. In this article, global perspectives of oil palm planting material are discussed to assess the status and prospects of oil palm industry with respect to new varieties and planting material production.

BACKGROUND OF BREEDING FOR SEED PRODUCTION

The discovery of shell gene (*dura*;Dominant homozygote (Sh+ Sh+) forms thick-shell *dura* (D), *tenera*:Heterozygote (Sh+ Sh-) forms thin-shelled *tenera* (T) and *pisifera*homozygote (Sh- Sh-) forms shell-less *pisifera* (P)) in the oil palm fruits by Beirnaert and Vanderweyen (1941) has led to commercial production of *Dura* ×*Pisifera* (D×P) planting materialwhich revolutionized the oil palm cultivation in the world. The universal oil palm improvement scheme is reciprocal recurrent selection scheme (RRS). This is being followed by majority of the oil palm seed producers. In case of RRS, the *dura* and *pisifera*populations are maintained in the seed garden in separate block. After evaluation and selection of parental palms and progeny testing, the crossing programme is undertaken to produce *tenera*. The performance of inter-origin crosses is attributed to the additive effect of favorable genes combination from the parents. According to Rajanaidu et al. (2000), the RRS is preferred because of about 18% palm oil hike per cycle in the hybrids over their base population. World over oil palm breeding and seed production is moving towards second (or)third cycle materials of *dura* and *tenera*s and some of the centres are establishing new seed gardens. *Elaeis oleifera* (HBK) is a promising genetic resource for some of the desirable traits related to biotic and abiotic stress tolerances. In spite of desirable qualities, the cultivation of pure stand of *E. oleifera* is not viable economically, due to its low yields (< 1.0 tonne oil/ha/yr) as compared to the *E. guineensis* (4-5 tonnes oil/ha/yr.). However, since the two species hybridize easily, interspecific hybrids could be obtained with yields around 90% of the *E. guineensis*. To introgress the traits of oil quality and low height increment (dwarfness) from *E. oleifera* into *E. guineensis*, two species were hybridized to produce *Oleifera* × *Guineensis* (O×G) hybrids. Subsequently, O× G hybrid was backcrossed to its *E. guineensis* parent to improve the yield (Moretzsohn et al. 2002). Recent development and extensive replanting programme with commercial planting of EG×EO hybrids attributed to outbreak of disease problems in some oil palm growing regions of South America (De Franqueville 2003). BRS Manicoré is a first O×G hybrid developed by Embrapa (Cunha and Lopes 2010). Hybrid seed production is done by controlled pollination between selected *Dura* and *Pisifera* palms. In recent years, the tissue culture technique clonal propagation has been promoted for developing elite oil palm materials (Sakhanokho and Kelley 2009). Apart from traditional method of seed production, clonal propagation through tissue culture and semi clonal production of selected parental palms are also popularized by the industry owing to problem of segregation un-uniformity in seed derived palms. There is a potential application of tissue culture technique to multiply parental palms (which have been progeny-tested) to produce semi- and bi- clonal seeds. A number of companies such as AAR, UP and FELDA Agricultural Services Sdn. Bhd. (FASSB) have since been marketing semi-clonal seeds. The major players possessing good wealth of germplasm and sound seed production programme (Murugesan and Shareef 2015) are 1. Malaysian Palm Oil Board, 2. Indonesian Oil Palm Research Institute, 3. Nigerian Oil Palm Research Institute, 4. Palmelite (Commercial arm of CIRAD, France, 5. Agricultural Service and Development (ASD, Costa Rica), 6. Sime Darby, Malaysia, 7. Asian Agri group, Indonesia and 8. AAR, Malaysia. 9.Socfindo, Indonesia), Corporation Centre for Oil Palm, (CENIPALMA), Indu Palma, Hacienda La Cabana (all in partnership with Palmelite), Brazilian Agricultural Research Corporation, Palmeras del Ecuador S.A. are some organizations from South America, five organizations (1. The Institute of Agricultural Research for Development (IRAD), Cameroon, 2. Centre National De Recherche Agronomique (CNRA, Ivory Coast), 3. Institut National des Recherches Agricoles du Benin (INRAB, Benin), 4. Cote de Ivoire and 5. The Oil Palm Research Institute (OPRI) of Ghana Formerly, West Africa Institute for Oil Palm Research (WAIFOR) is involved in seed production programme from Africa apart from NIFOR. In the subsequent section, seed production in some of the important global level organizations are reported with a view know progress and current advances in planting material production. Breeding for seed production in major seed producing countries are given below:

BREEDING FOR SEED PRODUCTION IN INDONESIA

The palm oil production derived from 9.3 million ha of oil palm plantation estates. The majority of (50 %) is from private organizations and 38 % growers/ farmers and rest of the area managed by state owned plantations (Gustina Siregar et al. 2018). Planting material production has been elaborately reported by Edy Suprianto et al. (2016). Oil palm planting materials produced through sound base of breeding and plant biotechnology from IOPRI are widely adopted by in Indonesian oil palm industry. It collaborated with CIRAD at the early stages and utilized RRS Breeding Scheme to produce high yielding planting material. The first cycle of improvement covering 1950s and the sixties at La Me Station (Cote d'Ivoire) and the second cycle deployed in West Africa, South America, and South East Asia from 1970s to the end of last millennium were the corner stones in the network. During this period the per hectare yield increase was 42% more or less 1.0 % per year besides reduction in palm height and resistant to Fusarium wilt (De Franqueella and Renard (1990) and Jacquemard et al. (2001). Introduction of new oil palm genetic material from Cameroon and Angola has opened the opportunity for IOPRI to develop oil palm cultivars with novelty traits. Improving oil quality has been implemented by backcross program of O× G hybrids with the best parents from RRS schemes (Edy Suprianto et al. 2016). Asian Agri group is one of the major seed producers from private side in Indonesia. It is reported that parental materials of AA group were progeny tested in 486 hectares and 112 top D× P combinations from 12 *dura* families and Ekona, Nigeria and Ghana of '*pisifera*s' were formed base of hybrid seed production. Currently, 3rd Generation of Planting Materials (GEN-3 Topaz) are utilised in the present cycle of seed gardens. AA is reported to have production capacity of 15 million D× P seeds per year (Mukesh Sharma et al. 2016). Aek Loba Plantation is a largest oil palm plantation of PT Socfin Indonesia; it is located in Asahan, North Sumatera, and Indonesia. They utilise Deli Dabou and Deli Bangun Bandar as well as La Mé, Yangambi and NIFOR for hybrid seed production in Aek Loba Seed Production unit (ALSP). It started to produce oil palm seeds in 2008 and have production potential of 50 million seeds per year and supplied 14 million seeds in the year 2017 (Harold Owen Williams, (2016) and www.socfindo.co.id). Recently, PT-SMART-Research Institute, a subsidiary of Golden-Agri

Resources Ltd (GAR), has announced its breakthrough in cultivating exceptionally high-yielding oil palm planting materials-Eka 1 and Eka 2 – are registered in Indonesia's Catalogue of Seeds and were approved for cultivation on 21 April 2017 by the Directorate General of Plantation, Ministry of Agriculture. The company claims that they carry the potential of increasing the company's crude palm oil yield to more than 10 tonnes of CPO/hactare/year at prime age (10-18 years) from the current capability to achieve around 7.5-8 tonnes/ hectare/year under optimal weather and soil conditions (Anonymous, 2017). The total production potential and requirement of seeds for Indonesia is summarised in the section world production potential and requirement etc.

BREEDING FOR SEED PRODUCTION IN MALAYSIA

Malaysian Palm Oil Board (MPOB) carries out numerous explorations in Africa and South America since 1973 with cooperation of host countries and collects materials and shares equally between the host countries and MPOB. Collections in Nigeria provided an important source of dwarf palms for breeding for dwarf palm population (Rajanaidu et al. 1998). These collections were planted in MPOB, Kluang Research Station and Kertong as field gene banks and they are used for evaluation and utilization. It is the largest germplasm collection in the world. Several trials laid out using materials from Tanzania, Senegal, Guinea Conakry and Ghana was evaluated for Harvest Index (Malike et al. 2011). Tanzanian germplasm showed the highest mean of Harvest Index (HI) with significant values. From the two expeditions undertaken to Angola; the first 1991 collection has been planted and evaluated in Kluang Johar showed high potential for yield and long stalk. The second expedition was undertaken during 2010 and 125 accessions from 10 provinces of 25 sites (5 bunches per site) jointly by MPOB, Director General of Estate Crops, Indonesia and Nacional Do Café Angola (INCA) were collected which had several promising traitsviz., compactness, high mesocarp and long stalk (Marhalil and Rajanaidu 2011). Population collected from Cameroon, Nigeria and Sierra Leone showed high genetic diversity. Cameroon and the DRC (Ex-Zaire) showed high tolerance to Ganoderma. Similarly, materials collected all over the world were characterized and their evaluation is still going on (Hayiti et al. 2004). Indonesia and Malaysia are the largest consumers of oil palm planting materials in the world. About 500,000 ha planted in Indonesia and 100,000 ha in Malaysia. The field gene bank of oil palm is located at the MPOB Research Station at Kluang, Johor, Malaysia (Rajanaidu, 1986).Nigerian population is the main collections and apart from that prospection was made from other countries in Africa such as Angola, Cameroon, Zaire, Ghana, Guinea, Gambia, Madagascar, Sierra Leone, Senegal and Tanzania (Rajanaidu et al. 2013). Malaysian Palm Oil Board has released 14 PS (Planting Series) to the industry (Table 2). The new varieties/planting materials with novel were developed from population of Nigeria, Angola, etc. and transferred to oil palm industry and companies. The details of those planting materials are given in Table 1. Currently, there are 14 PS series with PS1 being designated as slow height increment of the Nigerian population 12. PS2 is the high iodine value of the Nigerian palms from trial 0.151. PS3 is the high kernel palms in response to the lauric oils demand. PS4 is the high carotene in the *E. oleifera*. Thin-shell *tenera*s are the attributes of the PS5. PS6 is the large fruit *dura*s while PS7 focuses on the high bunch index. PS8 features high vitamin E of the *E. guineensis* while the peach palm (*Bactris gasipaes*) for palm heart production makes PS9. For ease of harvesting, the long stalk palms from the Angola population give rise to PS10. PS11 also contributes to high carotene from *E. guineensis* instead of *E. oleifera*. There are PS12 and PS13 which are known for then high oleic and low lipase respectively. Recent PS series of PS 14 has special biochemical trait of high crude protein (Zulkifli et al. 2017)

New generation of oil palm planting materials are mainly derived from Dami, Chemara, MARDI, Sofino, Socfin, Dabou, Banting Deli *dura* s and sources of *pisifera*s are Nifor (Calabar), Ekona, Yangambi, La Me and AVROS (Rajanaidu et al. 2007). The seed production and supply to large and smallholders in Malaysia are undertaken through agencies approved by Malaysian Palm Oil Board (MPOB). Certification is issued from Standards and Industrial Research Institute of Malaysia (SIRIM 2005).The leading seed producers of oil palm in Malaysia are 1. Applied Agricultural Resources Sdn. and Felda Global Ventures (FGV). AAR is an associated company of Boustead Holdings and Kuala Lumpur Kepong Berhad known for varieties with dumpy characteristic. Between 1986 and 2003, AAR produced AA D×P planting materials from selected Deli *Dura*× Dumpy AVROS *Pisifera*. Through the years, further breeding, selections and improvements made on AAR's breeding programme resulted in the creation of the AA Hybrida IS. Hybrid seeds are produced through bi-clonal seed production. FGV is one of the largest oil palm seed producers in Malaysia.FGV is reported to produce 25 million oil palm seed per year

Table 1: Details of varieties/planting materials of oil palm developed from research institutes of Malaysian Palm Oil Board

Sl. No	Name of the germplasm/population	Name of the * Planting material	Traits/variety characters	Reference
1	Nigerian germplasm	PS1	Dwarf palm	Rajanaidu et al. (2000)
2	Nigerian germplasm	PS2	High iodine value	
3	Nigerian germplasm	PS 3	Large kernel	
4	Nigerian germplasm	PS6	large fruit *dura*	Kushairi et al. (2003a)
4	Nigerian germplasm	PS12	High Oleic acid	Isa et al. (2006)
5	Angola germplasm	PS10	Long female bunch stalk	Noh et al. (2005)
6	Angola germplasm	D×P	High variability in Fatty Acid Components	Noh et al. (2002)
7	Madagascar germplasm	Selected individual palms	Iodine value (IV) (>60) (Normal 50)	Kushairi et al. 2003b
8	Tanzania germplasm	PS5	Extremely thin-shelled *tenera*	Kushairi et al. (2003c)
9	Tanzania germplasm	PS7	High Bunch Index	Junaidah et al. 2004
10	Tanzania, Cameroon, Nigeria and Angola germplasms	-	High Bunch Index	Fadila et al. (2016)
11	Angola, Cameroon, Nigeria, Tanzania and Zaire germplasm	Selected individual palms (PS8)	High Vitamin E	Kushairi et al. (2004)
12	*Elaeis oleifera* germplasm from Hon*dura*s, Brazil, Panama, Colombia, Costa Rica, Suriname, Ecuador and Peru	PS4	High carotene value	Mohd Din et al. (2002)
13	Tanzanian germplasm	PS 11	High carotene content	Mohd Din et al. (2006)
14	Cameroon, Guinea and Tanzania germplasm	PS13	Low lipase	Maizura et al. (2008)
15	Ghana, Cameroon, Gambia, Senegal, Tanzania and Zaire	PS14	High crude protein	Noh et al. (2014)
16	Nigerian germplasm	Ideal palm	Balanced bunch number and bunch weight (15Kg × 15Kg ×15g) including fruit weight	Rajanaidu et al. (2011)

* PS9 is the planting material developed from peach palm

for local and overseas market. (Abdul Rahim et al. 2017). FGV have the second largest oil palm germplasm collection after MPOB. FGV had released Felda Yangambi planting material in 2002 and an improvised version Felda Yangambi ML161 in the subsequent years and followed by Felda 3-way D×P was released in the early 2010. FGV through its subsidiary company, Felda Agricultural Services Sdn Bhd (FASSB) has emerged as one of the top seed producer in Malaysia, producing 23 - 26 million per annum and commanding more than 43% of the Malaysian seed market in 2015. To date FASSB has sold over 330 million seeds of Felda Yangambi and 4.9 million seeds of Felda 3-way. Sime Darby, Guthrie, H&C (Golden Hope) breeding programmes were consolidated into a single entity under Sime Darby which has operations in Malaysia, Indonesia, Liberia, Papua New Guinea and Solomon Islands and Sime Darby plantation division takes up seed production. Hybrid seed variety called 'Calix 600' is produced which has ability to produce 10t of oil /ha after 24 to 36 months of field planting. It is reported that genome select high - yielding planting material developed from Sime Darby is under advance stage of field validation trial (Teh et al. (2016) and Kwong et al. 2017). It is reported that the Sime Darby has mission to achieve 100% replacement of traditional hybrids with genomic selection by 2023 (https://biosearch-cdn.azureedge.net/assetsv6/customer-case-study-sime-darby.pdf)

BREEDING FOR SEED PRODUCTION FROM ASD COSTA RICA

Information about ASD Costa Rica has been reported by Alvarado and Escobar (2016). Agricultural Services and Development (ASD) is a private organisation in Costa Rica involves in oil palm R&D and distributing oil palm seeds and clones in all the regions of tropical America, Asia and Africa since 1986. According to Alvarado et al. (2009), ASD can supply wide range varieties namely, Deli, African Bamenda, African Tanzania, Compacts with classical *pisifera*s (AVROS, Yangambi, Ekona and La Me), Ghana, Nigeria and Evolution (compact pollen source populations). African oil palm was introduced in the year 1926 at Lancetilla Botanical garden of Hon*dura*s by United Fruit Company; erstwhile company of Agricultural Services and Development. They were responsible to start small plantations in Guatemala, Honduras, Nicaragua, Costa Rica, Colombia and Ecuador. Today, the Agro Industry 'Numar group' possesses 21,000 hectares of own oil palm captive plantations and 19,500 hectares with partners. Development and distribution of oil palm varieties and clones is one of the main activities for ASD apart from crude palm oil production, processing, refining, bi-product diversification and marketing. ASD started seed production at Coto, Costa Rica in 1975 using Deli *dura* introduced from Malaysia. In the year 1977 itself seeds exported to Honduras and Colombia. A dedicated wing of seed production i.e. ASD de Costa Rica was established in the year 1986 at Costa Rica SA. Initially ASD started to supply traditional varieties such as Deli ×AVROS, Deli ×Ekona and Deli × Yangambi. Subsequently new varieties with desired traits have been added to the list (Table 2). It is estimated that 295 million seeds have been supplied by ASD which might had covered 1.7 million hectares world-wide. Oil palm seeds are certified by National Seed Bureau of Government of Costa Rica. ASD has 450 hectares for field experiments in Coto and owns one of the most diverse oil palm germplasm collections in the world. They had introduced several BPRO from Malaysian Research Stations and intensively use MAR 559 for seed production due to high additive genetic effect in relation to several economic traits. Angola *dura* is commonly used as female parents which were selected from Ivory Coast and Kade Research Station in Ghana. Apart from above, ASD use Bamenda (Cameroon) and Kigoma (Tanzania) (Barbosa and Chinchilla 2003). It is reported that Deli *dura* types had better oil and kernel yields than African types (Richardson 1995). Calabar materials have a shorter leaf length and higher leaf area than other traditional materials. Ekona materials have greater oil to bunch ratio. ASD Costa Rica breeding programme has been producing commercial oil palm planting materials since 1974. The seed production programme is oriented towards the exploitation of the genetic potential present within Deli and AVROS BPROs. They recently included new sources of germplasm viz., Djongo, La Me, Nigeria and Ekona. During the period between 1986 to 2015, ASD has been reported to supplied seeds to cover >1.8 million hectares plantations in tropical America, Asia and Africa (Alvarado and Escobar 2017)

OIL PALM BREEDING AND SEED PRODUCTION IN PALMELIT

Palmelite is a commercial wing of CIRAD-IRHO France. It is a joint venture owned by CIRAD and Sofiproteol. Since its inception in 2009, Palmelite have been supplying CIRAD planting materials worldwide. Palm elite company was established in the year 2009 with seven partners and five experimental stations in Latin America, Africa and Asia, three disease resistance screening units for Ganoderma basal stem rot and Fusarium wilt and two tissue culture laboratories in close association with CIRAD, France which is now PalmElit's majority shareholder. For several years from now, CIRAD has been supplying base variety of 'Deli x La Mé' materials and of late started supplying different variants suited to different locations of agro-climatic conditions with qualitative traits in addition to high FFB, CPO, compactness and unsaturated fatty acids. This mean there is a provision for varieties with slow height increment, resistances against diseases, and low lipase material etc. (Turnbull et al. 2016). The other promising materials are Deli × Yangambi and interspecific *E. oleifera*×*E.guineensis* hybrid. La Me is a spectacular outcome of French Agricultural Services during the initial period of 1920 in Cote de Ivoire then French Colony in West Africa. During the period between 1925 to 1935, Deli seeds from North Sumatra was planted in Dabou (Cote de Ivoire) and subsequent selection from the population resulted in Deli Dabou' (another

Table 2. Special features and suitability of environments of ASD de Costa Rica varieties and clones (Alvarado y and Escobar 2017)

Sl. No	Name of the variety	Special features	Suitability
1	Deli× Nigeria	Produce two types bunch colours viz, virescens and nigrescens 50 % each	Facilitate easy identification bunch ripening at the time of harvest
2	Evolution	>30 % oil content with large bunch size >22kg and fruit weight of 11g	It is recommended for favourable environment
3	Deli×La Me	Produce small bunch < 18Kg with moderate oil content	Suitable for Costa Rica Nicaraqua where drought occurs. Low incidence of spear rot
4	Tanzania ×Ekona	Slow vertical growth 40-50cm/year, large kernel and thin shell	Tolerant to drought and low temperature
5	Bemenda ×Ekona	Slow vertical growth medium bunch size 18-22Kg and small fruits (<9g)	Good performance even in areas with low solar radiation and high altitude
6	Deli ×Ghana	Short leaves 7-7.3 meter and accommodate 160 palms/ha	Good performance reported even in areas with low solar radiation and high altitude up to 1000 MSL
7	Compact × Ghana	The short rachis (6.5m) and it can accommodate 170palms/hectare	Good performance is reported even in high altitude. Advance generation is called as Challenger
8	Deli×Compact	The leaves are <7m and it can accommodate 170palms/ha. Oil content reported was >30%	Suitable for favourable environments without any stress. Adavance variety is named as 'Supreme'
9	Amazon	*E. oleifera* × *E.guineensis* hybrid. Mother palm is from Manaus Brazil and crossed with compact *pisifera*. High unsaturated oil content around 22%. Fruits are medium size	High tolerance to spear rot and pollen is self-compatible. Compact palms
10	Titan, Tornado and Sunrise	Ortets of best compact palms of ASD company used as explants for cloning. Short rachis and slow vertical growth. It is reported to accommodate 170-200 palms per hectare	It is reported to be tested in commercial plantations of Costa Rica, Ecuador, Nicaragua, Guatemala, Colombia and Thailand

Breeding Population of Restricted Origin) (Cochard 2008). After establishment of IRHO (1942) and CIRAD (1984) (Corley and Tinker 2003), modified Reciprocal Recurrent Selection (RRS) breeding scheme was followed utilising Deli *dura* and African *tenera*s. The second cycle of RRS population was planted in Indonesia, Cote de Ivoire, Cameroon and South America (Nouy et al. 1991) and FFB along with oil yield to the tune of 15-18% obtained. In Africa, Fusarium wilt resistant materials were developed at Dabou (Renrad et al. 1980). Subsequently new varieties which are resistant to dreaded fusarium wilt were released to the growers. It is to be noted that casual organism for bud rot in South America is not known till date as there were report of 100 % mortality in commercial plantations with commercial varieties. In some cases, 30-40% death of palms as per reports by Amblard et al. (2009) and Louise et al. (2014). CIRAD has taken up collaborative breeding programme with PHV Colombia, SEPALM and Murrin Ecuador to manage bud rot complex in South America and released #PC2.0 a high resistant and #PC1.0 partially resistant varieties. During that period (1980s), progress in tissue culture was also achieved step by step (Pannetier 1981). According to *Dura*nd-Gasselin et al. (2010), liquid media embryo suspension culture has been employed for successful protocol but 5% somoclonal variation was reported in the plantations and recent efforts in Indonesian unit of Palm elite expected breakthrough for breeding and tissue culture planting materials. Another novel approach developed by Palmelite is 'Super machos palms' which help to overcome non-pollination problem in commercial planation with poor fruit set and FFB yield in view of non-availability of pollen due to high female sex ratio. Palm elite are also supplying seeds of 'super machos' of *E.guineensis* material with very high male sex ratio (www.palmelite.com). In the past years, Palme Elit has developed different categories of planting materials adapted to different agro-climatic conditions. CIRAD commercial seeds are produced by its long-standing partners in Benin (CRA-PP), Ivory Coast (CNRA), Cameroon (CEREPAH) and Indonesia. They also started seed gardens in Colombia, Ecuador and Thailand. In order to assist Palm Elite some companies were identified in different regions. The companies identified are 1. Hacienda La Cabana (Colombia, Mexico, Venezuela and central America), 2. Palmeras de los Andes (Ecauder and Brazil), 3. Mr. Lambert Pie Pau (Peru), 4. IRAD/CEREPAH (Cameroon), 5. CNRA (Ivory coast) and 6. INRAB/CRA-PP (Benin). Presently the planting materials produced from CIRAD conglomerations are commercialised under the brand CIRAD® are made available through the seed gardens established worldwide in close collaboration with subsidiaries (www.palmelite.com).

OIL PALM BREEDING AND SEED PRODUCTION IN AFRICA

Oil palm breeding for seed production has following objectives. 1. To maximize the productivity of palm oil and palm kernel oil 2. Breeding for dwarf palms to accelerate high density planting 3. To develop resistant and tolerant varieties to Fusarium wilt and drought and production of palms for premium oil quality (Unsaturated fatty acids). Like Deli in South East Asia, some of the important Breeding Population of Restricted Origin (BPRO) is originated from African Oil Palm Breeding Centres. Mass selection and breeding work was started as early in 1920 in Democratic Republic of Congo (DRC) and resulted in the development of famous 'Djongo' (BPRO) which is one of the pedigree parent of SP540 *pisifera*. It is to be noted that SP540 is the main male parent of Deli *Dura* in most of the seed production programme in South East Asian countries. Democratic Republic of Congo (DRC) is also famous for single gene inheritance of shell thickness as per the the work of Beirnaert and Vanderweyen (1941). One more world famous BPRO is 'La Me' from West African country namely Cote de Ivoire; selection and breeding work in wild palm grooves at LaMe and Bingerville Botanic Gardens resulted in spectacular 'La Me -BPRO' with high bunch numbers. La Me is also one of the world-famous breeding materials known to all the oil palm seed producers. At La Mé (Côte-d'Ivoire), the genetic resources namely 'Man' with low fluidity oil and slow growing Akpadanou population (Benin origin) were characterized for conservation, utilization and future breeding (Ricardo, 2013). These base materials have been utilized to develop planting materials with high oil quality. Another notable breeding work performed by Institut de Recherche pour les Huiles et Oleagineux (IRHO-French Research Organisation) is exchange breeding materials among five oil palm stations viz, La Me (Cote deIvoire), Pobe(Benin), Sibiti(Congo), Yangambi (DRC) and SOCFIN (Malaysia) Crossing programme was established with inter and intra population to find out best combiners (Gascon and de Berchoux 1964). Accordingly, best combiners of intra populations were adjusted as best which led the development of cross combinations utilizing Deli South East Asian countries × African *pisifera*s from African locations. From plethora of reports, it is inferred that the oil palm research centres namely La Dibamba (Cameroon), La Me (Cote de Ivoire), Pobe (Benin) and NIFOR, Benin City (Nigeria) and Pamol (Cameroon) had been pursuing either Reciprocal Recurrent Selection or Modified Reciprocal Recurrent Selection. Notable breeding programme and seed production Africa is known worldwide through Nigerian Institute for Oil Palm Research which was established in 1939 as Oil Palm Research Station (OPRS). A most important significant contribution from NIFOR is bunch analysis procedure reported by Blaak et al. (1963). This is a vital protocol used extensively in all the seed production centres for palm selection. According to Okwuagwu, (1986), oil palm field gene bank was established during 1912 with genetic resources from Calabar, Aba, Nkwele from South Eastern Nigeria and later promising parental palms were selected for improvement and breeding. The NIFOR base materials consist of five Deli *dura*, nine African *dura*, and 13 *tenera* material which were subjected to improvement by RRS with new introductions in the second cycle of breeding programmes. Exchange of genetic material also contributed to widen NIFOR genetic base (Okwuagwu 1986). It is reported that the original collections/introduced materials are maintained in field gene bank maintained in different locations of Nigeria *viz*., Aba, Ufuma and old Nsukka province (Okwuagwu et al. 1993 and Omoti 2003). The existing collections of Nigerian Research Institute for Oil Palm includes 1954 Ufuma and Aba collections, 1973 NIFOR/MARDI collections from 45 Nigerian locations from the marginal zone of the old Nsukka province. Apart from this, various African, deli origins have been made and exploited for breeding and selection. Very detailed evaluation of these collections has been carried out both in Nigeria and elsewhere (Rajanaidu et al. 2001). NIFOR had extensive collections from the main oil palm belt, Eastern part of Nigeria (High lands 200-400 m above sea level) was covered during recent expedition where greatest diversity exists. The area included was Afikpo, Abakaliki, Okigwe and Umuahia which were unexploited (Okwuagwu et al. 2011). They recommended the use of molecular markers to get information on germplasm diversity. Ataga (1994) reported high kernel variation in Nigerian germplasm collections at Benin City, Nigeria. Though African oil palm is originated in Africa; its yield and production are low when compared to South East Asian countries as it has been grown traditionally as subsistence crop in small-scale farming systems for thousands of years. In view of domestic marketing and supply-side constraints, subsidies for other edible oils competing crops availability of palm oil is always problem. Improved breeding schemes undertaken in French colonies resulted in significant yield improvements in some estates with best *tenera* progenies. However, there is a growing concerned about significant genetic erosion in natural oil palm groves. There is the new initiative called ‘Africa Palm Oil Initiative (APOI)’ by Tropical Forest Alliance (2020) have sustainable developmental plans in Africa for oil palm industry. It is reported that several multinational planation companies are evincing interest to develop oil palm based agro-industry projects in Africa (www.tfa2020.org).

OIL PALM BREEDING FOR SEED PRODUCTION IN INDIA

The systematic plantation of oil palm was established in India during 1961 at Thodupuzha (Kalayanthani, Vettimattom, Idukki district), Kerala with dura and tenera materials introduced from Malaysia and Nigeria (Nampoothiri 1994, Pillai and Nampoothiri 1981 and Murugesan et al. 2011).The Dura × Dura population consisting of over 700 palms available at Thodupuzha formed the base breeding material for Indian Oil Palm industry. Tenera (D×P) hybrids were produced, crossing 11 promising dura palms of Thodupuzha with pisifera (30.103) imported from Nigerian Institute for Oil Palm Research (NIFOR), Nigeria. These hybrids were planted during 1976 in the progeny trial at Palode, Thiruvanathapuram district of Kerala. After field evaluation, two hybrids (65D × 30.103P and 120D × 30.103P) were selected as most promising ones with a potential of yielding >4.6 tons of palm oil per hectare under rainfed condition (Nampoothiri et al. 1993). Selfed and inter se matted 65D and 120 D dura progenies were established as separate seed garden during 1982 for hybrid seed production at Palode oil palm station (Murugesan et al. 2006). In order to have wider choice of suitable *pisiferas* (as pisifera pollens were imported from Nigeria and non-availability of selected pisifera), seven high yielding teneras with the progenitors 65D × 30.103Pand 120D × 30.103P were selfed and progenies were planted at Palode (Kerala) during 1991 (Murugesan et al. (2008) and Murugesan et al. 2011). Intense selection on the Thodupuzha descendants by selfing/ inter se crossing gave rise to present advanced dura and T×T populations planted in 1989 at M/S NavaBharat Agro Products, Lakshmipuram, West Godavari district of Andhra Pradesh to produce indigenous planting material and based on the yield (150 kg /palm /year) performance 45 dura palms out of 380 dura palms and six pisifera palm out of 519 T×T. The field performance of these hybrids are planted around Jangareddygudem (Andhra Pradesh) was performing well (Rethinam and Murugesan, 1998). Subsequently four seed gardens namely Rajahmundry (Department of Horticulture, Government of Andhra Pradesh), Taraka (Department of Horticulture, Government of Kamataka), Thodupuzha (Oil Palm India Limited, Joint venture of Government of Kerala and India) and Palode (Regional Station of Indian Institute of Oil Palm Research, Kerala) (Rethinam et al. 2000); Murugesan et al. 2006). Studies on Interspecific hybridization of *Elaeis guineensis* ×*Elaeis oleifera* planted in 1995 at Palode Centre showed superior over conventional tenera which has to be exploited for seed production (Rethinam and Vinod Kumar 1998).Two advanced breeding materials fromASD Costa Rica imported under the UNDP subprogramme “Breeding for Seed Production” along with advanced dura crosses from Palode were planted as sixth seed garden at National Research Centre for Oil Palm, Pedavegi during 2000 (Rethinam et al. 2001). Under FAO assistance, during 1995-96, India collected wild and semi wild oil palm germplasm from Cameroon, Tanzania, Zambia and Guinea Bissau (Pillai et al. (2000) and multidisciplinary team has been evaluating for breeding, improvement and seed production (Rethinam et al. (1999-2000); Mathur et al. 2001, Suresh et al. 2004, Murugesan and Mandal 2010 and Murugesan et al. 2015) and six genetic stocks with unique traits (early fruit maturity, dura palm with dark orange fruit colour, long bunch stalk, sterile pisifera with viresence fruit colour, dwarf palm with high fruit set and compact tenera palm) are registered with ICAR-National Bureau of Plant Genetic Resources (Anjali Kak and Veena Gupta 2017). All the germplasm accessions were conserved as field gene bank maintained at Pedavegi, Andhra Pradesh and Palode, Kerala. As oil palm parental materials planted in the seed gardens of Palode, Thodupuzha, Taraka and Navabharath have grown tall and to augment the continuous availability of quality planting material, Government of India, in collaboration with ICAR Indian Institute of Oil Palm Research is now focusing on establishment of new seed gardens with new parental materials developed from exotic germplasm. Four more new seed gardens namely, Morumpudi, Dept. of Horticulture, Rajahmundry (AP), Gopannapalem, Dept. of Horticulture, Rajahmundry (AP), Taraka (Taraka-II), Department of Horticulture, Taraka, Karnataka, Kabini, Department of Horticulture, Taraka, Karnataka were established during 2012, 2014, 2012 and 2012, respectively (https://nmoop.gov.in). The tables 3 and 4 clearly infer that though there is potential to produce 4.9 million seeds annually from existing seed gardens only 50% could be produced and the new seed gardens established will be in a position to produce seeds in another six to ten years.

Table 3: Oil palm seed gardens (Old and new) in India- Potential and supply status (Source: (https://nmoop.gov.in).

Sl.No	Name of location	Year of planting	Potential (Lakhs)	Supply (Lakhs) (2013-14)	Balance (Lakhs)
1	ICAR-IIOPR, Pedavegi, Andhra Pradesh	2000	6.0	3.1	2.9
2	ICAR-IIOPR, Research-Research Centre, Palode, (Kerala)	1982	8.0	3.1	4.9
3	M/s. Navabharath Private Ltd., Lakshmipuram (A.P.)	1990	6.0	3.8	2.2
4	Department of Horticulture, Rajahmundry (A.P.)	1992	10.0	4.7	5.3
5	Oil Palm India Limited, Thodupuzha (Kerala)	1994	11.0	6.0	5.0
6	Department of Horticulture, Taraka, (Karnataka)	1994	8.0	3.7	4.3
	Total	-	49.0	24.4	24.6
7	Morumpudi, Department of Horticulture, Rajahmundry (A.P.)	2012	5.0*	New	-
8	Gopannapalem, Department of Horticulture, Rajahmundry (A.P.)	2014	5.0**	New	-
9	Taraka (Taraka-II), Department of Horticulture, Taraka, Karnataka	2012	5.0*	New	-
10	Kabini, Department of Horticulture, Taraka, Karnataka	2012	8.0*	New	-
	Total	-	23.0		

* Expected year of initiation of seed production-2020
** Expected year of initiation of seed production-2020

Table 4: Availability of exotic and indigenous planting material and area expansion in India (Source: https://nmoop.gov.in)

Exotic/indigenous/Area coverage	Year wise supply (Lakhs) and area coverage (hectares)				
	2010-11	2011-12	2012-13	2013-14	Total
Exotic	26.00 26	34.00	70.50	40.20	170.70
Indigenous	8.46	16.22	20.32	24.40	57.24
Area coverage (Ha)	17,925	28,388	26,300	22,948	95,561

According to Rethinam et al. (2012), India has potential area of 1,933,250 hectares in 18 states -Andhra Pradesh, Karnataka, Tamil Nadu, Goa, Gujarat, Maharashtra, Chhattisgarh, Kerala, Odisha, Bihar, West Bengal, and North Eastern states like Mizoram, Assam, Arunachal Pradesh, Tripura, Meghalaya, Nagaland and Andaman Nicobar Islands. Rethinam (2018) has also elaborated the planting material production programme for next 20 years in a policy paper for which large quantity of planting materials of 400 million are estimated which necessitate import of bulk quantity of exotic seed materials from other seed producing countries. The starting of production of indigenously developed hybrids from ICAR- Indian Institute of Oil Palm Research in collaboration with All India Co-ordinated Research Project on Palms (AICRP on Palms) may take 10 years from now.

As on to day, India imports bulk of its demand of planting materials through import from foreign countries as supply from indigenous source is only half of the demand as per the estimate in the National Mission on Oil Seeds and Oil Palm. The report of NMOOP had clearly indicated the above fact (Table 4). Government is advocating augmenting indigenous seed production in India. According to Murugesan et al. (2004) the performance of indigenous seed materials is on par with exotic materials. Top official level Indian delegation led by Joint Secretary (Oilseeds) visited Malaysia during 22-25 August, 2016 and recommended for high density oil palm planting materials and encouraged, new varieties such as Calix and Guthrie from Malaysia and exchange of germplasm for research and improvement of new varieties (https://nmoop.gov.in). Accordingly, two sources of germplasm namely, Sierra Leone and Senegal of 20 different accessions were introduced to India from MPOB after field evaluation (Murugesan and Sunil Kumar (2015) and Murugesan et al. (2016) and both resources have lower Free Fatty Acid content apart from drought tolerance.

GLOBAL HYBRID SEED PRODUCTION POTENTIAL AND ESTIMATES

D×P seeds

In 2009, global seed production was estimated at 490 million (Kushairi et al. 2011) and Malaysia and Indonesia require about 120 million seeds per year for new commercial planting and replanting demands which will be fulfilled through D×P seeds as the production of clonal seeds and tissue culture plantlets are limited.In Malaysia, Oil palm D×P seed production capacity has more than doubled from 50 million in 1995 to 109 million in 2000 and currently at 124 million in 2010 and 131 million in 2013 (Rajanaidu et al. 2013). Indonesia (250 million), Malaysia (132 million), Papua New Guinea (30 million) and Costa Rica (30 million) were the main producers and capable of exporting a large quantity. Palm elite joint venture company has 1600 hectares of field trials eight seed gardens in Africa, America and Asia. Palm elite has sound base for planting material production. It is reported that out of 200 million seeds of worldwide market of oil palm seeds, 30 to 50 million seeds are supplied per year from Palm elite. ASD has been supplying oil palm planting materials to meet the global expansion of the crop as commercial basis. To date, ASD has marketed 30 million seeds of compact variety. ASD-Bakrie Indonesia Oil Palm Seed (ASD-Bakrie) develop new high-quality planting materials which are adapted to local microclimate. PT ASD-Bakrie Indonesia Oil Palm Seed has been set forth to expand their production quantity until 20 million seeds per year. Apart from Nigeria, nineteen African countries are growing oil palm for palm oil and kernel oil production. Out of twenty countries only six countries namely Nigeria, Cameroon, Cote de Ivory, Ghana, Congo and Benin are having capability to produce large scale quality planting materials of oil palm. According to Bakoumé (2016), African continent has seed production potential of 50 million seeds per year. Cameroon is reported to produce about 13 million seeds followed by Ghana (4 million seeds). Palm elite (commercial arm of CIRAD) takes care seed production at Pobe Benin and NIFOR is having the seed production potential of 7 million seeds per year but reported to supplied 1.76 million germinated seeds during 2015. The other seed producers in Central/South America are, Gene Palm, Honduras (2 million), Mungas and Lowe in Colombia (2million), La Cabina CIRAD resale (1.5 million) INIAP Equador (2 million) and Embrapa Brazil (1 million).

Clonal/semi clonal seeds

A total of eleven companies (Clonal palm, FELDA, AAR, Sime Darby, IOI, Bornea Samudra and others) are reported to achieve commercial scale clonal palm production in Malaysia (Soh, et al. 2011). Besides conventional D×P seed production about 6 million plantlets are produced through micro propagation (Malaysia 5 million, Indonesia 0.5 million and Coast Rica 0.5 million) at global level. (MPOB 2018)

Interspecific hybrids

Elaeis oleifera (American oil palm) is partially domesticated species of oil palm as it is readily crossable with American oil palm and Inter specific hybrids are mostly produced in South and central American countriesto the tune of 2.5 millionEquador (CIRAD partner): 1. million, Colombia (La Cabana): 0.3 million, Colombia (Indu palm): 0.2 million, Brazil (EMBRAPA): 1.00 million). (Cunha et al. 2012).

POTENTIAL COMMERCIALLY AVAILABLE GLOBAL PLANTING MATERIAL

Over a period of time, oil palm undergone tremendous progress in Fresh Fruit Bunch and palm oil yield and productivity due to the efforts and intensive research and development carried out by public and private research organizations. Before the invention of single gene discovery by Beirnaert and Vanderweyen (1941), dura type of planting materials was utilized for commercial cultivation. Subsequently, the type of material progressed from D×P seeds, tissue cuture plantlets, inter specific hybrids and clonal/ semi clonal seeds/genomic selection. SHELL gene discovery by MPOB and Orion Genomics paved the way for precision breeding in oil palm (Nathan Lakey, *et al* 2016). Therefore, there is wide choice available now to order for planting materials with high yield and quality as well as resistant to biotic and abiotic stresses. Few of the planting materials which are commercially available worldwide are given as bullet points below.

- ASD Costa Rica had developed several commercial hybrids (avalanche, amazon, supreme, challenger, Bamenda, Kigoma, LaMe, Evolution Blue, Spring and Themba) and clones (drake, sabre, sunrise, titan and tornado) which were reported to field tested in different environments/ countries. ASDs ‘Tornado’ has yield potential of 43.6 ton of FFB/ha with oil to bunch ratio of 36.7%. One O ×G hybrid ‘Amazon’ can accommodate 135plams in a hectare of land.

- Palmelite is supplying oil palm seeds in the name of ‘CIRAD®’. They had developed many hybrids and clones for achieving high yield coupled with special features of disease resistance (Ganoderma and Fusarium wilt), premium oil quality (low lipase and acidity) and high-density planting. The produce namely ‘#S’ and #D denoted for dwarf and high-density hybrids, respectively. The ‘#S’ have 46-50cm of height increment year^{-1} with 26-28% Industrial Extraction Ratio of CPO and 160 palms population hacatare^{-1} can be accommodated for ‘#D’

- Sime Darby’s hybrid ‘Calix 600’developed from Deli dura and AVROS Pisifera is reported to produce up to 10 MT/ha/yr. with precocity in FFB production.

- AAR Hybida IS being the commercial hybrid developed by Applied Agricultural Resources Sdn. Bhd (AAR), Malaysia. Under a favorable growing environment, maximum of 35tonnes of FFB and 8-9t of CPO per hectare is reported in Hybrida1 during 7-10 years after planting.

- Felda Global Ventures (FGV)-Agricultural Services Sdn Bhd. had developed ‘Yangambi’ 3-way crosses with an FFB yield level ranging from13.45 -23.59 ton/ha from 1 to 3 years and 23.59 to 31.47 t/ha from 4 years and above with oil yield of 8.92 t/ha, OER 26.99 % and kernel oil of 0.94 t/ha.

- Sawit Kinabalu Seeds Sdn.Bhd, Sabha, Malaysia had developed D×P planting Materials for achieving high FFB, OER, bunch numbers and precocity. The expected yield levels reported was 13 to 16 ton from the first year harvest itself s and go on increase to 29 to 34 tons FFB/ha.

- IOI Deli × AVROS seed – is produced for commercial sale by IOI Group-Batang Melaka, Malaysia. The IOI Deli x AVROS hybrid seed is reported to gives high yields from the earliest years of production and is widely adaptable to different planting environments.

- Topaz oil palm is a D ×P custom commercial hybrid developed by Asian Agri; Indonesia is reported to have higher yields even in marginal soils and reduced vertical growth. The parent of Topaz has been extensively progeny tested in North Sumatra and Riau.

- PT Dami Mas Sejahtera (Subsidiary of Golden Agri Resources Ltd, Indonesia) is one of the top D×P seed suppliers in Indonesia and markets 'Dami Mas Sejahtera D×P seeds'. It has launched high-yielding new planting materials namely, Eka 1 and Eka 2 during 2017.

It is to be noted that varieties/hybrids have been developed through different breeding programmes in the countries *viz*., Malaysia, Zaire, Nigeria, Ivory Coast, Indonesia and Papua New Guinea and field tested for the environmental conditions of their own areas (Rey et al. 2004). Therefore, it is necessary to study the hybrid performance in the field trial under different environments and local conditions before taking decision on order for planting materials (Romero et al. 2007 and Rodriguez and Romero 2019).

CONCLUSION

Oil palm breeding for seed production has direct influence on growth of oil palm industry at global level. Oil palm industry aims to improve not only productivity of oil but also emphasis for different qualitative traits and develop new seeds/varieties suitable for different agro-climatic conditions from diverse germplasm by adopting conventional breeding and molecular approaches. In view of recent developments of newer countries taking up oil palm cultivation, existing oil palm growing countries expanding the areas, newer varieties developed for resistance to diseases, tolerance to drought, improved architecture, decrease of oil acidification etc. Choice of planting material will differ according to many local factors. It is difficult to assess global level seed requirement, because in majority of oil palm growing countries, the crop is grown by small farmers and in case of Africa, oil palm is grown with different agro- system. It is suggested to study the hybrid performance in the local conditions before taking decision on order for planting materials. India is developing oil palm in an area of about 2.0 million ha over a period of two decades, requires large numbers of planting materials of about 400 million sprouts in 20 years or approximately 20 million seeds. The following two pronged approaches are suggested for planting material requirements in India. 1. Strengthening and augmentation of indigenous seed production and import of promising exotic materials after evaluation in local conditions.

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