

CHAPTER 5

DISCUSSION

5.1 Performance of Senegal Germplasm

A total of nine populations and 14 progenies were evaluated in this study. The populations were SEN 01, SEN 02, SEN 03, SEN 04, SEN 05, SEN 06, SEN 07, SEN 10 and SEN 12. The progenies were SEN 01.03, SEN 02.06, SEN 02.09, SEN 03.07, SEN 04.02, SEN 04.03, SEN 05.01, SEN 05.03, SEN 05.08, SEN 06.08, SEN 07.03, SEN 10.03, SEN 10.05 and SEN 12.03.

FFB yield of the Senegal populations ranged from 8.59 kg/p/yr to 160.93 kg/p/yr. The mean FFB yield in the trial was 80.61 kg/p/yr, BNO 19.05 no./p/yr and ABW 4.15 kg/p/yr. The best performer was SEN 02.06 palm number 394 with the highest FFB yield of 160.93kg/p/yr (Appendix B). This is due to the high BNO of 27.25 no./p/yr and a moderate ABW with 5.91 kg/bunch. Most of the palms from progeny SEN 02.06 scored a high FFB yield with moderate BNO and ABW. However, progeny SEN 05.03 had the best mean performances for FFB (109.92 kg/p/yr) with BNO 22.30 no./p/yr and 4.83 kg/p/yr.

The overall FFB mean (80.61 kg/p/yr) for Senegal population was lower compared to the commercial progenies and other germplasm materials that were studied by several researchers. The low mean for FFB yield might due to the natural selections even though the palms were planted in Malaysia. Senegal had low rainfall where mean annual rainfall ranges from 200 to 1500 mm (Camberlin and Diop, 2003) compared to the Malaysian annual rainfall of 2000 to 2500 mm. Goh (2000) in his studies stated that overall FFB yields were relatively poor with rainfalls of less than 2000 mm/year. Hartley (1988) stated that the ideal requirements for higher FFB yield in oil palm are annual rainfall of 2000 mm or greater without a marked dry season and a mean maximum temperature of 29-33°C.

In the three trials involving D×P progenies, the FFB yields were 127 kg/p/yr, 168 kg/p/yr and 184 kg/p/yr respectively (Table 22). Studies carried out by Kushairi et al. (2000a) showed that Tanzanian germplasm had a mean FFB of 112.99 kg/p/yr for *dura* and 122.2 kg/p/yr for *tenera* and the Angolan germplasm in trials 0.311 and 0.312 (Table 23) had a mean FFB of 114.57 kg/p/yr and 105.71 kg/p/yr for *dura* respectively.

Table 22: Mean Performance of D×P Progeny Trials of Advanced Planting Materials in Malaysia

Trial	FFB (kg/p/yr)	BNO (no./p/yr)
0.189 ¹	127.14	8.12
0.284 ²	168.18	15.36
0.809 ³	184.43	12.22

¹ Industry D×P planted in Ulu Paka in 1983, Yield recordings and Bunch Analysis 1987-1998. Source: Kushairi et al. (2000b)

² Industry D×P planted in Lahad Datu in 1991, Yield recordings 1995-1998. Source: Kushairi et al. (1999a)

³ PORIM D×P planted in Klang in 1978, Yield recordings 1985-1995. Source: Kushairi et al. (1999b)

However, the Tanzanian *dura* had a higher BNO and lower ABW (Table 23). The Senegal population also had a higher BNO but a lower ABW. This relationship deviated from the normal in oil palm breeding. The Deli *dura* is noted for its high ABW and low BNO and the *tenera* for its low ABW and high BNO (Kushairi et al., 2000a).

Table 23: Mean Yield of Tanzania and Angola Germplasm

Trials	Traits		
	FFB (kg/p/yr)	BNO (no./p/yr)	ABW (kg/p/yr)
Tanzania			
Trial 0.256	112.99	13.00	8.77
Angola			
Trial 0.311	114.57	16.25	7.26
Trial 0.312	105.71	15.05	7.25

Source: Kushairi et al. (2000a)

The BWT for Senegal population in this study was low with the average mean of 3.62 kg ranging from 0.90 kg to 8.17 kg compared to other germplasm materials. This might due to the small size of the bunch and small fruit of Senegal. A general comparison is made between the populations studied in Senegal, Nigeria, Cameroon, Zaire, Tanzania, Angola, Sierre Leone, Guinea and Ghana (Table 24). The data showed that the *dura* mean BWT seemed to increase from Senegal to Angola. The Tanzanian germplasm had BWT comparable to those collected in Nigeria, Cameroon, Zaire and Angola. Senegal germplasm had the lowest BWT among all germplasm collections (Rajanaidu et al., 2000).

Table 24: Comparison of Bunch Weight (BWT) of Oil Palm Genetic Material Collected in West African Countries

Country	BWT (kg)
Senegal	3.62
Sierra Leone	9.47
Guinea	11.4
Ghana	11.72
Nigeria	11.8
Cameroon	16.8
Zaire	17.6
Tanzania	18.4
Angola	21.4

Source: Rajanaidu et al. (2000)

The main components of oil yield (OY) are the dry weight fractions in F/B, M/F and O/WM (Corley and Tinker, 2003). The amount of shell and kernel in an oil palm fruits affect the mesocarp content. Therefore, reducing the S/F and K/F in order to get higher mesocarp is essential (Hartley, 1988).

Trial mean for M/F in Senegal population was low, 34.78% compared to Angola germplasm collected in 2010 by MPOB with mean of 48.2% (Marhalil and Rajanaidu, 2011). M/F of Senegal ranged from 24.34% to 52.58%. Similar finding was reported by Sapey et al. (2012) on germplasm in the Northern Region of Ghana with M/F ranging from 29.40% to 52.63%. Studies conducted by Okwuagwu et al. (2011) on germplasm in the Eastern Nigeria had M/F of 51.2% to 48.2%.

The trial mean for S/F and K/F were 49.57% and 15.64% respectively. The percentage of S/F for the Senegal progenies was quite high ranging from 35.45% to 59.49% compared to the studies conducted by Noh et al. (2010) on D×P materials with S/F mean of 10.82% ranging from 7.57% to 18.58% The high percentage of S/F explains

the low percentage of M/F in Senegal population. Studies conducted by Kushairi et al. (2000) on the Tanzanian *dura* germplasm showed average percentage of S/F (39.01%) and average percentage of M/F (47.65%).

Table 25 below shows the range of values for bunch characters in the Senegal progenies compared to other germplasm materials and Deli *dura* descendants. The average O/B of Senegal progenies is definitely low compared to the Deli progenies and other germplasm materials. Nigerian, Tanzania and Angola germplasm had high O/B despite the comparison involving the mean of more than 100 germplasm compared to the six selected Deli progenies. However, F/B value shows that even though Senegal has the lowest F/B among all, the value was not really different compared to O/B values. S/F and K/F values for all the germplasm were quite high compared to the Deli progenies.

Table 25: Mean Comparison of Senegal, Nigerian, Tanzania, Angola and Deli *dura* Palms for Bunch Characters

Trial	O/B (%)	F/B (%)	M/F (%)	O/WM (%)	K/F (%)	S/F (%)
Senegal	8.54	57.68	35.02	41.74	15.65	49.32
Nigerian ¹	13.4	61.50	44.90	48.60	12.20	42.40
Tanzania ²	13.91	63.42	47.65	46.02	13.40	39.01
Angola ³	15.64	65.37	50.19	48.21	11.12	38.69
Deli <i>dura</i> ⁴	19.8	63.70	63.90	48.70	7.40	28.6

¹ Nigerian Germplasm

² Tanzanian Germplasm Bunch Analysis 1995-2000.

³ Angola Germplasm Bunch Analysis 1997-2002

⁴ Six selected Deli derived progenies

Source: Rao (1987)

Source: Kushairi et al. (2003)

Source: Kushairi et al. (2003)

Source: Hartley (1997)

Trial mean for RL at 8 years of planting was 3.85 m with the range of 2.00 m to 4.94 m. Hardon (1969) and Rajanaidu et al. (1990) reported that the mean length of RL is 6.1 m and 5.97 m at eight years of planting respectively. Rachis length (RL) may be used

as a guide for determination of planting density. With shorter RL, more palms can be planted in a unit area (Corley, 1973b). Senegal population seems to have a short RL and this can be useful in selecting palms with short RL to increase planting density. However, the increase in planting density and palm age leads to reduced productivity per palm which is mainly expressed in reduced bunch yield (Corley, 1973b).

Reducing height (HT) has always been of interest in oil palm breeders because of the high cost of harvesting tall palms. Senegal population palms were quite tall, varied from 1.20 m to 4.50 m with the trial mean of 2.81 m. The mean height increment of Senegal was 0.47 m per year at 8 years of planting. The shortest palm with 1.20 m was from SEN 05.04. Compared to Tanzania and Angola germplasm, both of these populations have a shorter height with mean of 1.15 m and 2.71 m respectively and mean high increment of 0.19 m per year and 0.45 m per year at 8 years of planting respectively (Kushairi et al., 2003).

The petiole cross section (PCS) in Senegal varied from 7.77 cm² to 35.20 cm² with overall mean of 16.01 cm². Lee et al. (1990) reported that the PCS value for the *Deli dura* was between 43.7 cm² to 48.2 cm². Jagoe (1952) reported that PCS is inversely proportional to HT of a palm. Wider PCS was found in a short palm whereas smaller width of PCS was found in a tall palm. This explains the smaller width of the PCS having tall palms in Senegal population.

In Malaysia, fractional interception of light (f) is seldom a major problem to control productivity (Squire, 1985). The leaf area index (LAI) is an important crop parameter to determine light interception (f). The leaf area (LA) and the leaf area index

(LAI) of Senegal population varied from 1.95 m^2 to 8.58 m^2 and 1.15 to 5.05 respectively. The average mean for LAI was low 2.80. Corley (1976) reported that in Malaysia's environment, the maximum value that can be achieved for LAI is less than 10. The optimum LAI was 6 to 7, very high LAI may indicate excessive vegetative growth and hence lower the BI (Corley, 1973b).

Hanif (2000) reported that one of the four possible ways to increase the oil production is by increasing the bunch index (BI) which derived from the ratio of bunch dry matter (BDM) to total dry matter (TDM) production $[\text{BDM} / (\text{BDM} + \text{VDM})]$. Trial mean for BDM and VDM of Senegal was 6.33 t/ha/yr and 11.71 t/ha/yr respectively. Trial mean for total dry matter (TDM) of Senegal was 18.03 t/ha/yr. Trial mean for light conversion efficiency (e) for Senegal progenies was 0.86 g/MJ. Squire (1984) in his studies calculated that value of e 's ranging from 1.0 to 1.6 g/MJ. He concluded that in general, value of e in oil palm was low compared to other crops.

Trial mean for bunch index (BI) in Senegal population was 0.35 ranging between 0.05 from progeny SEN 10.03 to 0.56 from progeny SEN 05.08. Study on evaluation of BI in African germplasm conducted by Padila et al. (2011) showed that the Tanzania germplasm recorded the highest BI with the mean of 0.53. Very low BI was recorded by the Madagascar germplasm with mean of 0.08. BI for Senegal germplasm was low (0.36) compared to Nigeria (0.44), Cameroon (0.44), Zaire (0.40), Angola (0.48), Sierra Leone (0.42), Guinea (0.42) and similar to Ghana (0.36) and Gambia (0.34).

5.2 Genetic Variability and Heritability

The genetic composition of the variance components depends on the relationship between the members of the progenies. If all the palms from each progeny have the same male parent, they are related as full sibs. If on the other hand, each palm of the progenies had a different male parent so they are related as half sibs. However in this study, we assume that the germplasm material most probably comprises of groups of full sibs (Rao, 1987).

BNO and ABW are significantly influenced by environmental factors to determine FFB yield. The magnitude and dimension of environmental effects may vary in genotypes. Thus, it is important to study genotype $\times$ environment interaction in order to evaluate genotype in terms of FFB yield (Raffi et al., 2002).

ANOVA of 14 progenies showed a highly significant difference ($P \leq 0.01$) for FFB, BNO and ABW among the progenies. This indicates that there was a significant amount of genetic variability among all the progenies for the three traits. However, progeny $\times$ replication interaction for BNO was highly significant. The result indicated that FFB and ABW perform consistently across the replicates but not for BNO. BNO showed that there was a difference between the performances over the two replications. In the study that conducted by Rao (1987) on the Nigerian germplasm, blocks $\times$ families for BNO was significant in all four years indicating that BNO performed differently among the blocks that were carried out.

Variance component estimated for FFB shows that the genetic variance for population (σ^2_p) was 16% and genetic variance for progenies (σ^2_g) was 27.6%. For BNO,

genetic variance (σ^2_p) was 7.81% and genetic variance (σ^2_g) was 21.3%. For ABW, genetic variance σ^2_p was 17.7% and genetic variance (σ^2_g) was 26.8%. The magnitude of progenies (σ^2_g) variance component was higher than σ^2_p variance components suggesting that the differences between open-pollinated families for these three traits were mainly due to variation between progenies rather than variation between populations.

Variance components within palms (σ^2_w) among Senegal progenies were generally high for FFB (68.19%), BNO (68.88%) and ABW (73.19%). The high variation detected within the palms indicated most of the phenotypic variation was among the variation within palms (Kushairi, 1992).

Heritability (h^2_B) estimated for FFB (56%) and ABW (52%) was high but moderate for BNO (42%). The heritability of Senegal populations was low compared to Nigerian population studied by Rao (1987) which had the h^2_B of FFB (66%), BNO (53%) and ABW (72%). However, h^2_B of Senegal population was high compared to D×P hybrids studied by Rafii et al. (2013) which had the h^2_B of FFB (13.96%), BNO (22.68%) and ABW (43.93%). Several researchers (Thomas et al., 1969; Ooi et al., 1973; Rajanaidu and Rao, 1988) have noted that the genetic variability for yield and its component was low. Hardon et al. (1985) concluded that the heritability for FFB is generally low, moderately high for ABW and high for BNO.

For bunch analysis traits, ANOVA showed significant difference for all traits in progenies level but no significant differences detected for K/F and K/B in population level. This indicates that there was variation within progenies for K/F and K/B but not among the population. However, σ^2_g for K/F (7.59%) and K/B (10.785) was low.

Estimation of σ^2_p was low ranging from 7% to 15.3% and variance components for progenies (σ^2_g) were higher ranging from 4.78% to 25.64%. The genetic differences in Senegal population for bunch analysis traits were mainly due to variation between progenies rather than variation between populations.

Heritability (h^2_B) estimated from the variance components for M/F (10%), K/F (15%), S/F (30%), O/B (26%), K/B (26%) and F/B (22%) were very low. However the h^2_B of O/DM (48%), O/WM (40%), OY (46%) and KY (44%) were moderate. Rao (1987) in his studies of Nigerian germplasm also had low heritability for F/B (13.4%), M/F (23.03%) and S/F (26.25%). However, the heritability of O/B in Nigerian germplasm was high and Rao (1987) noted that it was found to be the most heritable between 43% and 86%. Heritability of O/B appears to be usually lower than M/F but higher than F/B (Soh and Chow, 1993). However, the germplasm material seems to have lower M/F than O/B.

For vegetative traits, the population variance components (σ^2_p) were low varied from 3.3% to 26.0%. HT and RL had the highest σ^2_p with 21.9% and 26% respectively. LW, FP and LAR had the lowest σ^2_p of 3.3%, 5.5% and 5.2% respectively. However, the variance components within the palms (σ^2_w) were high ranging from 75.61% to 96.77%. Rajanaidu (1980) in his study of Nigerian germplasm showed that in term of their proportionate contribution to the total phenotypic variation, neither differences between populations nor between the progenies can be regarded as a major source of variation because differences within the palms have a much higher proportion of the total phenotypic variation same as the Senegal progenies. Rajanaidu (1980) concluded that this

is expected because the species is an outbreeding and environmental variation contributes to the σ^2_w in the variation.

The heritability (h^2_B) estimated for vegetative traits were quite low to moderate ranging from 12% to 66%. The lowest heritability estimated was from FP with only 12%. RL and HT had a quite a high heritability of 66% and 64% respectively. The heritability for PCS (44%), LL (48%), LW (24%), LN (34%) and LA (36%) were quite moderate. Rajanaidu (1980) studied the vegetative characters in Nigerian germplasm. In his study, heritability of vegetative characters was also low compared to the Senegal germplasm with RL (33%), LL (32%), LA (23%), LN (36%), LW (44%) and the lowest FP (4%).

Estimation of population variance components for physiological traits was low; σ^2_p varied from 8.5% to 20.7% and σ^2_w was high, 75% to 92%. This indicated that the phenotypic variation in physiological traits was mostly influenced by variance within palms. Variation within palms consists of genetic factor and environment (Kushairi, 1992). Heritability (h^2_B) estimated for all the traits were average, BDM (54%), VDM (44%), TDM (42%), BI (56%), e (44%) and NAR (40%). In the study conducted by Fadila et al. (2011), heritability estimated for BI were generally low in Tanzania (9.26%), Cameroon (19.82%), Angola (17.24%) except for Nigeria (59.38%) and Sierra Leone (61.36%).

5.3 Phenotypic Relationship Among All Traits

In Senegal populations, FFB correlated positively with BNO and ABW. High average BNO greatly influenced the increasing of FFB yield. High numbers of BNO even from a small bunch will increase the FFB yield. Despite having low trial mean for ABW, Senegal population still produced quite a high BNO. Progeny with high BNO and small bunches can produce high yielding FFB (Soh, 1983). BNO and ABW were also positively correlated with each other. This deviates from the usual findings where negative correlation is found between BNO and ABW (Hardon et al., 1985).

In the study of Nigerian germplasm, Rao (1987) found that both BNO and ABW were significantly correlated with FFB but between BNO and ABW they were strongly negatively correlated. The negative correlation between BNO and ABW was of a concern since selecting for high BNO will unfortunately decrease the ABW and vice versa. But in this study, BNO and ABW were positively correlated assuming that selecting high BNO will also increase in bunch weight. Population SEN 05 had the highest mean for FFB and also the highest mean for BNO and ABW. We can conclude that high number of BNO and high ABW contribute in the high FFB yield in Senegal populations.

Oil to bunch (O/B) is an important character having strong correlation with its derived components, F/B, M/F and O/WM. O/B value is high when M/F is high. The correlation value r between O/B and M/F was strong $r = 0.71^{**}$. The significant negative correlation of S/F and K/F with M/F is an additional source of variation in O/B. Population SEN 07 had the highest mean for O/B, F/B and M/F indicating the strong relationship of O/B with F/B and M/F and the lowest mean for S/F. S/F was found to be

positively correlated with MNW and KB. The increase in kernel size and MNW leads to increases in shell size causing high percentage of S/F, thus reduction in the mesocarp content. Indirect selection for more heritable fruit quality trait by increasing M/F may be more effective in increasing OY (Kushairi et al., 1999c).

Corley et al. (1971) have shown that FP is positively correlated with FFB and Tan (1978) had shown that FP is positively correlated with BNO. In Senegal population, both FFB and BNO were found to be positively correlated with FP. Smith (1992) in his study confirmed that FFB yield is positively correlated with palm height (HT). Corley et al. (1971) noted that if selection were made solely on FFB yield, there was a tendency to select tall and vigorous palm. However in Senegal population, HT was not significantly correlated with FFB.

The oil palm FFB yield and bunch oil are found to be influenced by physiological traits. Oil production can be increase by increasing the TDM by increasing LA and rate of photosynthesis. VDM was positively correlated with LA at $r = 0.41^{**}$. Hardon et al. (1972) reported that fractional interception of light (f) is positively correlated with LAI and TDM. Palms with higher percentage of LAI had high f thus increasing TDM (Squire, 1984). Therefore, to increase FFB yield, dry matter production should be increased by maximizing the usage of f (Corley, 1973b). In this study, TDM was positively correlated to f and LAI at $r = 0.41^{**}$ and 0.36^{**} . TDM is also influenced by light conversion efficiency (e). SEN 01 and SEN 02 who had the highest mean for e (0.92 g/MJ) also had the highest mean for TDM. BDM is greatly influenced by LA. When rate of photosynthesis is increased, net assimilation rate (NAR) also will be increased (Rees,

1963). However, in this study, BDM was not significantly correlated with LA and LA was negatively correlated with NAR at $r = -0.53^{**}$.

Bunch index (BI) is derived from the ratio of bunch dry matter (BDM) to total dry matter (TDM) production. The estimation requires the measurement of trunk height (HT), trunk diameter (DIA), rate of frond production (FP) and petiole cross-section (PCS), as well as FFB yield (Corley and Tinker, 2016). In this study, BI was positively correlated to FFB ($r = 0.85^{**}$) and TDM ($r = 0.27^{**}$), negatively correlated to DIA ($r = -0.25^{**}$) and PCS ($r = -0.29^{**}$) and not significantly correlated with HT and FP.

Rajanaidu et al. (2011) stated that yield might be increased by selection of palms with low vegetative growths such as short height, low trunk and lower leaf production whereby greater proportion of the dry matter photosynthesized become incorporated in fruit bunches. Fadila et al. (2016) studied the evaluation of bunch index in MPOB germplasm collection also found negative correlation in Senegal germplasm between BI to DIA ($r = -0.28^{**}$) and PCS ($r = -0.36^{**}$).

Positive correlation between BI and TDM ($r = 0.27^{**}$) was found in this study. Planting material with high TDM or biomass is now a great demand due to the recent greenhouse gas (GHG) emission and global warming concerns. Palms with high TDM have the capability to absorb large amount of CO_2 and this indicate possibility of a role of high BI palms in the reduction of GHG emissions (Rajanaidu et al., 2011). Fadila et al. (2016) in her study also found positive correlation between BI and TDM (low to medium) among the germplasm; Zaire ($r = 0.18^{**}$), Cameroon ($r = 0.21^{**}$), Senegal ($r = 0.28^{**}$),

Sierra Leone ($r = 0.36^{**}$), Tanzania ($r = 0.39^{**}$), Guinea ($r = 0.40^{**}$) and Ghana ($r = 0.38^{**}$)

5.4 Potential Genotypes in Senegal Germplasm

One of the objectives of this study is to identify potential genotypes for further introgression in breeding and expand the current breeding materials. It is important for breeders to be able to distinguish the variation between populations or between progenies. If the genetical variation in a character of interest fell to differences between populations, the breeders need to choose palms from the best populations. If in the other hand the variation falls to differences between progenies, the breeders needs to choose the best palms from the best progenies. The knowledge of the genetical structure of oil palm populations for a character of interest allows the breeders to exploit the variation more efficiently and provides important information for future prospection of materials (Rao, 1988). In the case of Senegal, the magnitude of progenies variance component (σ^2_g) was higher than populations variance component (σ^2_p) suggesting that most of the traits fell to differences between progenies so choosing the best palms from the best progenies is essential.

Based on the heritability estimation of all the traits, FFB (56%), BNO (42%), O/DM (48%), O/WM (40%), OY (46%), KY (44%), PCS (44%), RL (66%), HT (64%), BDM (54%) and BI (56%) were highly heritable. These traits could be exploited for further breeding.

Even though the trial mean for FFB yield was low (80.61 kg/p/yr), we can see from the frequency distribution in Figure 2 in Chapter 4 that the distribution of FFB yield is approximately symmetric suggesting that there were variation because many palms had low and high yields. For example, palm from progeny SEN 02.06 had the highest FFB yield of 160.93 kg/p/yr. Palms from population SEN 02 and SEN 05 mostly had FFB yield more than 120 kg/p/yr. These palms could also have the potential for development in drought tolerant environment due to the dry area of Senegal and the low rainfalls.

Rival (2016) stated that breeding programmes aimed at the genetic improvement of the oil palm focusing on the generation of planting material able at outstandingly performing under all types of environment. The use of planting material originating from various different backgrounds is recommended as a response to the environmental conditions encountered. Zeng et al. (2016) also identified and selected MM5 palms and Huanzhou population as high-yielding for cold-tolerant palm.

Besides that, O/DM and O/WM were also highly heritable. The trial mean for O/DM and O/WM for Senegal population was 70.13% and 41.22%. Most of palms in Senegal had O/DM more than 60% and O/WM more than 40%. Though most of the traits in bunch quality traits had low heritability, Senegal palms recorded the highest crude protein content with majority of the materials had more than 20%, varied from 17.55% to 24.80% and mean of 21.19% compared to the D×P materials, which varied from 12.63% to 19.62% (Noh et al., 2008). In his studies, the screening for the high protein kernel which is mainly geared towards the production of high protein animal feed can be an economic importance that will definitely benefit the industry for the future.

As for vegetative traits, PCS, RL and HT were highly heritable. Corley et al. (1971) found a high correlation between PCS and total dry weight of the leaf and this relationship is useful for estimating leaf dry weight without destroying the palms. Short LL, HT, and small PCS are the prerequisite characters in selecting palms for compactness. Among all the palms in Senegal, two palms had the smallest PCS and lowest RL and HT; palm 112 from progeny SEN 04.01 with PCS (9.84 cm²), RL (3.38 m) and HT (1.80 m) and palm 173 from progeny SEN 10.03 with PCS (9.02 cm²), RL (2.81 m) and HT (2.15 m). Compact palms can be utilized for high density planting and are capable of producing higher yield per hectare (Noh et al., 2014).

Oil yield has been the major concern in oil palm cultivation. Hanif (2000) reported that one of the four possible ways to increase the oil production is by increasing the bunch index (BI) which is derived from the ratio of bunch dry matter to total dry matter production ($BDM / BDM + VDM$). Selecting palms with high BI can help to increase the oil production. Kushairi et al. (2002) suggested that planting materials with bunch index of more than 0.6 would be efficient for higher yield. In Senegal populations, the best performance BI with more than 0.50 came from progeny SEN 02.06, SEN 02.09, SEN 04.03 and SEN 05.08. The highest BI recorded with 0.56 was from palm 399 from progeny SEN 05.08.