doi: 10.25081/jpc.2025.v53.i2.9999
Journal of Plantation Crops, 2025, 53 (2): 1-12

Characterization of oil palm germplasm using IBPGR descriptors and identification of promising genetic stocks

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(Manuscript received: 02.02.2025, Revised: 06.04.2025, Accepted: 29.05.2026)

Abstract

Oil palm (*Elaeis guineensis* Jacq.) improvement depends on the availability and effective utilization of genetically diverse germplasm. The present study aimed to characterize 24 selected oil palm germplasm accessions maintained at ICAR–Indian Institute of Oil Palm Research, which included *Elaeis guineensis* (17*duras* and 2 *teneras*) and *Elaeis oleifera* (5 accessions), using IBPGR (1989) descriptors and to identify palms with economically important traits. The accessions represented diverse geographic origins from Africa, South America, and Southeast Asia. Considerable variability was recorded for tree form, fruit form, bunch traits, bunch quality components, and vegetative characters. *Dura* and *tenera* fruit forms were observed in *Elaeis guineensis*, with predominance of *dura*, while *E. oleifera* exhibited thick-shelled fruits. Bunch weight ranged from 3.76 to 44.01 kg, while oil to bunch varied from 5.70 to 21.50%. Palm height ranged from 2.2 to 9.0 m, indicating the presence of both compact and tall palms. Based on trait-specific performance for bunch traits, bunch components, and vegetative characteristics, palms *viz*., DOPR-G23 (O6), DOPR-G24 (O22), DOPR G53 (E.61), and DOPR-G59 (E.48) were identified as potential parental sources for utilisation in breeding programmes, being superior for high bunch weight, high fruit to bunch, high oil to bunch, and low shell to fruit, respectively.

***Keywords*:** Oil palm, IBPGR descriptors, FFB, breeding and genetic stocks

Introduction

Oil palm (*Elaeis guineensis* Jacq.) is essentially a forest tree species originating from Africa that has been introduced and distributed to many parts of the world and is presently expanding into new environments owing to the increasing global demand for vegetable oils. Oil palm plays a dominant role in the international vegetable oil economy. Global palm oil production is projected at about 78 million metric tonnes in 2024/25, with Indonesia and Malaysia together accounting for more than 80% of the world's output, and Indonesia producing around 47.0–47.5 million tonnes and Malaysia about 19.0–19.2 million tonnes in 2024. Major usage of palm oil and demand continue to grow, driven by food processing, industrial uses and biofuels. China, India, Pakistan and countries in the European Union remain among the largest importers of palm oil globally. India's domestic total edible oil production in 2023–24 was about 12.18 million tonnes, which met only around 44 % of domestic consumption; the remaining about 56 % was met through imports. Palm oil constitutes the largest share of India's edible oil imports to roughly 55 % to 60 % of the total edible oil imported (USDA, 2025 and Ural *et al*., 2025). Global trends indicate that consumption of palm oil is increasing rapidly for both

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edible and industrial purposes. In India, cultivation of oil palm under irrigated conditions has been operationally successful in states like Andhra Pradesh and Telangana, which account for nearly 98% of national production, while other states including Karnataka, Kerala, Tamil Nadu, Odisha, Chhattisgarh, Goa and Mizoram also have notable areas under cultivation. Recently, oil palm cultivation has also expanded to several North Eastern states, including Mizoram, where it is promoted across multiple districts with supportive policies and farmer initiatives (Government of India, NMEO-OP, 2022). This expansion necessitates the availability of diverse germplasm with wide genetic variation for horticulturally desirable traits (Rauf and Camacho-Villalobos,2025). Among the various germplasm collections established at ICAR–Indian Institute of Oil Palm Research (ICAR-IIOPR), the primary collections prospected under the FAO programme and *Elaeis oleifera* accessions are considered important from the utilisation point of view. These collections comprise material originating from West Africa, East Africa, Central Africa, South America and Southeast Asia, representing both very old plantings (1981–1992) and relatively younger plantings (1998). Characterisation of germplasm is now an essential requirement for intellectual property rights (IPR) protection and registration of genetic stoc ks, besides serving as a foundation for crop improvement and development of new varieties (Bhagya *et al.*, 2024). Descriptor lists for plant genetic resources have been developed by Alliance Bioversity and CIAT (formerly Bioversity International), the International Board for Plant Genetic Resources (IBPGR) and the International Plant Genetic Resources Institute (IPGRI). For oil palm, a descriptor list was published in 1989 by IBPGR in collaboration with Dr. N. Rajanaidu of Malaysian Palm Oil Board (MPOB). In the present study, 24 selected individual palms were characterised using the IBPGR oil palm descriptors. With this background, the present study was undertaken with the objective of identifying palms with desirable traits for effective utilization in crop improvement programmes

Materials and Methods

Several exotic oil palm germplasm collections were field planted in the field gene bank of the Research Centre of ICAR-Indian Institute of Oil Palm Research (formerly National Research Centre for Oil Palm and Directorate of Oil Palm Research) at Palode, Thiruvananthapuram, Kerala, during 1981–2000. A total of 651 palms of introduced (mainly NIFOR Nigeria) germplasm (planted during 1981–1990), 26 palms of *E. oleifera* (planted in 1992), and 86 palms of African germplasm of FAO exploration (planted in 1998) were evaluated for their performance at ICAR-IIOPR.In the present study, 24 selected oil palm accessions representing the earliest introductions namely DOPR G-1 (221) from Nigeria; DOPR G-25 (Chi.1) and DOPR G-26 (Chi.2) of unknown origin (planted at Chitherae state of Oil Palm India Limited); DOPR G-22 (E.45) from Surinam; and DOPR G-23 (O6) and DOPR G-24 (O22) from Malaysia and Costa Rica, respectively were subjected to characterisation as per IBPGR (1989) descriptors. The basic passport data of germplasm accession details are given in Table 1. All the selected individual palms were assigned accession numbers adopted from the germplasm institute register. Detailed data and observations were collected on an individual palm basis. Observation and data on tree, fruit forms, stem structure, bunch characters and bunch components analysis were done to fulfil the format of IBPGR (1989) (Figure. 1). Five fresh fruit bunches (FFB) from each palm were utilised for bunch analysis as per the procedure described by Black *et al.,* (1963), and the average of the values was presented in the descriptor results. Three years (2007–2009) consecutive yields were taken for reporting under yield evaluation.The minimum general descriptors of oil palm germplasm, including tree characteristics, fruit forms, and relative age based on stem structure, were recorded during 2007–2009 and subsequently reevaluated during 2015–2017.The methodology prescribed by Corley *et al.,* (1971) was adapted to measure vegetative growth of the palms.

Table 1. Oil palm germplasm accessions maintained at the field gene bank (FGB), ICAR–IIOPR Research Centre, Palode

Sl. No	Institute ID	IC Number	Year of planting	Country of origin	Biological status
1	DOPR G - 1 (221)	IC0597691	1981	Nigeria	Hybrid progeny
2	DOPR G - 22 (E.45)	IC 0597686	1988	Surinam	Hybrid progeny
3	DOPR G - 23 (O 6)	IC0597690	1992	Malaysia	Unknown
4	DOPR G - 24 (O 22)	IC0597686	1992	Costa Rica	Unknown
5	DOPR G - 25 (Chi. 1)	IC0599984	1981	Unknown	Unknown
6	DOPR G - 26 (Chi. 2)	IC0599984	1981	Unknown	Unknown
7	DOPR G-30 (E2)	IC0597688	1998	Guinea Bissau	Wild
8	DOPR G-30 (E12)	-Do-	1998	Guinea Bissau	Wild
9	DOPR G-34 (E12)	-Do-	1998	Guinea Bissau	Wild
10	DOPR G - 35 (E15)	-Do-	1998	Guinea Bissau	Wild
11	DOPR G - 36 (E17)	-Do-	1998	Guinea Bissau	Wild
12	DOPR G - 44 (E.33)	-Do-	1998	Guinea Bissau	Wild
13	DOPR G-45 (E 35)	-Do-	1998	Guinea Bissau	Wild
14	DOPR G-46 (E 38)	-Do-	1998	Guinea Bissau	Wild
15	DOPR G-47 (E 40)	-Do-	1998	Guinea Bissau	Wild
16	DOPR G - 53 (E.61)	IC0597687	1998	Tanzania	Semi-wild
17	DOPR G - 53 (E.66)	-Do-	1998	Tanzania	Semi-wild
18	DOPR G - 53 (E.82)	-Do-	1998	Tanzania	Semi-wild
19	DOPR G - 54 (E.74)	IC0597689	1998	Tanzania	Semi-wild
20	DOPR G-56 (E-84)	-Do-	1998	Tanzania	Semi-wild
21	DOPR G-58 (E55)	-Do-	1998	Tanzania	Semi-wild
22	DOPR G - 59 (E.48)	-Do-	1998	Zambia	Semi-wild
23	DOPR G - 59 (E.77)	-Do-	1998	Zambia	Semi-wild
24	DOPR G - 52 (E.86)	-Do-	1998	Cameroon	Semi-wild

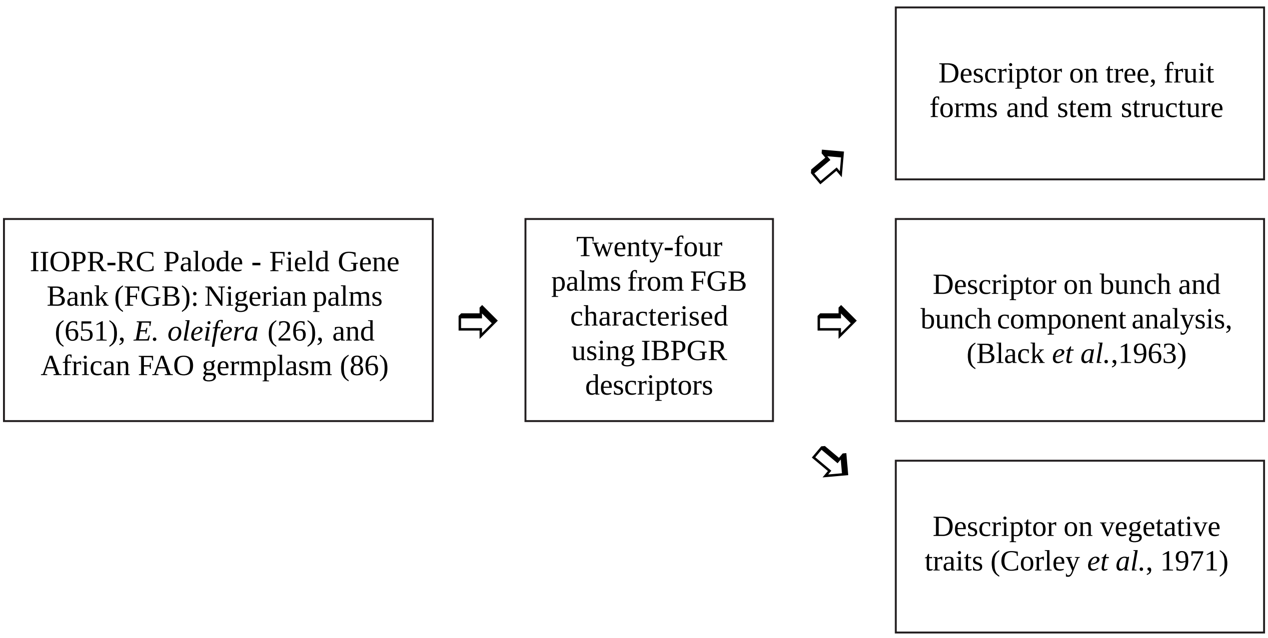


Fig. 1. Schematic representation of the experimental materials and methodology

The experimental site is located at Palode in Thiruvananthapuram district (8°452 N latitude and 77°592 E longitude) at an altitude of 210 m above mean sea level. The evaluation was carried out under Field–I laboratory conditions. The field gene bank location receives an annual rainfall of 2815 mm with maximum and minimum temperatures of 32.1 °C and 22 °C, respectively. It has forest laterite soil with a pH range of 5.0 to 5.5. Simple statistical analysis was done to analyse the data and reported in this article.

Results and Discussion

Descriptors on tree, fruit forms and relative age by stem structure

Descriptor on tree, fruit forms and relative age by stem structure are given in Table 2. Among the various germplasm collections planted at field gene bank at Palode,exotic primary collections namely Nigeria, Surinam, Malaysia, Costa Rica, Guinea Bissau, Tanzania, Zambia and Cameroon prospected under FAO programme and other *oleifera accessions* were considered as important from utilisation point of view. Apart from above prospection, collections were also made from commercial material and farmer's field and they were planted during1981-1992 in the old germplasm block at Palode. Based on the descriptors for oil palm characterization (IBPGR, 1989), on tree, fruit forms and relative age by stem structure, the following results were obtained. All the 24 accessions evaluated exhibited normal tree form and normal fruit type and idolatrous or mantled fruit forms are absent. *Dura* and *tenera* fruit forms were observed in *Elaeis guineensis*, with predominance of *dura*, while *E. oleifera*, exhibited thick-shelled fruits similar to *dura*. Seventeen accessions were *duras*, followed by *oleifera* (5 accessions), while *tenera* was represented by two accessions (DOPR-G1 and DOPR-G55). This composition is useful because it retains broad genetic representation including *oleifera* derived genetic resources, which are commonly valued as donors for traits such as reduced height increment/compactness and other adaptive traits in interspecific breeding (Murugesan *et al.*, 2020). With respect to external fruit pigmentation, *nigrescens* type predominated in 23 accessions, whereas one accession (DOPR-G53) exhibited the *virescens* type. Mesocarp pigmentation was highly uniform among the collection, being orange-red in most accessions, while deep orange mesocarp was observed only in the virescens accession (DOPR-G53). Mesocarp pigmentation with deep orange mesocarp was only observed in the virescens accession (DOPR-G53)-61. This accession represents a unique trait worth retaining as a potential donor/marker for pigmentation -related variation (Singh *et al.*, 2014). Stem texture is used as a field descriptor to support relative age/ structural differences among palms when palms are compared within a common evaluation period and site conditions. Relative age estimation based on stem texture showed that 23 accessions had rough stem texture, whereas only DOPR-G1 exhibited smooth stem texture during the evaluation period. General descriptors of oil palm germplasm on tree, fruit forms and relative age by stem structure is given in Table 2. The Accession No. DOPR 1 (221) came from Nigerian Institute of Oil palm Research and showed dwarf vegetative charecters. Similarly, DOPR G - 22 (E.45) had dumpy characters with unique green and deep orange fruit colours. DOPR G - 23 (O 6) and DOPR G - 24 (O 22) showed vigorous growth and proved to be inter specific hybrid nature. The other *oleifera* sources namely DOPR G-25(Chi.1) and DOPR G-30 (E2) are also showed compact growth and regarded as best donors for breeding for dwarf palms. DOPR-G1 is distinct from the rest of the evaluated set in a key morphological descriptor. The dwarf/compact growth expression noted for DOPR-G1 (NIFOR, Nigeria) and for the *oleifera* sources (e.g., DOPR-G25 and DOPR-G30) is practically important because compact palms are preferred in breeding for ease of harvest and plantation management. Further, the observation that DOPR-G23 (O6) and DOPR-G24 (O22) showed vigorous growth and "interspecific hybrid nature" is alilgned with published reports that interspecific (*E. oleifera* × *E. guineensis*) hybrid derivatives are exploited in breeding, particularly for traits linked to reduced height/compactness and oil quality (Sunil Kumar *et al.*, 2014).

Table 2. Minimum general descriptors of tree form, fruit form, and relative age by stem structure in oil palm germplasm

Sl No.	Institute Code	Fruit form*	Tree form	Fruit colour - external fruit	pigmentation fruit colour - mesocarp	Relative age by stem texture
1	DOPR-G1 (221)	*Tenera*	Normal	Nigrescens	Orange red	Smooth
2	DOPR-G22 (45)	Not applicable (*E.oleifera*)	Normal	Nigrescens	Orange red	Rough
3	DOPR-G23 (0.6)	Not applicable (*E.oleifera*)	Normal	Nigrescens	Orange red	Rough
4	DOPR-G24 (0.22)	Not applicable (*E.oleifera*)	Normal	Nigrescens	Orange red	Rough
5	DOPR-G25(Chi. 1)	Not applicable (*E.oleifera*)	Normal	Nigrescens	Orange red	Rough
6	DOPR-G26 (Chi.2)	Not applicable (*E.oleifera*)	Normal	Nigrescens	Orange red	Rough
7	DOPR-G27 (F16)	*Dura*	Normal	Nigrescens	Orange red	Rough
8	DOPR-G28 (F. 56)	*Dura*	Normal	Nigrescens	Orange red	Rough
9	DOPR G-35 (E 15)	*Dura*	Normal	Nigrescens	Orange red	Rough
10	DOPR G-44(33)	*Dura*	Normal	Nigrescens	Orange red	Rough
11	DOPR G53 (E.61)	*Dura*	Normal	Virescens	Deep orange	Rough
12	DOPR G56(84)	*Dura*	Normal	Nigrescens	Orange red	Rough
13	DOPR G59 (48)	*Dura*	Normal	Nigrescens	Orange red	Rough
14	DOPR G30 (E29)	*Dura*	Normal	Nigrescens	Orange red	Rough
15	DOPR G43 (E30)	*Dura*	Normal	Nigrescens	Orange red	Rough
16	DOPR G45 (E35)	*Dura*	Normal	Nigrescens	Orange red	Rough
17	DOPR G46 (E38)	*Dura*	Normal	Nigrescens	Orange red	Rough
18	DOPR G47(E40)	*Dura*	Normal	Nigrescens	Orange red	Rough
19	DOPRG50 (E46)	*Dura*	Normal	Nigrescens	Orange red	Rough
20	DOPR G51 (50)	*Dura*	Normal	Nigrescens	Orange red	Rough
21	DOPR G52 (E86)	*Dura*	Normal	Nigrescens	Orange red	Rough
22	DOPR G55 (E51)	*Tenera*	Normal	Nigrescens	Orange red	Rough
23	DOPR G57 (E54)	*Dura*	Normal	Nigrescens	Orange red	Rough
24	DOPR G58 (E55)	*Dura*	Normal	Nigrescens	Orange red	Rough

**E. oleifera* exhibited thick-shelled fruits

Descriptors of germplasm on bunch characters

Descriptors of germplasm on bunch characters are given in Table 3. Considerable variability was observed among the 24 accessions for bunch and spine–related quantitative and qualitative traits prescribed under IBPGR bunch and bunch analysis descriptors. Bunch weight ranged from 3.76 to 44.01 kg with a mean of 11.40 kg and high variability (CV = 99.00%), indicating wide diversity in bunch size. Bunch length varied from 27 to 67.5 cm (mean 34.07 cm, CV = 35.36%), while bunch breadth and depth ranged from 40 to 140 cm (mean 77.97 cm, CV = 37.84%) and 16 to 46 cm (mean 21.92 cm, CV = 34.32%), respectively. Spine length showed a broad range (0.25–11.3, mean 4.13, CV = 34.46%), whereas spine thickness ranged from 0.63 to 7.23 mm with a mean of 3.30 mm and CV of 43.10%. With respect to qualitative spine traits, green spine colour was confined to six accessions (DOPR-G1 to DOPR-G26), while the remaining accessions exhibited orange spines, conforming to the colour classes described in the descriptor list. Spine density was predominantly low (score 3), with a few accessions showing high density (score 5), resulting in a mean of 3.58 and CV of 27.31%. Stalk length varied from 6 to 28 cm (mean 11.38 cm, CV=40.65%), further reflecting substantial inter-accession variation. Previous characterization studies have shown that bunch weight, bunch length, and bunch breadth/depth are strongly influenced by genotype and often display moderate to high variability across germplasm collections, similar to the present findings. These traits are directly associated with fresh fruit bunch (FFB) yield and therefore serve as reliable indicators for preliminary selection of high-yielding genotypes (IBPGR, 1989).The observed variation in spine length, thickness, colour, and density further demonstrates the usefulness of spine-related descriptors in discriminating among accessions. Although spine traits are not direct yield determinants, they are stable morphological markers that assist in accession identification, classification, and maintenance of genetic purity. Comparable trends of variability in spine traits and stalk length have been reported in oil palm germplasm evaluations, highlighting their value as supplementary descriptors in morphological characterization (Corley and Tinker, 2016).

Bunch stalk length, although not a direct yield component, has practical implications for bunch support, ease of harvesting, and bunch presentation within the canopy. Previous studies have indicated that stalk-related characters show appreciable variability and are useful as morphological characterization (IBPGR, 1989; Corley and Tinker, 2016). The high CV observed in the present study indicated that selection for desirable stalk length is feasible to develop palms with improved bunch architecture and better field manageability.

Table 3. Essential descriptors of bunch characters for oil palm germplasm

Sl. No	Institute Code	Bunch Weight [Kg]	Bunch length [cm]	Bunch breadth [cm]	Bunch depth [cm]	Spine length (cm)	Spine thickness (mm)	Spine colour	Spine density	Stalk length [cm]
1	DOPR-G1 (221)	11.3	32.25	87.5	22.00	4.34	2.33	Green	3.00	10.75
2	DOPR-G22 (45)	12.5	44.67	92.9	26.00	3.60	4.05	Green	3.00	9.70
3	DOPR-G23 (0.6)	44.55	67.5	140	30.00	3.80	6.11	Green	3.00	8.50
4	DOPR-G24 (0.22)	21.65	39.33	126	30.00	3.24	7.23	Green	3.00	6.00
5	DOPR-G25(Chi. 1)	25.70	52.50	128.5	31.00	0.34	4.17	Green	3.00	9.50
6	DOPR-G26 (Chi.2)	32.02	55.00	135.00	18.00	0.25	0.63	Green	3.00	12.0
7	DOPR-G27 (F16)	5.04	27.00	62.00	20.00	3.60	3.25	Orange	5.00	9.00
8	DOPR-G28 (F. 56)	7.16	30.00	69.00	21.00	4.07	3.62	Orange	5.00	13.00
9	DOPR G-35 (E 15)	2.19	30.00	60.00	16.00	4.10	2.73	Orange	5.00	9.00
10	DOPR G-44(33)	4.06	40.00	80.00	46.00	4.00	1.75	Orange	5.00	28.00
11	DOPR G53 (E.61)	8.01	38.00	40.00	28.00	5.76	4.59	Orange	5.00	12.00
12	DOPR G56(84)	4.49	32.00	70.00	19.60	4.30	4.03	Orange	3.00	11.00
13	DOPR G59 (48)	18.71	35.00	80.00	22.40	6.60	3.27	Orange	3.00	6.00
14	DOPR G30 (E29)	4.11	33.00	83.75	23.45	3.88	3.51	Orange	3.00	12.00
15	DOPR G43 (E30)	3.38	21.00	55.75	15.61	3.68	3.12	Orange	3.00	8.00
16	DOPR G45 (E35)	5.41	27.50	65.00	18.20	4.00	3.22	Orange	3.00	16.00
17	DOPR G46 (E38)	7.01	20.75	61.00	17.08	4.11	2.57	Orange	5.00	14.00
18	DOPR G47(E40)	5.28	30.20	78.50	21.98	3.80	3.04	Orange	3.00	11.00
19	DOPRG50 (E46)	3.3	24.50	58.00	16.24	4.73	2.59	Orange	3.00	13.00
20	DOPR G51 (50)	3.97	23.75	48.00	13.44	4.12	3.72	Orange	5.00	12.00
21	DOPR G52 (E86)	3.16	17.75	44.75	12.53	3.24	1.84	Orange	3.00	12.00
22	DOPR G55 (E51)	8.39	25.50	55.33	15.49	11.3	2.35	Orange	3.00	10.00
23	DOPR G57 (E54)	10.99	39.50	91.00	25.48	4.29	2.91	Orange	3.00	9.75
24	DOPR G58 (E55)	4.83	31.00	59.25	16.59	4.02	2.63	Orange	3.00	11.00
Mean		11.40	34.07	77.97	21.92	4.13	3.30	-	3.58	11.38
STDev		11.25	12.05	29.50	7.52	1.42	1.42	-	0.98	4.63
Max		44.01	67.50	140.00	46.00	11.3	7.23	-	5.00	28.00
Min		3.76	27.00	40.00	16.00	0.25	0.63	-	3.00	6.00
CV (%)		99.00	35.36	37.84	34.32	34.46	43.10	-	27.31	40.65

Descriptors of germplasm on bunch quality components

Descriptors of germplasm on bunch quality components is given in Table 4. Wide variation was recorded among the 24 accessions for bunch composition and oil-related traits prescribed under IBPGR bunch analysis descriptors (fruit/bunch, mesocarp/fruit, oil/wet mesocarp, shell/fruit, kernel/fruit, oil/bunch, single fruit weight, single nut weight and kernel/bunch). Fruit proportion in bunch ranged from 31.62 to 84.76% with a mean of 51.47% (CV 38.55%), while mesocarp proportion per fruit varied from 29.65 to 77.20% (mean 50.19%, CV 41.87%). Oil content of wet mesocarp showed values between 17.45 and 57.16% with a mean of 48.21% (CV 33.83%). Shell proportion per fruit ranged from 10.25 to 48.98% (mean 33.30%, CV 33.94%), whereas kernel proportion per fruit varied from 4.50 to 25.47% (mean 14.43%, CV 18.47%). Oil recovery at bunch level (oil/bunch) ranged from 5.70 to 21.50% with a mean of 11.90% (CV 14.01%). Single fruit weight exhibited wide variation (1.70–30.12 g, mean 8.12 g), and single nut weight ranged from 1.08 to 16.72 g (mean 4.21 g). Kernel oil contribution to bunch varied from 1.00 to 7.85% with a mean of 3.32%. Based on individual palm performance for economically important bunch composition traits, DOPR-G24 (0.22) and DOPR-G53 (E.61) were outstanding with very high fruit/bunch proportion (84.76 and 73.12%, respectively) coupled with high oil/bunch values (20.2 and 21.5%), indicating superior conversion of bunch biomass into oil. DOPR-G1 (221) combined high mesocarp/fruit (77.2%) with high oil/wet mesocarp (54.6%) and oil/bunch (20.4%), making it a promising palm for mesocarp oil productivity. DOPR-G28 (F.56), DOPR-G59 (48), DOPR-G47 (E40), DOPR-G50 (E46), and DOPR-G57 (E54) expressed high oil/wet mesocarp (>53%) with moderate to good oil/bunch values. For kernel-related traits, DOPR-G26 (Chi.2), DOPR-G45 (E35), DOPR-G56 (84), DOPR-G35 (E15) and DOPR-G59 (48) recorded comparatively higher kernel/bunch contributions, indicating potential for kernel oil improvement. Palms such as DOPR-G27 (F16) and DOPR-G53 (E.61) also possessed higher single fruit and nut weights, contributing to yield potential. Overall, DOPR-G24, DOPR-G53, DOPR-G1, DOPR-G28 and DOPR-G59 emerge as the most promising palms for selection towards higher oil yield, while DOPR-G26 and DOPR-G45 may be considered as donor palms for enhancing kernel traits in breeding programmes. Oil/bunch is primarily determined by the proportion of fruit in the bunch, mesocarp content of the fruit, and oil concentration in the mesocarp. Similar patterns of wide variation for these components have been reported in diverse oil palm germplasm collections and are considered typical of heterogeneous genetic resources (IBPGR, 1989).The good performance of DOPR-G24 and DOPR-G53 for high fruit/bunch and high oil/bunch is explained by the established relationship where higher fruit set per bunch and favourable mesocarp characteristics enhance oil recovery at the bunch level (Pedapati *et al.*, 2024; Kin, 2019). Similarly, the high mesocarp/fruit, high oil/wet mesocarp, and high oil/bunch observed in DOPR-G1 are preferred for augmenting mesocarp oil productivity. Variation in kernel/bunch and kernel/fruit proportions, with accessions (DOPR-G26, DOPR-G45, DOPR-G56, DOPR-G35 and DOPR-G59) showing higher values, indicates additional avenues for improving kernel oil yield. Corley and Tinker (2016) emphasized that although mesocarp oil constitutes the major fraction of palm oil yield, kernel traits remain important in breeding programmes aimed at enhancing total oil output and value.

Table 4. Essential descriptors of bunch quality components for oil palm germplasm

Sl. No	Institute Code	Fruit bunch [%]	Mesocarp/ fruit [%]	Oil/wet mesocarp [%]	Shell/ fruit [%]	Kernel/ fruit [%]	Oil/ bunch [%]	Single fruit weight [g]	Single nut weight [g]	Kernel oil bunch [%]
1	DOPR-G1 (221)	48.3	77.2	54.6	10.7	7.3	20.4	8.00	1.7	1.10
2	DOPR-G22 (45)	53.4	75.94	37.8	11.9	9.51	9.25	8.27	2.55	3.13
3	DOPR-G23 (0.6)	47.36	61.2	32.52	29.15	11.65	11.87	9.33	3.88	1.52
4	DOPR-G24 (0.22)	84.76	60.33	29.96	29.96	8.84	20.2	6.46	2.61	4.44
5	DOPR-G25(Chi. 1)	61.46	55.77	32.08	35.26	8.79	11.03	15.41	6.95	4.69
6	DOPR-G26 (Chi.2)	61.71	47.38	17.45	40.67	11.95	5.70	15.00	8.22	7.85
7	DOPR-G27 (F16)	42.86	65.93	47.44	29.41	4.66	13.4	30.12	10.02	1.00
8	DOPR-G28 (F. 56)	54.47	62.18	53.84	33.29	4.50	18.24	14.59	6.52	1.40
9	DOPR G-35 (E 15)	65.62	41.71	49.34	35.91	22.50	13.50	2.27	1.32	5.60
10	DOPR G-44(33)	47.83	43.21	55.87	41.46	15.36	11.50	2.80	1.59	2.25
11	DOPR G53 (E.61)	73.12	60.94	55.94	35.36	15.53	21.50	17.91	16.72	2.65
12	DOPR G56(84)	52.56	46.95	50.29	25.59	18.89	10.89	4.63	2.17	5.96
13	DOPR G59 (48)	57.24	55.54	51.01	10.25	15.13	13.52	10.31	5.47	5.30
14	DOPR G30 (E29)	31.62	41.66	47.14	35.2	23.14	6.17	2.78	1.79	3.14
15	DOPR G43 (E30)	46.57	33.42	54.65	45.65	20.93	8.46	2.32	1.69	3.11
16	DOPR G45 (E35)	42.28	43.4	50.46	42.99	19.91	9.18	5.44	1.88	7.24
17	DOPR G46 (E38)	51.24	37.06	49.11	30.3	15.93	9.13	2.53	2.14	2.59
18	DOPR G47(E40)	51.14	37.08	54.99	34.07	25.47	10.42	1.70	1.08	2.97
19	DOPRG50 (E46)	39.14	38.61	57.09	48.83	17.76	8.50	2.99	1.73	1.88
20	DOPR G51 (50)	41.4	55.68	51.84	40.14	12.77	11.82	1.98	1.19	1.70
21	DOPR G52 (E86)	38.98	29.65	56.88	35.09	16.57	6.38	2.56	1.17	1.90
22	DOPR G55 (E51)	36.89	53.86	53.42	36.55	15.47	10.71	2.83	1.09	1.12
23	DOPR G57 (E54)	55.23	39.83	57.16	32.56	14.63	12.32	10.31	5.86	5.15
24	DOPR G58 (E55)	50.11	40.1	56.05	48.98	9.09	11.58	14.38	11.8	2.07
	Mean	51.47	50.19	48.21	33.30	14.43	11.90	8.12	4.21	3.32
	STDev	11.95	12.98	10.49	10.52	5.73	4.34	6.96	4.05	1.99
	Max	84.76	77.20	57.16	48.98	25.47	21.50	30.12	16.72	7.85
	Min	31.62	29.65	17.45	10.25	4.50	5.70	1.70	1.08	1.00
	CV (%)	38.55	41.87	33.83	33.94	18.47	14.01	22.46	13.08	6.42

Descriptors of germplasm on vegetative characters

Descriptors of germplasm on vegetative characters is given in Table 5. Substantial variation was observed among the 24 oil palm accessions for vegetative descriptors prescribed by IBPGR, namely height of palm, rachis length, number of leaflets, leaflet length, leaflet width and frond production per year. Palm height ranged from 2.2 to 9.0 m with a mean of 4.44 m (CV 38.61%), indicating the presence of both short- and tall-statured palms. Rachis length varied from 3.6 to 7.26 m (mean 5.29 m, CV 24.12%). Number of leaflets ranged from 152 to 320 per frond (mean 242.17, CV 22.01%), while leaflet length varied from 62.5 to 122 cm (mean 83.35 cm, CV 23.34%) and leaflet width from 2.5 to 7.18 cm (mean 4.70 cm, CV 32.46%). Frond production per year was relatively uniform, ranging from 22 to 26 fronds with a mean of 24.04 (CV 2.60%). Based on desirable criteria of moderate plant height, longer rachis, higher number of leaflets and larger leaflet size, accessions DOPR-G24 (0.22) (height 4.6 m, rachis 7.0 m, 320 leaflets, leaflet length 122 cm), DOPR-G26 (Chi.2) (3.85 m, 7.26 m, 280 leaflets, 114 cm), DOPR-G23 (0.6) (3.3 m, 6.8 m, 304 leaflets, 116 cm) and DOPR-G59 (48) (2.25 m, 4.4 m, 320 leaflets, 121.7 cm) emerged as superior palms combining compact stature with robust canopy architecture. Conversely, very tall palms such as DOPR-G50 (E46), DOPR-G45 (E35) and DOPR-G46 (E38) may be less desirable for future planting due to harvesting difficulties.

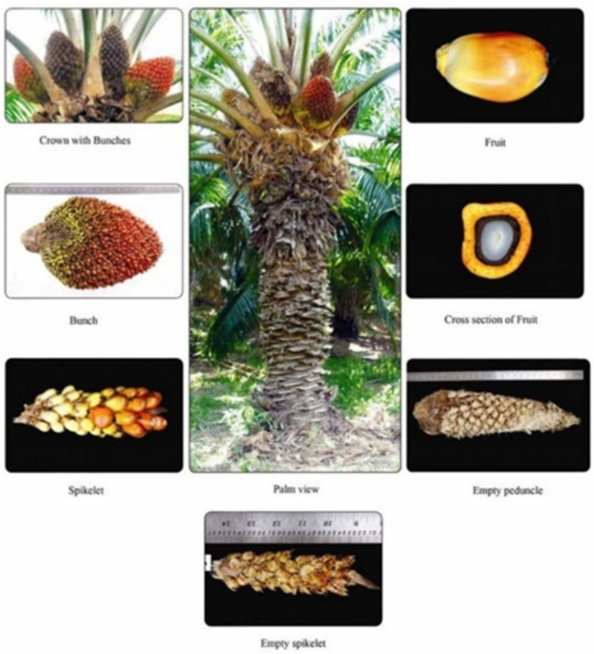
Table 5. Minimum descriptors for vegetative characters of oil palm germplasm

Sl. No	Institute Code	Height of the palm(m)	Rachis length (m)	No. of leaflet	Length of leaf let (cm)	Width of leaflet (cm)	Fronds production/ Year
1	DOPR-G1 (221)	2.20	4.85	240	85.33	4.00	24
2	DOPR-G22 (45)	2.35	6.40	240	97.30	6.02	24
3	DOPR-G23 (0.6)	3.30	6.80	304	116.00	7.00	24
4	DOPR-G24 (0.22)	4.60	7.00	320	122.00	6.50	24
5	DOPR-G25(Chi. 1)	4.0	6.70	290	106.00	7.13	26
6	DOPR-G26 (Chi.2)	3.85	7.26	280	114.00	7.18	24
7	DOPR-G27 (F16)	2.90	6.10	272	100.00	7.00	24
8	DOPR-G28 (F. 56)	2.84	6.50	320	68.33	4.00	24
9	DOPR G-35 (E 15)	3.00	4.60	240	70.70	3.50	22
10	DOPR G-44(33)	4.00	5.65	240	75.30	5.00	24
11	DOPR G53 (E.61)	4.50	6.14	300	62.50	6.50	24
12	DOPR G56(84)	4.00	7.00	208	67.67	2.50	24
13	DOPR G59 (48)	2.25	4.40	320	121.70	5.50	25
14	DOPR G30 (E29)	6.20	3.60	152	71.33	3.50	24
15	DOPR G43 (E30)	4.00	4.06	192	74.00	4.00	24
16	DOPR G45 (E35)	7.00	4.90	240	81.33	4.50	24
17	DOPR G46 (E38)	7.00	3.60	188	77.00	4.11	24
18	DOPR G47(E40)	6.15	3.60	168	71.00	4.17	24
19	DOPRG50 (E46)	9.00	4.20	210	71.33	3.67	24
20	DOPR G51 (50)	4.00	4.15	192	64.66	2.83	24
21	DOPR G52 (E86)	5.00	3.90	180	73.33	2.60	24
22	DOPR G55 (E51)	5.00	5.10	240	72.67	4.33	24
23	DOPR G57 (E54)	6.00	6.50	300	72.67	4.33	24
24	DOPR G58 (E55)	3.50	4.00	176	64.30	3.00	24
	Mean	4.44	5.29	242.17	83.35	4.70	24.04
	STDev	1.72	1.28	53.31	19.45	1.53	0.62
	Max	9	7.26	320	122	7.18	26
	Min	2.2	3.6	152	62.5	2.5	22
	CV (%)	38.61	24.12	22.01	23.34	32.46	2.60

Overall performance of germplasm accessions

Overall performance on bunch traits, bunch analysis (oil components) and vegetative descriptors indicates a few palms as practically superior candidates for selection, in line with recent literature that emphasizes (i) high oil-to-bunch (O/B) driven mainly byfruit-to-bunch (F/B), mesocarp-to-fruit (M/F) and oil in mesocarp, and (ii) acompact/harvest-friendly architecture (moderate palm height and acceptable rachis length) for efficient management and potential high-density planting. In this set,DOPR-G53 (E.61) – Tanzania combined high oil/bunch (21.5%) with high F/B (73.12%), high oil/wet mesocarp (55.94%), good kernel fraction (15.53%) and favourable vegetative stature (4.5 m height; 6.14 m rachis; 300 leaflets; 24 fronds/year), making it a Promising palm.DOPR-G24 (O22) – Costa Ricaalso ranked high for oil yield components (F/B 84.76%; oil/bunch 20.2%) with robust canopy traits (4.6 m height; 7.0 m rachis; 320 leaflets; 24 fronds/year), and is a prime candidate where slightly taller palms are acceptable.DOPR-G1 (221) – Nigeria is especially notable for compactness (2.2 m height) while still exhibited high mesocarp/ fruit (77.2%), high oil/wet mesocarp (54.6%)and high oil/bunch (20.4%). For combining large bunch sizewith good canopy structure,DOPR-G23 (O6) of Malaysia origin recorded thehighest bunch weight (44.6 kg)with satisfactory oil/bunch (11.87%), A dura accession DOPR-G59 (E.48) from Zambia showed reduced height (2.25 m) with very high leaflet number (320) and long leaflets (121.7 cm), and satisfactory oil traits (oil/bunch 13.52%). Palms with well-developed canopies generally support higher assimilate production, which in turn contributes to better bunch formation and oil accumulation Whereas, tall palms (e.g., DOPR-G50, DOPR-G45, DOPR-G46) are less desirable because excessive height is associated with harvesting difficulty and economic longevity (Corley and Tinker, 2016).Vegetative and bunch-quality data in the present study has given inference that bunch quality components such as fruit/bunch, mesocarp/ fruit, and oil in mesocarp and reduced vegetative growth are main contributors for enhancing high oil yield per palm. Accordingly, based on combined performance for bunch traits, bunch components, and vegetative traits, palms *viz*., DOPR-G23 (O6), DOPR-G24 (O22), DOPR-G59 (E.48), and DOPR-G1 (221) were identified as promising genetic stocks for utilisation in the ongoing breeding programme. Among these, DOPR-G23 (O6) was superior for high bunch weight, DOPR-G24 (O22) for high fruit/bunch, DOPR G53 (E.61)for high oil/bunch DOPR-G59 (E.48) for low shell/fruit, and DOPR-G1 (221) for high mesocarp/fruit. The proven performance of above selected palms was reported by Murugesan *et al*., (2014), Murugesan *et al*., (2020) and Murugesan *et al.*, (2009). Corley and Tinker (2016) emphasized the importance of these traits in the selection of superior parental palms for oil palm breeding programmes. The views of promising palms bunch and fruit characters are given in fig. 2. Selected dura palms (DOPR G53 (E.61) and DOPR G59 (E.48)) can be directly used as female parents in hybrid seed production, whereas *Elaeis oleifera* (DOPR-G23 (O6) and DOPR-G24 (O22)) requires interspecific hybridisation with *E. guineensis* (O×G hybrids) for effective utilisation. Since, DOPR-G1 (221) palm is a *tenera*, its immediate use as a parental line in hybrid seed production is limited, necessitating additional breeding cycles and thereby requires long duration (Corley & Tinker, 2016). Pedapati *et al*., (2021) has reported that bunch quality components such as fruit/bunch and mesocarp/fruit are positively associated with oil/bunch confirming that genotypes with higher fruit proportion and mesocarp content possess superior oil-yield potential. Babu *et al*., (2021) have highlighted that the integration of genomic tools, such as marker-assisted selection and genomic selection, can accelerate the identification of elite parental combinations and reduce breeding cycle duration in oil palm

Fig 2. Promising oil palm genetic stocks



a. DOPR G - 23 (O 6) - IC No. IC0597690

b. DOPR G - 24 (O 22) - IC 0597686

c. DOPR G - 59 (E.48) - IC0597689

Conclusion

The present study confirms that the exotic oil palm germplasm maintained at ICAR–IIOPR field gene bank possesses variability for fruit forms, bunch components, and vegetative traits so as to explore for parent selection. Characterisation using IBPGR descriptors enabled identification of trait-specific superior palms. Based on combined performance, DOPR-G23 (O6), DOPR-G24 (O22), DOPR G53 (E.61) andDOPR-G59 (E.48) were identified as promising genetic stocks for high bunch weight, fruit/bunch, oil/bunch, and low shell/fruit, respectively. These palms can be effectively utilized for hybridisation in breeding programmes aimed at developing high-yielding compact palms.

Acknowledgement

The author acknowledges the Directors and staff of ICAR–Indian Institute of Oil Palm Research (ICAR-IIOPR), Pedavegi, for their help and support in accomplishing this research work. The author is also grateful to the Director, ICAR–Central Tuber Crops Research Institute (ICAR-CTCRI), Thiruvananthapuram, for according approval. The author sincerely thanks Mrs. Haseela, Peringamala, and Mr. M. Shareef, Technical Assistant, NIRCA Research Centre, Hunsur, Karnataka, for their contributions while working in various oil palm research schemes at Palode.

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