DOI : 10.5958/0974-0112.2020.00058.4

Indian J. Hort. 77(3), September 2020: 406-411

Evaluation of wild oil palm germplasm for horticultural traits

P. Murugesan*,, D. Ramajayam, P. Naveen Kumar, Anitha Pedapati, G. Ravichandran, H. P. Bhagya and Vikramaditya Pandey*****

ICAR-Indian Institute of Oil Palm Research, Regional Centre, Palode, Thiruvananthapuram 695 562, Kerala

ABSTRACT

Wild oil palm germplasm introduced from Guinea Bissau (GB), Cameroon (CA), Tanzania (TS) and Zambia (ZS) sources were evaluated for fresh fruit bunch (FFB) yield, alternate bearing index (ABI) and important bunch components (BC) with an objective to select individual palms for utilization in hybrid seed production at ICAR, IIOPR, RC, Palode, India. The results of one-way analysis of variance (ANOVA) revealed that palms belonging to TS and ZS showed good performance when compared to GB and CA and all exhibited significant differences for bunch weight, FFB yield and other important BC except bunch numbers (BN). The high co-efficient of variation of 67.22 % and 71.80 % were reported for FFB yield and nut weight (NW), respectively. Evaluation on the basis of individual palms revealed that two individual palms of TS (TS78 and TS85) and five palms of ZS (ZS71, ZS72, ZS77, ZS48, ZS 84) had desirable traits of low ABI coupled with high mean FFB yield (kg palm^{-1} year^{-1}). Further screening, based on conjoined traits namely, ABI and oil to bunch (%) resulted in selection of three promising palms *viz.*, TS85, ZS72 and ZS48 from TS and ZS, respectively for further improvement and utilization in hybrid seed production programme.

Key words: *Elaeis guineensis*, alternate bearing index, bunch components.

INTRODUCTION

Deli dura, their descendants and AVROS *pisifera* forms bulk of the parental materials of oil palm utilized for breeding for seed production throughout the world and *deli* is also a source for >50% of global commercial planting material supply (Corley and Tinker, 4). The first systematic plantation of oil palm was established in India during 1961 at Thodupuzha, Idukki district of Kerala with descendants of *Deli dura* and *tenera* materials introduced from Malaysia and Nigeria (Murugesan *et al*, 8). The present area planted under oil palm is 3.6 lakh hectares whereas potential estimated area is 19.3 lakh hectares. Annual demand of planting material in the country is 5 million germinated seeds. The bulk of the demand of oil palm planting material in India is met through import and indigenous seed production have been strengthened by widening germplasm base and introgression of diverse germplasm (Murugesan *et al*., 7). In general oil palm breeding is focused on crossing palms with complementary yield components and inheritance of those components (Corley and Tinker, 4). The selection of mother palms involves evaluation of the fresh fruit bunch (FFB) yield and bunch characteristics. The alternate bearing, peak and lean FFB production is one of the most important limitations in oil palm cultivation which upsets Industrial Extraction Rate (IER).Webster (16) reported biennial tendency in oil palm, wherein at least 40 % of the palms have a distinct tendency for biennial bearing. Fruit production is evenly distributed throughout the year in tropical humid climates with regular and uniform rainfall especially in countries like Malaysia and Indonesia. Whereas, in areas with alternate wet and dry season there is trend of alternate bearing, which were reported in West Godavari state of Andhra Pradesh (Naveen Kumar *et al*., 9) and Mulde in Maharashtra (Gawankar *et al*., 6) from the experimental fields planted with *dura* and *tenera*, respectively. Attempts made to mitigate alternate bearing in oil palm by employing some horticultural techniques (supplemental irrigation and other intensive cultivation technologies) showed that the lean yield of FFB production could not be moderated. However, some genotypes/germplasm sources of oil palm maintain high sex ratio throughout the year which is predominantly controlled by genetic factors (Corley and Tinker, 4) which may eventually lead to regular bearing. In this direction, new criteria of ABI were introduced to screen and select promising palms from wild African germplasm for utilization in the oil palm improvement programme, introgression into breeding lines and for hybrid seed production.

MATERIALS AND METHODS

A total of 52 pre-selected individual palms from oil palm germplasmsourced from Guinea Bissau(GB2,

*Corresponding author's E-mail: gesan70@gmail.com
**ICAR-CTCRI, Thiruvananthapuram, Kerala 695 017
***ICAR-Horticulture Science Division, Indian Council of Agricultural Research KAB-II, Pusa, New Delhi 110 012

GB8, GB10, GB12, GB13, GB15,GB17,GB20,GB25, GB26, GB27, GB29, GB30, GB32, GB33, GB35, GB37, GB38, GB39, GB43, GB45, GB46 and GB50), Cameroon (CA86), Tanzania (TS61, TS73, TS82, TS47, TS56, TS74, TS76, TS51, TS58, TS78, TS79, TS83, TS84, TS85) and Zambia (ZS48, ZS57, ZS60, ZS71, ZS77, ZS54, ZS63, ZS72, ZS80, ZS81, ZS52, ZS55, ZS68 and ZS70) were evaluated for Fresh Fruit Bunch (FFB) yield, Alternate Bearing Index (ABI) and Bunch Components (BC) at the Regional Centre of the ICAR-Indian Institute of Oil Palm Research Palode, Kerala (8° 45'N and 77° 59' E and 210 m above sea level, humid tropical, maximum and minimum temperature of 32.1°C and 22°C, respectively and laterite forest soil).The germplasm of Cameroon was collected during April, 1994, Guinea Bissau in May, 1994, Tanzania andZambiacombinedly during January-February 1995 through FAO assistance and seedlings were planted during 1998 at Palode (Pillai *et al.*, 11). A map showing African germplasm collection source countries are given in Fig 1.

The germplasm prospection in Africa covered various sites within each country *viz.*, Guinea Bissau represented with six collection sites (Cacheu region (Caio), Cacheu region (Canchungo), Cacheu region (Bula), Cacheu region, Ilha de Bubaque and Bubaque island), Cameroon with one site (Bamenda Highlands), Tanzania with four (Kitanga,

Fig. 1. Map indicating countries of collection of wild oil palm germplasm from Africa under FAO sponsored exploration.

Ujiji, Nyumbagwa and Businde) and three sites (Mukange, Lukwesa (Kilwa island) and Kazemba) of Zambia. The topography of locations, soil and climate of above sites are given in Table 1. The number and weight of harvested fruit bunches from each palm were recorded during 2009-10 to 2014-15 and the bunch analysis was carried out as per Nigerian Institute of Oil Palm Research's (NIFOR) methodology (Blaak *et al.*, (1). Alternate Bearing Index (ABI) was calculated as per the formula of Pearce and Dobersek-Urbanc, (10) by taking the bunch number and bunch weight as two determinants of yield.

$ABI = [1/(n-1)] \times \{[|a_2-a_1|/(a_2 + a_1)] + [|a_3-a_2|/(a_3 + a_2)] + ... + [|a_n-a_n-1|/(a_n+ a_n-1)]\}$, where'n' = Total number of years evaluated $a_1, a_2, ..., a_{n-1}, a_n$ = production in the corresponding year.All the parameters and harvest and BC data recorded were statistically analyzed and the means of the values were grouped by using the Fisher's Least Significant Difference ($P \leq 0.05$) wherever required.

RESULTS AND DISCUSSION

Dura palms are evaluated and selected for hybrid seed production on the basis of progeny testing through intensive selection based on family and individual palm performance (Corley and Tinker, 4). Accordingly, in the present study a total of 52 individual palms from four wild oil palm germplasm sources were assessed based on five years harvest yield data. The result on one way analysis of variance (ANOVA) revealed that palms belonging to TS and ZS showed good performance when compared to GB and CA and exhibited significant differences for bunch weight, FFB yield, fruit weight (FW), nut weight (NW), fruit to bunch (FB), mesocarop to fruit (MF), oil to bunch (OB), shell to fruit (SF) and shell thickness (ST) except bunch numbers (BN). Majority of the accessions belonging to TS and ZS sources had better yield and BC than GB and CA sources (Table 2).Guinea Bissau population of oil palm showed high level of homozygosity (Murugesan *et al.*, 7) for most traits. The degree of variations in some of the collections are low possibly due to the fewer oil palms naturally occurring in the regions where the climate is unfavourable as seen in Northern dry regions of Ghana in Africa (Sapey *et al.*, 13). The population of oil palms sampled and collected from Guinea Bissau (GB) seems to be near the border of natural distributed (Pillai *et al.*, 10) oil palm groves and improved commercial plantations established by Portuguese (Carrere, 2). Heritability of weight of bunches per palm is known to be quite high in oil palm as bunch weight is less responsive to stress (Woittiez *et al.*, 17) than bunch number, but have a

Table 1. Topography, soil type and climate details of the locations of wild African oil palm germplasm.

Country Sources	Name of the locations	Germplasm codes	Longitude	Latitude	Temperature (°C)	Soil type and climate
Guinea Bissau (GB)	Cacheu region (Caio)	GB 2	16º11'52.06" W	11º55'57.29" N	20 to 36°C	Clay enriched soil Hot and humid tropical
	Cacheu region (Canchungo)	GB 8, GB 12, GB 30, GB 35 GB 46	16º02'4.66" W	12º04'24.49" N	22°C	-Do-
	Cacheu region (Bula)	GB 20, GB 32, GB 33, GB 45	15º42'31.37" W	12º06'22.65" N	22°C	-Do-
	Cacheu region	GB 13, GB 15 GB 50	16º03'50.46" W	12º03'18.51" N	22°C	-Do-
	Ilha de Bubaque	GB 10, GB 17, GB 25, GB 29, GB 39	15º52'13.73" W	11º14'49.74" N	28 to 29°C	-Do-
	Bubaque island	GB 26, GB 27, GB 37, GB 38, GB 43	15° 49' 59.99" W	11° 16' 60.00" N	27 to 30°C	- Do-
Cameroon (CA)	Bamenda Highlands	CA86	10º09'60.00" E	5º55'59.99" N	24°C	Sandy clay and Tropical
Tanzania (TS)	Kitanga	TS61, TS 73,TS82	31º55'0" E	8º49'60" S	27°C	Black soil and Tropical dry
	Ujiri,	TS 47, TS 56, TS 74, TS 76	29º40'28.42" E	4º54'41.33" S	30°C	Sandy loam, Tropical dry
	Nyumbagwa	TS 51, TS 58, TS 78, TS 79, TS 83	29 ˚ 41'E	4 ˚ to 54 ˚ S	30°C	Dark loamy/swamp Tropical
	Businde	TS84, TS85	30º55'60" E	1º07'0" S	26°C	-Do-
Zambia (ZS)	Mukange	ZS48, ZS 57, ZS 60, ZS 71, ZS 77	32° 34' 00" E	9° 41' 00" S	-NA-	-Do-
	Lukwesa (Kilwa island)	ZS 54, ZS 63, ZS 72, ZS 80, ZS 81	28º27'4.89" E	9º16'17.41" S	-NA-	Sandy loam and Tropical dry
	Kazemba	ZS 52, ZS 55, ZS 68, ZS 70	32º34'52.54" E	12º11'5.03" S	20°C	-Do-

major impact on yield. FFB yield (kg palm^{-1}year^{-1}) of individual palms of GB, CA, TS and ZA sources is given in Fig. 2. The result revealed that palm ZS80 had maximumFFB yield of 187.42Kg palm^{-1}year^{-1} which was on par with TS58, TS78, TS84, TS85, ZS48, ZS71, ZS77, ZS72 and ZS68. The lowest FFB of 19.5 kg was recorded in TS74 which was on par with GB13, GB15, GB39, GB45 and GB50), TS61, TS47, TS56, TS76, TS79, ZS57, ZS54, ZS63, ZS52 and ZS70.There is considerable yield variation in the present germplasm materials as evidenced from theminimum and maximum FFB yield of 19.5 to 187.4 Kg palm^{-1} year^{-1}, respectively.

A total of seven Tanzanian and Zambian palms viz., ZS71 (164.38), TS85 (177.67), ZS72 (184.05), ZS77 (163.3), TS78 (173.08), ZS48 (179.82) and ZS 84 (173.94) recorded high mean FFB yield (kg palm^{-1} year $^{-1}$). The mean high value of co-efficient of variation of 67.22 % and 71.80 % were reported for FFB yield, nut weight (NW) and other BC indicated ample scope for selection of parental palms. According to Sitepu *et al*. (14), the ideal *dura* palm supposed to have medium bunch weight and relatively low bunch numbers. Because, in oil palm industry, heavier bunches are not preferred as it is difficult to handle and sterilize in the mill. In practice, attention is focused on both bunch yield and bunch quality components (Corley and Tinker, 4) for selection of parents for seed production. Lean and peak FFB production or alternate bearing in oil palm is one of the important problems which affects oil palm processors, growers and policy makers. Unlike, traditional oil palm growing countries like Malaysia and Indonesia, oil palm in India experiences peak and lean production of FFB. This is attributed mainly due to non-receipt of uniformly distributed rain fall and influence of genotype of planting materials. Considering the potential utility, new criteria of ABI were introduced to screen and select promising palms from present experimental materials of wild African germplasm collected from primary and secondary centres of origin of oil palm. Alternate bearing (AB) is the process by which cycles of heavy yield (ON crop) in one year are followed by a light yield (OFF crop). To further understand regular FFB production, Alternate Bearing Index (ABI) of potential palms within each population was calculated. The evaluated palms were separated into two groups based on their sensitivity to alternate bearing. The majority of the palms belonging to GB and CA in the present population (80.7 %) had ABI ranging from 0.109 to 0.500 and constituting the first group, whereas seven palms namely, TS78 (0.075), TS84 (0.081), TS85 (0.051), ZS48 (0.081), ZS71 (0.036), ZS77 (0.075) and ZS72 (0.058) had ABI below 0.100

Table 2. One-way analysis of variance (ANOVA) for FFB yield and bunch components of wild African oil palm.

Source	BW	BN	FFB	FW	NW	FB	MF	OB	SF	ST
GB	5.19^{B}	8.05	40.02^{B}	2.93^{B}	2.13^{B}	44.37^{C}	42.76^{B}	9.77^{B}	40.40^{A}	1.81^{B}
TS	12.05^{A}	6.86	83.49^{A}	5.85^{A}	4.80^{A}	50.39^{B}	53.56^{A}	13.80^{A}	33.79^{B}	2.37^{A}
ZS	12.89^{A}	7.86	104.55^{A}	7.64^{A}	6.02^{A}	56.56^{A}	46.27^{B}	13.12^{A}	36.26^{AB}	2.44^{A}
CA#	6.64	5.83	28.08	1.88	1.17	38.98	29.65	6.38	35.09	1.63
CV (%)	48.76	26.93	67.22	48.88	71.80	13.90	16.57	24.28	20.91	26.70
SE(d)	1.58	0.73	16.51	0.87	0.99	2.42	2.73	1.01	2.76	0.20
LSD at 5%	3.17	NS	33.19	1.74	1.20	4.86	5.48	2.03	5.55	0.40
Significant or NS	**	NS	**	**	**	**	**	**	*	**

GB: *Guinea Bissau*, TS: *Tanzania*, ZS: *Zambia*, CA: *Cameroon* **-Significant at 1%, *-Significant at 5%, NS-Non significant

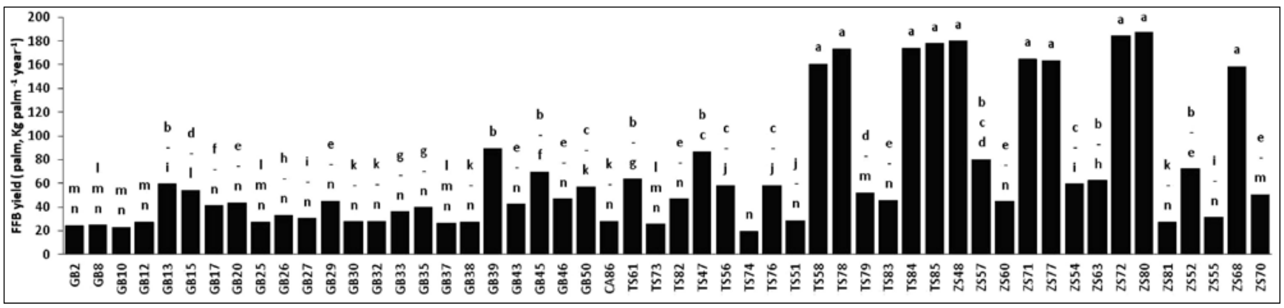

Fig. 2. Performance of individual palms of GB, CA, TS and ZA sources of African oil palm based on five years average FFB yield (kg palm^{-1} year^{-1}).

(Fig. 3). Higher ABI value indicates higher alternation. ABI could be used as an effective tool to exclude palms with irregular FFB bearing habits. From the regular bearing palms, palms which possess oil yielding heritable traits need to be advanced. Further, individual palm performance based on bunch quality components were also taken up for evaluation.

The oil yield per palm was maximum in ZS 48 (32.36 kg) which was on par with TS85 and ZS72 followed by TS58, TS84, ZS77, ZS80 and ZS68. Hybrid combinations involving Tanzanian *duras* with AVROS pisiferas were best for FFB and oil yield (Chapman *et al*. (3). Significantly high oil content (19.51%) was recorded in TS61 which was on par with GB13, TS82, TS47, TS79, TS85, ZS48, ZS57 and ZS72 accessions. Similarly, the lowest oil content was recorded in TS78 (5.61%) which was on par with GB26, GB27, GB29, GB30, GB32, GB35, GB37,

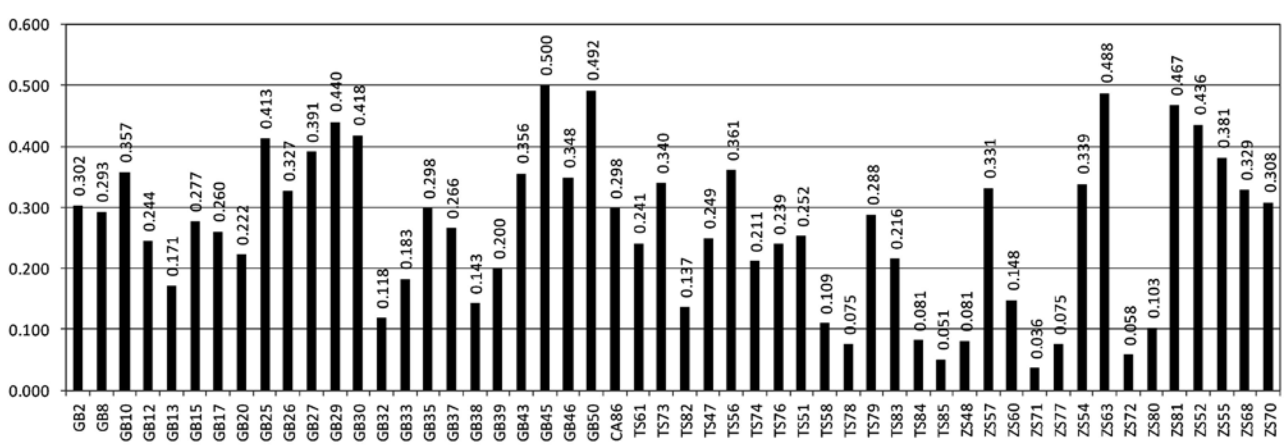

Fig. 3. Mean Alternate Bearing Index (ABI) for oil palm germplasm from individual palms of GB, CA, TS and ZA sources.

GB38, GB43, GB45, GB46, CA86 and ZS70. (Fig. 4). Rajanaidu and Jalani (12) compared extreme fruit weights of 3.7 and 26.4g and found high oil to bunch in heavier fruits.

Standard Industrial Research Institute of Malaysia (SIRIM) advocates O/B ratio of more than 16%as minimum desirable for the *dura* palms with unknown pedigree. None of the palms from GB source had prescribed O/B ratio, whereas one in Cameroon, five in Tanzania and two in Zambia had desirable O/B ratio. Since, bunch production, fruit set and other related ratios did not show any particular trend, selection exclusively on the basis of bunch components be avoided and yield and other heritable traits reported for evaluation of palm performance could be combined for selection as recommended by Escobar (5). Corley and Tinker (4) reported high heritability for fruit components and advocated attention to both yield and quality of bunch. Murugesan *et al*., (8) concluded in one of the studies that bunch quality characters should be super imposed on high yielding palms before attempting to use them for hybridization. Soh (15) studied four numbers of traits namely FFB yield, number of bunches, average bunch weight, oil to bunch percentage and height increment in an important progeny trial involving Deli *duras* and AVROS *pisiferas* in Malaysia. New criteria of ABI were introduced to screen the palms for regular production of bunches. All the top-ranking palms with low values of ABI in terms of regular bunch production cannot be forwarded to further cycle as it has to undergo progeny testing with previously selected *pisifera* palms and accommodating all the crosses in the field trial will be difficult. Taking into consideration of usual progeny testing requirement of conventional progeny trials in oil palm, three palms namely TS85, ZS72 and ZS48 can be forwarded for further evaluation and improvement. Though, ZS -80 had maximum mean FFB yield, it is not recommended for selection because of non-possession of other important/heritable traits *viz* bunch numbers, fruit to bunch and oil to bunch ratios whereas ZS72,TS-85 and ZS48 have recorded potential FFB yield along with desirable values of one or two additional traits and lower ABI.

The good performance recorded from individual palms belonging to Tanzania and Zambia may be due to introduction of better materials from West Africa. Moreover, the collection of the samples under taken in the Kigoma districts of plateau near the Lake Tanganyika and the river beds and valleys and river banks near Uij. Similarly, in Zambia, sample collection confined to Luapula valley and palm groves of some parts of Kilwa island in the Lake Mwerulake (Table 1). The selected individual palms from African sources in the present study may be selfed or crossed with Palode *duras* for generating female parental base population. Simultaneously, selected *tenera* sibs of Palode source may be selfed to select *pisifera* male parents. The D×T and D×P test crosses are being made between the afore-mentioned two populations. *Dura* and *pisifera* palms within these can be utilized for hybrid seed production based on field results to be obtained. In the present study, final selection was done based on conjoined traits namely, ABI and oil to bunch (%) which resulted in selection of three promising palms *viz*., TS85, ZS72 and ZS48 for introgression into breeding programme and for hybrid seed production in India. The selfed or *inter se* matted progenies of selected palms of Tanzanian and Zambian sources were planted as new seed garden at Palode (Kerala) and their performance has been systematically evaluated for utilization in seed production programme.

ACKNOWLEDGEMENTS

We acknowledge former Directors and former breeders and present Director of Indian Institute

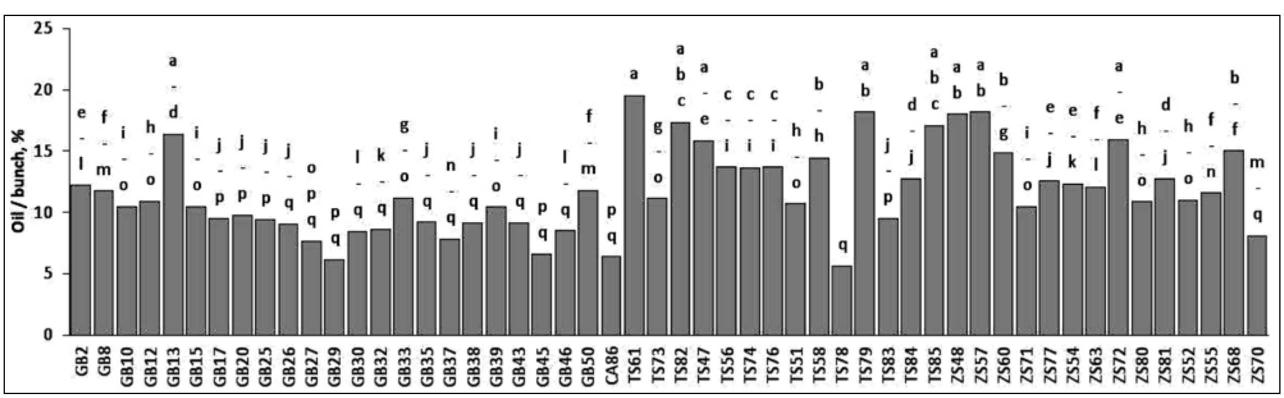

Fig. 4. Oil/bunch (%) of individual palms of GB, CA, TS and ZS of African oil palm germplasm sources.

of Oil Palm Research for their support. Senior author acknowledges Dr.V. Ravi, Director, ICAR-CTCRI, and Thiruvananthapuram for manuscript correction.

REFERENCES

1. Blaak, G., Sparnaaij, L.D. and Menendez, T. 1963. Breeding and inheritance in the oil palm (*Elaeis guineensis* Jacq.). II. Methods of bunch quality analysis. *J. West African Inst. Oil Palm Res.* **4**: 146-55.

2. Carrere, R. 2010. Oil palm in Africa: past, present and future scenarios. *WRM series on tree plantations* No. 15 (Rain Forest Movement), 79 p

3. Chapman, K. R., Escobar, R. and Griffee, P. 2003. Cold tolerant or altitude adapted oil palm hybrid development initiatives in Asia/Pacific region. *AU. JT*, **6**: 134-38.

4. Corley, R.H.V. and Tinker, P.B. 2003. Selection and breeding. ***In***: The Oil Palm (4th Eds.). Blackwell Science Ltd. *World Agriculture Series*, pp. 133-50.

5. Escobar, R. and Alvarado, A. 2003. Strategies in production of oil palm compact clones and seeds. ***In*:** Proceedings of the 2003 *Int. Palm Oil Cong. Agric. Conf.*, MPOB. Malaysia, pp. 75-90.

6. Gawankar, M.S, P. Devmore, Jamadagni B. M.and Djoshi, G.2004. Effect of dry and wet season on sex ratio and fresh fruit bunch yield in *tenera* oil palm. *Indian J. Plant Physiol.* **9**: 42-46.

7. Murugesan, P, Mary Rani, K.L Ramajayam, D, Sunil Kumar, K, Mathur, R.K, Ravichandran, G, Naveen Kumar, P and Arunachalam, V. 2015. Genetic diversity of vegetative and bunch traits of African oil palm (*Elaeis guineensis*) germplasm in India. *Indian J. Agric. Sci.* **85**: 892–95.

8. Murugesan, P., Gopakumar, S. and Haseela, H. 2011. Performance of *tenera* × *tenera* progenies derived from Thodupuzha (Kerala) oil palm germplasm II. Bunch quality components. *Indian J. Hort*. **68**: 303-06.

9. Naveen Kumar, P, R.K. Mathur, P. Murugesan, G.K. Reddy, K. Sunil Kumar, D. Ramajayam and G. Ravichandran, 2017. Seasonal variation in fresh fruit bunch production in *dura* oil palm. *Indian J. Agric. Sci.* **87**: 1184-89.

10. Pearce, S.C. and Dobersek-Urbanc, S. 1967. The measurement of irregularity in growth and cropping. *J. Hort. Sci*. **42**: 295-305.

11. Pillai, R.S.N., Blaak, G. and Paul Closen, H. 2000. Collection of oil palm (*Elaeis guineensis* Jacq.) germplasm from Africa. *Int. J. Oil Palm*. **1**: 23-37.

12. Rajanaidu, N. and Jalani, B.S.1994. Prospects for breeding for kernels in oil palm (*Elaeis guineensis*). *Planter*. **70**: 307-18.

13. Sapey, E K. Adusei-Fosu, D. Agyei-Dwarko and G. Okyere-Boateng, 2012. Collection of Oil Palm (*Elaeis guineensis* Jacq.) Germplasm in the Northern Regions of Ghana. *Asian J. Agric. Sci.* **4**: 325-28

14. Sitepu, B., Nelson, S.P.C. and Caligari, P.D.S. 2002. Bunch number and bunch weight-choosing their optima. Paper presented at 2002, Int. Oil Palm Conf., Indonesian Oil Palm Research, and Bali 8-12 July.

15. Soh, A.C. 1994. Ranking parents by best linear unbiased prediction (BLUP) breeding values in oil palm. *Euphytica*, **76**: 13-21.

16. Webster, C.C. 1939. A note on a uniformity trial with oil palms. *Trop. Agriculture*; Trin. **16:** 15-19.

17. Woittiez, Lotte S., Mark T. van Wijk, Maja Slingerland, Meine van Noordwijk, and Ken E. Giller. 2017. Yield gaps in oil palm: A quantitative review of contributing factors. *European J. Agron.* **83**: 57-77.

(Received : May, 2020; Revised : August, 2020; Accepted : August, 2020)