DOI : 10.5958/0974-0112.2021.00009.8

Indian J. Hort. 78(1), March 2021: 61-66

Evaluation of seedlings of oil palm germplasm from Sierra Leone and Senegal in India

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ABSTRACT

The oil palm (Elaeis guineensis Jacq.) germplasm of the present study, namely, Sierra Leone (SLE) and Senegal (SEN), are important genetic resources as their diversity is presumably very high due to their locations in the centre of origin of West Africa. A total of nine accessions each from two sources (SEN and SLE) were evaluated for vegetative growth traits in the nursery viz, seedling height, stem height, collar girth, leaf number, length of leaf, width of leaf, leaf area, petiole thickness and petiole length of the seedlings and their diversity were estimated using Shannon Weaver Index (SWI). The results revealed that accessions, namely, SLE14 (66) and SLE13 (349) showed vigorous seedling growth, whereas SEN02 (191) had shown dwarf vegetative growth. Diversity estimates ranged from 0.00 in SLE12 (186) for the number of leaves and 0.954 in SEN01 (38) for collar girth. SLE01 (38) and SLE03 (17) showed high diversity estimates, and the lowest diversity estimate was observed in SEN01 (284). Sierra Lone sources of accessions showed higher diversity than those from Senegal. The outcome obtained from the present nursery study can be utilized for advanced breeding evaluation in matured palms

Keywords: Shannon Weaver Index, Oil palm, Sierra Leone, Senegal, Diversity, Seedlings

The narrow genetic base is one of the important concerns in all oil palm growing countries which are affecting progress of development of new varieties in one way or other as presently oil palm hybrids are developed mostly by utilizing Breeding Population of Restricted Origin (BPRO) and their descendants. One such BPRO is 'deli dura' which is extensively used as parental palms for hybrid seed production in many global seed production centres (Corley and Tinker, 3). According to Hayati *et al*. (5), deli dura (one of the important BPRO) has low level of genetic diversity due to repeated selfing and inter se matting. India has diverse agro-climatic condition and a total area of 1.93 million hectares of potential area has been identified by Rethinam *et al.* (16) for oil palm cultivation in 18 states to meet the vegetable oil demand indigenously. Thodupuzha dura (Deli origin) and their descendants with narrow genetic base has been utilized for seed production in India (Murugesan et al., 11) and Pillai *et al*. (15). As direct access to germplasm is becoming more and more difficult under the Convention on Biological Diversity (1992), a collaborative research project involving Malaysian Palm Oil Board (MPOB) and Indian Institute of Oil Palm Research (IIOPR) was undertaken and a total of 20 accessions, 10 each from Sierra Leone and Senegal were introduced to India. Oil palm yield has been reported to be influenced by many factors including vegetative characteristics *viz*., leaf area, rachis length etc., (Okoye *et al.*, 14); because in mature palms these leaf characters determine light interception and it has direct effect on photosynthesis which influence fresh fruit bunch yield (Ithnin *et al.,* 6). Like above, plethora of reports are available on evaluation of matured palms of wild germplasm based on vegetative characters; but there is lack of information on vegetative growth variation in germplasm collections from Sierra Leone and Senegal Origin. Early evaluation is necessary to know the intricacies of genetic back round of wild germplasm so as to make a plan for effective utilisation including ex-situ conservation (Hayati *et al*. 5) as vegetative characters are reported to be have high positive correlation with oil yield. In the present study, nursery evaluation was conducted for early assessment of diversity of wild germplasm with an aim to utilise evaluation results for future improvement programme.

MATERIALS AND METHODS

Twenty accessions, 10 each of Sierra Leone (SLE) and Senegal (SEN) origin, received from Malaysian Palm Oil Board (MPOB) during 2016 to India (ICAR-IIOPR) through ICAR-National Bureau of Plant Genetic Resources (NBPGR) under the project entitled International Collaborative Research Project on Oil Palm Germplasm Exchange between India and Malaysia by import permit No.555/2015.

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All the accessions are *dura* type. The consignment of germplasm accessions were given with EC Nos. (869395; 869396; 869397; 869398; 869399; 869400; 869401; 869402; 869403; 869404; 869405; 869406; 869407; 869408; 869409; 869410; 869411; 869412; 869413 and 869414), source codes and alternate identities (SEN01 (Palm No.:284); SLE13 (PN:349); SLE06 (PN:22); SEN02 (PN:191); SLE03 (PN:534); SEN05 (PN:201); SLE14 (PN:223); SEN11 (PN:203); SLE01 (PN:38); SEN10 (PN:35); SLE03 (PN:17); SEN03 (PN:249); SLE14 (PN:40); SEN06 (PN:286); SLE14 (PN:56); SEN12 (PN:159); SEN12 (PN:186); SLE06 (PN:103); SLE14 (PN:66) and SEN01 (PN:349)) by NBPGR. The seeds of the germplasm were brought to Research Centre of ICAR - Indian Institute of Oil Palm Research (IIOPR) at Palode, Kerala and germinated seeds were raised in quarantine nursery facility established for imported germplasm. Fresh seeds were processed for dormancy breaking briefly, pericarp and mesocarp were removed from the fruit and then, seeds were kept at 40 ºC for 60 days in a temperature-controlled room and aseptic de-operculum seed dormancy breaking techniques was followed as per the procedure followed by Murugesan (10). Subsequently, sprouted oil palm seeds were sown in nursery and evaluation was conducted five months after planting. Except, two accessions (EC869408 and EC869412) which had very late germination, all other 18, (9 accessions each of Senegal (all except SEN06 (PN: 86)) and Sierra Leone (all except SLE06 (PN: 103) were evaluated for seedling vegetative growth *viz.* seedling height, stem height, collar girth, leaf number, length of leaf, width of leaf, leaf area, petiole thickness and petiole length using either meter ruler or digital caliper. Seedling height was measured from the surface of substrate to apical tip of leaves, by straightening the leaves upwards. The vegetative measurements were taken by adopting the procedure reported by Corley *et al*. (2). Five randomly selected seedlings were utilized for one replication and three replication were used for evaluation of vegetative growth of each germplasm accessions. The collar girth was taken at perpendicular angle at the plant base where roots originate from the shoot. The leaf numbers were counted manually. All the individual values were summed to get total in each character and scores were used to construct Shannon Weaver Index (26) and as per given formula.

$$H' = -\sum_{i=1}^{n} p_i \log_2 p_i$$

Where' 'n' is the total number of character states, p_i = proportion of individuals in the i^n state of character Each H´ estimate is normalized by dividing log2n (Grenier *et al*., 4). The seedling growth data were also subjected to statistical analysis using OPSTAT for Analysis of Variance (ANOVA) to test differences.

RESULTS AND DISCUSSION

In this section, results of vegetative characters of seedlings followed by diversity estimate (SWI) are presented. According to N'Cho *et al*. (13), vegetative characters are comparatively stable than reproductive characters and leaf characters have advantages of use in the nursery stage. Evaluation of seedlings on the basis of height and root-collar diameter is reported in crop improvement studies to assess quality attributes, precocity and vigour of the seedlings in the nursery. Mean vegetative growth of seedlings of Serena Leone and Senegal sources of germplasm are presented in Table 1 vegetative characters are also suitably depicted in Fig 2 for comparison of the individual accessions. An accession (SLE14: 66) had 45.02 cm, 6.98 cm, 10.05 cm, 5.60 nos., 26.46 cm, 4.29 cm, 114.54 cm^2, 0.53 cm and 8.01 cm for total seedling height, stem height, collar girth, number of leaves, leaf length, leaf width, leaf area, petiole thickness and petiole length, respectively. Similarly, SLE13 (349) of Sierra Leone recorded vigorous growth 43.82 cm, 9.64 cm, 9.64 cm, 6.47 nos., 27.19 cm, 3.90 cm, 105.80 cm^2, 0.53 cm and 8.11 cm, respectively for above seedling characters. Based on overall mean values of growth of seedlings, it is revealed that SLE14 (66) and SLE13 (349) had significantly vigorous seedling growth when compared to other accessions.The slow vertical and dwarf growth of 23.50 cm, 4.71 cm, 30.24 cm^2, 0.22 cm and 2.65 cm, respectively for seedling height, collar girth, leaf area, petiole thickness and petiole length were observed in SEN02 (191). It is apparent that SLE14 (66), SEN10 (35), SLE13 (349) and SLE01 (38) showed thick collar girth (10.05 cm, 9.95 cm, 9.64 cm and 9.56 cm, respectively) and similarly, SLE14 (66), SLE13 (349) and SEN01 (349) registered high petiole thickness (0.53 cm, 0.53 cm and 0.51 cm, respectively) and SLE13 (349), SEN01 (349) and SEN10 (35) put forth a greater number of leaves (6.47, 6.40 and 6.13, respectively). The SLE14 (66) (EC869413) had much better seedling characteristics compared to other accessions and showed uniqueness for characters *viz*., highest leaf area (114.54), collar thickness (10.05cm) and petiole thickness (0.53). The collar girth and leaf area are considered as indication of vigorous growth of palm seedlings (Kurup *et al.,* 7). The petiole traits significantly contribute adaptive evolution of oil palm and reported the usefulness of petiole dimensions of

Table 1. Mean vegetative growth of seedlings of Serena Leone and Senegal source of germplasm

Germplasm Code and Palm No.	Total height (cm)	Stem height (cm)	Collar girth (cm)	No. of leaves	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Petiole thickness (cm)	Petiole length (cm)
SEN01 (284)	27.84	5.48	5.48	4.87	16.03	2.77	45.10	0.21	4.16
SEN01 (349)	41.93	5.61	9.24	6.40	24.29	3.48	85.19	0.51	6.92
SEN02 (191)	23.50	2.47	4.71	4.27	14.44	2.07	30.24	0.22	2.65
SEN03 (249)	30.91	8.50	8.50	5.47	18.08	2.89	53.51	0.29	5.25
SEN05 (201)	25.90	3.48	6.58	5.07	17.82	2.49	48.22	0.28	4.29
SEN10 (35)	33.79	4.73	9.95	6.13	21.03	3.59	76.94	0.29	6.16
SEN11 (203)	23.78	2.93	5.73	5.00	15.43	2.53	40.00	0.24	3.31
SEN12 (159)	29.58	4.79	6.90	4.93	17.69	2.90	51.81	0.35	5.11
SEN12 (186)	24.75	3.05	6.08	4.40	15.34	2.65	42.26	0.26	3.45
SLE01 (38)	38.92	9.56	9.56	5.93	23.71	3.79	95.77	0.40	6.49
SLE03 (17)	28.41	7.82	7.82	5.60	17.49	3.18	61.21	0.30	4.65
SLE03 (534)	30.41	9.40	9.40	5.11	18.29	4.09	75.42	0.35	4.72
SLE06 (22)	28.38	3.22	8.24	5.13	19.57	4.15	82.04	0.41	4.50
SLE13 (349)	43.82	9.64	9.64	6.47	27.19	3.90	105.80	0.53	8.11
SLE14 (40)	33.25	5.00	8.77	5.20	21.18	3.64	77.81	0.41	5.33
SLE14 (56)	30.71	3.29	8.80	4.60	19.86	4.02	75.94	0.41	4.32
SLE14 (66)	45.02	6.98	10.05	5.60	26.46	4.29	114.54	0.53	8.01
SLE14 (223)	26.24	3.01	6.92	4.67	16.79	3.10	55.29	0.31	3.74
Mean	31.51	5.50	7.91	5.27	19.48	3.31	67.62	0.35	5.07
CD	5.71	1.73	1.97	0.66	3.49	0.67	22.96	0.09	1.16
CV (%)	10.9	18.86	14.94	7.48	10.75	12.13	20.38	15.64	13.75
Max	45.02	9.64	10.05	6.47	27.19	4.29	114.54	0.53	8.11
Min	23.5	2.47	4.71	4.27	14.44	2.07	30.24	0.21	2.65
Std dev	6.75	2.53	1.69	0.65	3.80	0.67	23.79	0.10	1.55

coconut palms in relation to adoptive evolution and wind tolerance (Corley *et al.,* 2). Among different seedling characters, highest variation (20.38%) was recorded for leaf area followed by stem height (18.86%) and least variation (7.48%) was observed in number of leaves followed by leaf length (10.75%) and seedling height (10.9%). The maximum standard deviation (23.79) was observed in leaf area followed by seedling height (6.75). The selection criteria for ideal seedlings in terms of leaf number and collar girth has been emphasised by Manju (8). Collar girth is an important criterion in seedling selection was found to be positively correlated with all other characters indicating its relevance in seedling selection. Satyabalan and Mathew (17) could identify superior palms with high genetic value based on collar girth and leaf production of progenies in coconut. Hence, the information obtained in this study will be useful to correlate the early seedling growth performance with future growth evaluation in matured palms in the breeding trials which would pave the way for précised selection. The oil palm germplasm sources namely, Sierra Leone (SLE) and Senegal (SEN) have hot tropical climate and natural oil palm grooves. The oil palm is originated in West Africa and both these sources fall in this region and grouped under 'Extreme West Africa' under microsatellite markers genetic diversity study by Bakoume *et al.* (1). Both Senegal and Sierra Leone are located in west coast of West Africa (Fig. 1). Natural groove of oil palm is observed in Guinea Bissau and its neighboring countries and it is endemic in West and Central Africa including Senegal. Sierra Leone and Senegal are located very

Fig. 1. Map indicating locations of germplasm collection sites of Sierra Leone and Senegal sources (Oil Palm primary centres of origin) of germplasm in West Africa.

close to Guinea Bissau and one can expect high diversity for different traits including economically desired traits. The germplasm occurring in natural grooves have greater allele number and broader reference population. The African sub-continent holds a large diverse germplasm which has high oil yielding potential and quality traits. These collected accessions have undergone no selection and modern breeding and hence, it may possess high genetic diversity. Marhalil *et al.* (9) reported that some areas of Senegal, Nigeria, Cameroon, Tanzania, Madagascar and Angola are falls in arid or semi-arid climate and germplasm from these sources presumed to have potential tolerance to drought and heat stress. According to Myint *et al.* (12), Senegal source of germplasm has potential drought and heat tolerance due to dry weather condition prevailing in the collection sites. Bakoume *et al.* (1) obtained rare alleles of adoptive traits from all the locations of Senegal and Sierra Leone sources of germplasm and attributed to low rainfall and dry weather. Both the sources of collection site are located in the primary centre of diversity. The several assessments were made and concluded that geographical location and distance from centre of diversity has influence on intensity of diversity. Hayati *et al*. (5) observed higher diversity in the countries located in Western Africa. Therefore, systematic evaluation is recommended for such precious materials even starting from nursery stage. Higher value of Shannon and Weaver Index means there is high diversity and high diversity are valuable. SWI of vegetative growth of Sierra Leone and Senegal germplasm is given in Fig. 3. Diversity estimates ranged from 0.00 in SLE12 (186) for number of leaves to 0.954 in SEN01 (38) for collar girth. Lowest diversity estimate for all the studied traits *viz.,* seedling height (0.177), stem height (0.485), collar girth (0.418), no. of leaves (0.177), 3rd leaf length (0.283), 3rd leaf width (0.453), leaf area (0.459), petiole thickness (0.283) and petiole length (0.453) were observed in SEN01(284) from Senegal which exhibited unique identity. The result revealed that Sierra Leone accessions showed high

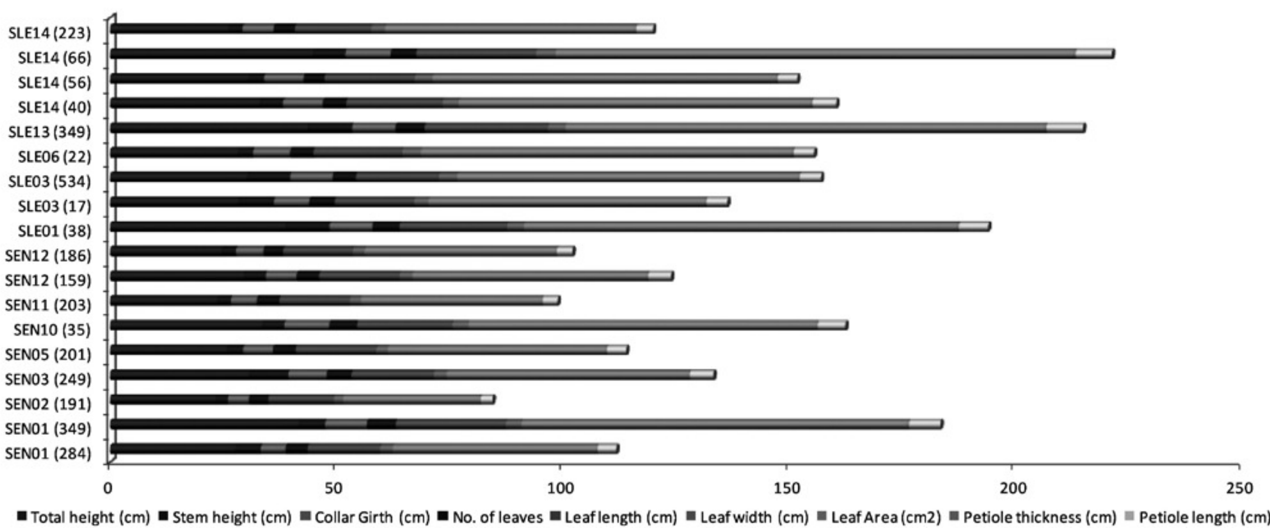

Fig. 2. Vegetative characters of Sierra Leone and Senegal sources of germplasm

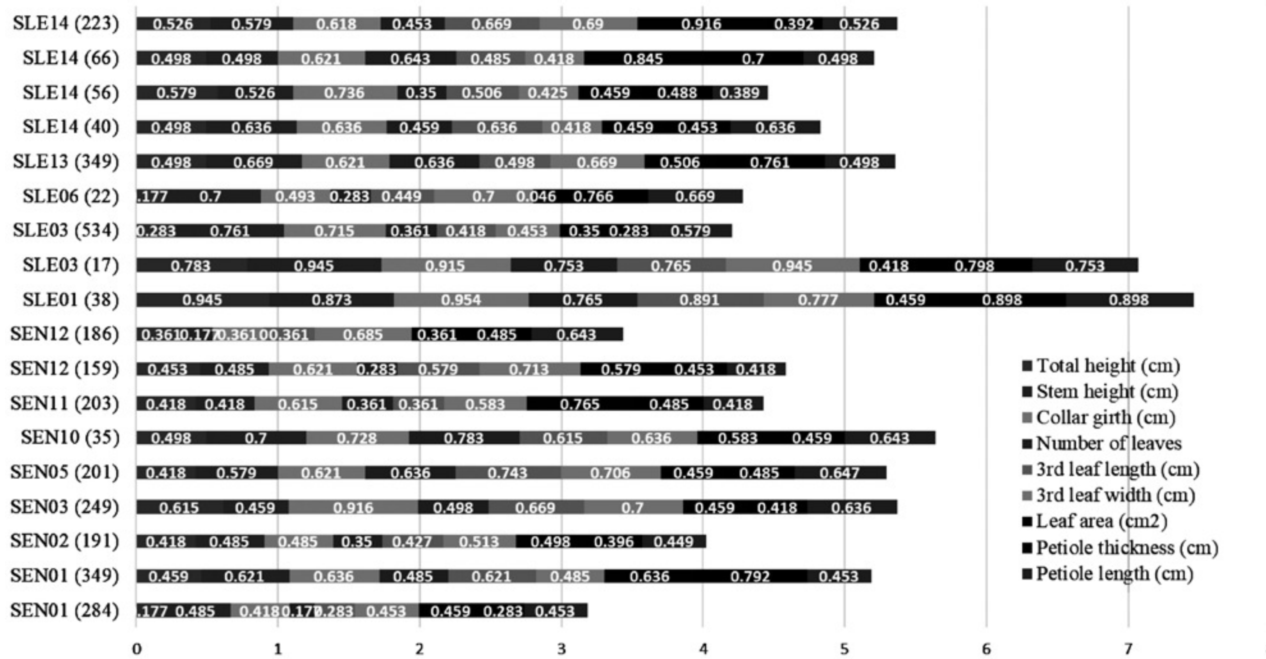

Fig. 3. Shannon–Weaver Index (SWI) of seedling growth of Sierra Leone and Senegal germplasm in India

diversity than Senegal. This study confirms that materials hailed from centre of origin exhibits higher diversity as Sierra Leone is located very nearer to oil palm i.e. Guinea Coast of West Africa. High genetic diversity was reported in Sierra Leone germplasm among the 26 germplasm collections from Africa as per report by Hayati *et al.* (5) and Senegal was reported medium diversity due to low sample size. As far as individual trait is concerned, collar girth showed high diversity than Senegal sources with one or two exceptions. In case of individual palm score index, SLE01 (38) had high diversity for collar girth (0.954) and seedling height (0.945). Collar girth was also high in SEN03 (249): (0.916) and SLE03 (17): (0.915). Two accessions namely SLE01 (38) and SLE03 (17) had significantly high diversity for all the seedlings parameters studied when compared to rest of the accessions.

Diverse germplasm for various desired traits is required to meet challenges in crop improvement of oil palm. The precious germplasm resources of Sierra Leone and Senegal germplasm are latest additions to existing germplasm of India and their early nursery evaluation of seedlings revealed that Sierra Lone sources of accessions showed high diversity than Senegal as per Shannon-Weaver Index of diversity. Two accessions namely, SLE03 (17) and SLE03 (38) had shown high diversity (Fig. 2). Whereas, SLE14 (66) and SLE13 (349) had significantly vigorous seedling growth when compared to other accessions. Lower diversity and dwarfism were noticed from SEN01 (284) and SEN02 (191) accessions of Senegal, respectively. The crucial preliminary results obtained in the present study need to be corroborated with other selection criteria during maturity phase for possible utilization and improvement in the breeding programme and hybrid seed production.

AUTHORS' CONTRIBUTION

Conceptualization of research (Murugesan, P), Designing of the experiments (Murugesan, P), Contribution of experimental materials (Murugesan, P), Execution of field/lab experiments and data collection (Murugesan, P and G. Somasundaram), Analysis of data and interpretation (G. Somasundaram and V. Pandey), Preparation of the manuscript (Murugesan, P, G. Somasundaram and V. Pandey)

DECLARATION

The authors declare no conflict of interest.

ACKNOWLEDGEMENT

Authors acknowledge Director, ICAR-IIOPR, Pedavegi for providing facility to conduct evaluation of germplasm at ICAR-IIOPR, Research Centre, Palode, Kerala, India. We also acknowledge DG, ICAR and DG, MPOB for approval of collaborative research project on exchange of germplasm between India and Malaysia.

REFERENCES

1. Bakoume, C., Wickneswari, R., Siju, S., Rajanaidu, N., Kushairi, A. and Billotte, N. 2015. Genetic diversity of the world's largest oil palm (*Elaeis guineensis* Jacq.) field gene bank accessions using microsatellite markers. *Genet. Resour. Crop Evol*. **62**: 349-60.

2. Corley R.H.V., Hardon, J.J. and Tan, G.Y. 1971. Analysis of growth of Oil palm I. Estimation of growth parameters and application in plant breeding. *Euphytic*a **20:** 307–15.

3. Corley, R.H.V. and Tinker, P.B. 2003. *The Oil Palm*. Blackwell Science Ltd., Oxford. 562 p.

4. Grenier, C., Hamon, P. and Bramel-Cox, P.J. 2001. Core collection of Sorghum. II. Comparison of three random sampling strategies. *Crop Sci.,* **37**: 992–97.

5. Hayati, A., Wickneswari, R., Maizura, I. and Rajanaidu, N. 2004. Genetic diversity of oil palm (*Elaeis guineensis* Jacq.) germplasm collections from Africa: implications for improvement and conservation of genetic resources. *Theor. Appl. Genet.,* **108**:1274–84.

6. Ithnin, M., Xu, Y., Marjuni, M., Serdari, M.N., Amiruddin, M.D., Low, E.T.L., Tan, Y.C., Yap, S.J., Ooi, L.C.L., Nookiah, N., Singh, R. and Xu, S. 2017. Multiple locus genome-wide association studies for important economic traits of oil palm. *Tree Genet. Genomes*. **13**: 103.

7. Kurup, S.S., Hedar, Y.S., Al-Dhaheri, M.A., El-Heawiety, A.Y., Aly, M.A.M and Alhadrami, G. 2009. Morpho-physiological evaluation and RAPD markers-assisted characterization of date palm (*Phoenix dactylifera* L.) varieties for salinity tolerance. *J. Food, Agric. Environ.,* **7(3&4):** 503-77.

8. Manju, P. 1992. Fruit component and seedling progeny analysis of komadan coconut types. Ph.D. thesis, Kerala Agricultural University, Thrissur.

9. Marhalil, M., Din, M.A., Rajanaidu, N. and Kushairi, A. 2015. Utilization of MPOB oil palm germplasm for climate change. **In:** *Proceedings of the International Seminar on Gearing Oil Palm Breeding and Agronomy for Climate Change*. Kuala Lumpur, Malaysia. pp. 7.

10. Murugesan, P. 2013. Aseptically breaking seed dormancy in oil palm. *ICAR News.* **19:** 2-3.

11. Murugesan, P., Merlin, J.M., Dipu, J., Bindu, S.J., Pillai, R.S.N. and Nampoothiri K.U.K. 2011. Yield potential and phenotypic variation of fruit and seed characteristics of oil palm duras at Thodupuzha. *J. Plant. Crops,* **39:** 114-18.

12. Myint, K.A., Amiruddin, M.D., Rafii, M.Y., Abd-Samad, M.Y., Ramlee, S.I., Yaakub, Z. and Oladosu, Y. 2019. Genetic diversity and selection criteria of MPOB-Senegal oil palm (*Elaeis guineensis* Jacq.) germplasm by quantitative traits. *Ind. Crops Prod.,* **139:** 1-11.

13. N'Cho, Y.P., Sangare, A., Bourdeix, R., Bonnot, F. and Baudouin, L. 1993. Assessment of a few coconut ecotypes – a biometric approach, study of tall populations. *Oleagineux,* **48:** 121–32.

14. Okoye, M.N., Okwuagwu, C.O., Uguru, M.I., Ataga, C.D. and Okolo, E.C. 2007. Genotype by traits relation of oil yield in oil palm (*Elaeis guineensis* Jacq.) based on GT biplot. **In:** *8th African Crop Science Society Conference*, Ahmad, K.Z. (ed.) El-Minia, Egypt. 27-31, pp 723–28.

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

16. Rethinam, P., Arulraj, S. and Rao, B.N. 2012. Assessment of additional potential areas for oil palm cultivation in India. Report submitted to Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India. Directorate of Oil Palm Research, Pedavegi, Andhra Pradesh, pp. 1-84

17. Satyabalan, K. and Mathew, J. 1977. Identification of prepotent palms in West Coast Tall variety based on growth of progeny in the nursery. **In***: International Symposium on Coconut Research and Development*, Kasaragod, India, pp-350-54.

Received : July, 2020; Revised : January, 2021;
Accepted : February, 2021