OIL PALM GENETIC RESOURCES - NATIVE E. OLEIFERA POPULATIONS IN BRAZIL OFFER PROMISING SOURCES[1]

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ABSTRACT - Interest in interspecific hybrids of *E. oleifera* and *E. guineensis* is related to the possibility of breeding for a higher unsaturated oil, reduced height increment and resistance to diseases. Progress in obtaining suitable hybrid progenies have been somewhat hampered by the lack of suitable *E. oleifera* genetic resources. Preliminary studies on some Brazilian populations give much hope that these populations can offer new sources of variability which can overcome earlier obstacles. Some of the advantages of these populations include a small peduncle size, good fruit set, good parthenocarpic fruit development, large fruit size, a high mesocarp content and a reduced shell content of the fruits. The possible impact of these new advantages on the hybrid progeny is discussed. A limitation of the Brazilian population is the rather vigorous vegetative growth of the palms.

Index terms: oil palm, caiuaué, *Elaeis melanoccoca*, *E. oleifera*, prospection, genetic resources,Amazon.

RECURSOS GENÉTICOS DE DENDÊ - POPULAÇÕES NATIVAS DE ELAEIS OLEIFERA DO BRASIL SE CONSTITUEM NUMA FONTE PROMISSORA

RESUMO - O interesse na hibridação interespecífica entre *E. oleifera* x *E. guineensis* está relacionada à possibilidade de melhoramento visando maior insaturação de óleo, redução no incremento de crescimento em altura e resistência à doença. Progressos na obtenção de progênies híbridas desejáveis, tem até certo ponto sido difícil pela falta de adequados recursos genéticos de *E. oleifera*. Estudos preliminares em algumas populações brasileiras mostram boas perspectivas de que essas populações podem oferecer novas fontes de variabilidade, podendo superar os obstáculos iniciais. Algumas das vantagens dessas populações, incluem o pequeno tamanho de pedúnculo, bom padrão de frutificação, bom desenvolvimento de frutos partenocárpicos, frutos de tamanho grande, alto conteúdo de mesocarpo e reduzida casca. O possível impacto dessas novas vantagens em progênies híbridas é discutido. Uma limitação das populações brasileiras é um crescimento vegetativo mais vigoroso das palmeiras.

Termos para indexação: dendê, caiaué, *Elaeis oleifera*, *Elaeis melanoccoca*, *E. oleifera*, prospecção, recursos genéticos, Amazonas.

INTRODUCTION

Interest in *E. oleifera* species is relatively recent. This is related to possibility of breeding for a higher unsaturated palm oil through inter-specific hybridisation with *E. guineensis*. The health risk associated with consumption of saturated fats and cholesterol have been well publicized. Although palm oil does not suffer to the same extent in this respect as animal fats and other vegetable oils, it has been suggested that palm oil could perhaps be used in larger proportions in table margarine blends (at least for some industrialised countries) if the level of unsaturated fatty acid was much higher.

While there is no doubt that having a more unsaturated palm oil would be advantageous for marketing purposes, a more important consideration is the improved physical properties of the oil, particularly in relation to the "liquid" fraction and cocoa butter fat substitute that can be recovered from it.

Apart from favourable oil characteristics which should enhance the market potential for palm oil, the species also offers the possibility of breeding for other useful characteristics, in particular disease resistance and shorter palms. The resistance of the hybrid to "Machitez" or sudden wilt have been well demonstrated in Colombia and is perhaps the only reason that the country has an oil palm industry at all in some regions. (Vallejo & Cassalett 1975). In Malaysia, there is some evidence to suggest that the species also offers the potential for

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breeding for resistance to ganoderma (upper stem rot) (Mokhtar, H. 1970). Recent studies with seedlings (Renard et al. 1980) have also indicated a source of resistance to fusarium wilt in this species. The importance of reduced height increment (shorter palm) need no emphasis particularly in the face of reduced availability of suitable agricultural workers which will become more acute in the near future and determine the economic life-span of the palms.

It is clear that with such advantages, the inter--specific hybrids have tremendous potential and will most likely from a source of future oil palm varieties.

The experimental evidence available so far (Tam et al. 1976; Hardon 1969) would suggest that the best immediate possibility for achieving the high yield and the higher unsaturated oil lies in the F_1 hybrids and some strategies for achieving this has discussed (Ooi 1978) and need only be considered briefly here.

The *E. oleifera* species itself is unlikely to be of value directly for commercial exploitation. While it does produce a highly unsaturated oil, its oil yield for extremely low, unlikely to achieve even 25% of the level of productivity for *E. guineensis* Hybrids between the two species show useful improvements in the oil yield and the level of unsaturation but they have still to reach satisfactory levels for commercial exploitation. Data from a study (Tam et al. 1976) is presented in Table 1 and 2 to show the trends that can be expected. In the F_1, the level of unsaturation of the oil has improved but not to levels comparable to that of the *E. oleifera* parent. However, more important is the fact that the bunch characteristics have still not improved to the level of the *E. oleifera* parent. Oil yield per bunch is only at 13.3% and at this level, the productivity of the hybrid is only 57% of that for *E. guineensis* and clearly, is still not a viable commercial preposition unless the price for the oil is doubled. Backcrossing does not offer a potential solution as, depending on the recurrent parent either oil quality or oil yield is improved but never both simultaneously.

Immediately therefore, the breeding strategy must lie within the F_1 hybrid progenies. The availability of suitable *E. oleifera* parents which will combine well with *E. guineensis* are clearly of paramount importance and to a great extent, progress in obtaining suitable F_1 hybrids have been limited by the range of *E. oleifera* genetic materials available.

The availability of tissue culture method of propagation would allow back-crossed and F_2 generations, where much individual variation exist, to be exploited. However, even then, only good parents will ensure the availability of genetically superior individuals.

Preliminary studies of native populations of *E. oleifera* in Brazil would suggest that these populations can be very important sources of new variability which can be exploited to achieve much more rapid advancement in the inter-specific hybridisation program. Some of these data are described and discussed in relation to their value in the interspecific hybridization program.

TABLE 1. Bunch composition of *E. guineensis, E. oleifera* and hybrids.

Components		E.g. (Tenera)	E.o	F_1 Hybrids	$F_1 \times$ E.g.	$F_1 \times$ E.o.	$F_1 \times F_1$
Fruit/bunch (fertile)	(%)	55.6	20.7	12.5	41.4	33.2	26.6
Frut/bunch (parthenocarpic)	(%)	4.2	22.3	31.4	5.8	20.7	24.6
Mesocarp/fruit	(%)*	80.2	41.4	73.9	75.0	47.3	49.9
Shell/fruit	(%)*	10.2	42.2	18.9	15.0	33.2	39.7
Oil/wet mesocarp	(%)*	49.6	19.8	41.2	46.0	35.3	39.6
Oil bunch	(%)	23.3	4.0	13.3	15.8	9.4	12,4

* Fertile fruits only
Source: Tam, Lim, Yeoh & Ooi (1976)

TABLE 2. Fatty acid composition of *E. guineensis, E. oleifera* and hybrids.

Fatty acid		E.g	E.o	F_1 Hybrid	F_1 x E.g	F_1 x E.o	F_1 x F_1
Lauric	(C_{12})	-	0.2	-	-	-	-
Myristic	(C_{14})	0.6	0.1	0.3	0.2	0.3	0.5
Palmitic	(C_{16})	49.2	21.2	41.2	40.0	33.0	35.3
Oleopalmitic	$(C_{16:1})$	-	0.8	-	-	0.4	0.1
Stearic	(C_{18})	2.2	1.5	1.5	3.0	1.4	2.7
Oleic	$(C_{18:1})$	40.2	57.9	47.8	46.5	54.1	49.5
Linoleic	$(C_{18:2})$	7.8	19.2	9.2	10.3	10.8	11.7
Unsaturation	(%)	48.0	77.9	57.0	56.8	65.3	61.3

Source: Tam, Lim, Yeoh & Ooi (1976)

Occurrence and distribution of *E. oleifera* in Brazil

E. oleifera is native to Central and South America and is known to occur in Costa Rica, Panama, Nicaragua, Venezuela, Colombia, Surinam and Brazil (Fig. 1). Whithin Brazil, the species is known to occur only in the upper reaches of the Amazonas river and its tributories. No reports have been made of its occurrence beyond Santarem city in the state of Para. The pattern of occurrence would suggest that the center of origin of *E. oleifera* is not likely to be in Brazil but elsewhere, most probably in Central America. The relatively lower level of variability within the species in Brazil as compared to those from Costa Rica, Panama and Colombia would tend to confirm this.

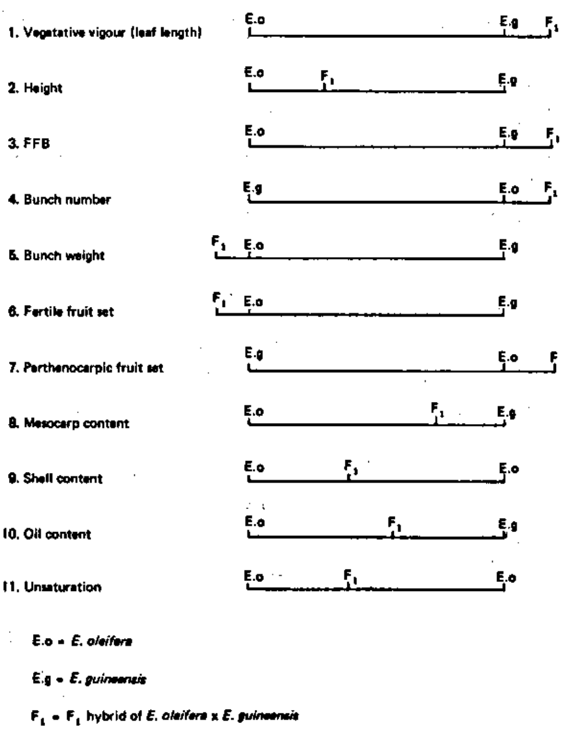

FIG. 1. Occurrença of *E. oleifera* in Central and South America.

Within Brazil, *E. oleifera* is know to be extremely widespread but precise information on their exact occurrence and distribution is still incomplete. They are known to occur along Rio Solimões, Rio Negro, Rio Madeira and their tributories. Definite sightings by persons familiar with the species indicated their occurrence at the following locations.

Tefé (Ooi 1980); Manicoré (Silva et al. 1981); Itacoatiara (Silva 1980); close to Manaus on the road to Porto Velho (Silva et al. 1980); Calderão (Ooi & Silva 1980); Careiro Island (per comm., Pinheiro 1980); Coari (per comm., with farmers from the area 1980); Autazes (per comm., Valois 1980); Codejas (per comm., with farmers from the area 1980); all within the state of Amazonas Caracarai in the state of Roraima, (per comm., W. Rodrigues, INPA 1980). Meunier (Meunier 1976) based on various sources and personal discussions, also reports of the presence of *E. oleifera* in Borba, Parintins, Maues, Taruman; Manarí e Santo Antonio do Amatari.

From the visits to some of the populations and from discussions, it would appear that while the populations occur fairly close to rivers, they are located on hight ground (terra firme) which are not proned to flooding and not along the periodically flooded banks (varzea). This is in contrast to the situation in Surinam and other parts of Central and South America where much of the natural populations occur within the flooded banks of the rivers. It would appear that the *E. oleifera* does not rely on the inhospitable environment of the flooded areas for their survival in Brazil. It is, of course, possible that the river banks which were among the first areas to be colonised, have been completely eradicated of these palms. This, however, appears very unlikely as many palm species (some with no known economic value) are retained and among these, no *E. oleifera* have been sighted. In fact, in most of the inland areas which have been cleared for agriculture, the species has not been completely eradicated and these form the most valuable source of genetic materials.

The population of *E. oleifera* visited tend to occur in compact clusters, to some extent reflecting a very poor dispersal mechanism. The palms are not known to have any economic value and humans are unlikely to be involved in their dispersal unlike the situation in *E. guineensis* where the population structure is related to human involvement (Ooi & Rajanaidu 1979).

The *E. oleifera* palms occur in the forest, secondary forest and in areas cleared for agriculture. Where the palms are growing in the primary and secondary forest, growth is very poor and little or no bunch production occurs. However, in areas which have been cleared for agriculture and the *E. oleifera* palms are retained, palm growth is extremely vigorous as can be seen from the data presented later, and very many bunches are produced. It is not uncommon to see plams with 10 to 15 well developed bunches. In general, these areas offer the best potential for prospection of *E. oleifera* genetics materials.

Although much of the palms occur on land that do not appear to be proned to flooding, the palms continue to exhibit a prostrate growth habit with the main part of the trunk lying along the ground and usually with massive quantities of potentially active roots.

Characteristics of palms from some native populations in Brazil

Preliminary visits were made to several locations where *E. oleifera* palms are known to occur, the aim being to confirm their presence and to collect information on these populations for the purpose of planning a prospection to collect *E. oleifera* genetic materials from these natural populations in Brazil. With the exception of 1 population, no attempt was made to select the sampled palms, not because of the need to avoid a biased sample but rather because there was no opportunity to do so as only a few of the palms had ripe bunches. To that extent therefore, the samples may be considered as random and the fact that so many palms with extremely useful breeding characteristics have emerged from the study gives hope that the prospection within natural populations in Brazil will yield very valuable breeding materials indeed and for this reason, despite the obvious limitation of the data, this paper has been presented.

Gereral growth characteristics

As has been mentioned earlier, although the palms are not growing under flooded conditions, they nevertheless, have prostate trunks which bear active roots.

Not unexpectedly, the palms show variation in their vegetative growth and vigour, depending to a large extent on the environment under which they are growing. Under forest conditions, due to the heavy shade, palm growth is poor, few leaves are produced and little or no fruit hunches are produced. Under secondary jungle, growth is improved and some bunch production occurs. However, under open conditions, the palms exhibit extremely good vigour. Data on some of the palm growing under such conditions are shown in Table 3.

Leaf number on these palms vary from 18 to 42 green leaves. The lower leaf number is due to the fact that much of these palms have been pruned for various uses including use a much for agricultural crops and leaf production in higher than is reflected from the data. However, a leaf number of 42 is clearly very outstanding for *E. oleifera* species. Frond size is variable but is realtively large, the whole frond in several extreme cases being well over 7 meters. These are extremely large fronds indeed for *E. oleifera* palms, and are comparable to those for *E. guineensis* but these are by no means the largest leaf possible. Of some interest is the unusually long petiole length from the point of insertion at the trunk to the first leaflet. From

TABLE 3. Vegetative parameters.

Sample nº	Frond nº	Frond petiole length: Trunk to Ist. leaflet (cm)	Frond petiole length: Ist. leaflet to end (cm)	Leaflet nº	Leaflet length. (cm)	Leaflet width. (cm)	Bunch nº	Male inf. nº
CND-Me 8112	27	134	527	186	109.5	5.45	1	10
CND-Me 8113	18	110	335	172	85.5	5.50	4	6
CND-Me 8114	27	215	495	176	120.5	6.10	4	6
CND-Me 8115	27	179	440	167	120.5	6.30	2	4
CND-Me 8116	19	164	322	149	85.0	5.05	6	4
CND-Me 8117	21	150	342	166	93.7	7.00	8	12
CND-Me 8118	18	150	340	128	80.5	6.00	7	3
CND-Me 8119	26	124	273	126	81.0	5.70	9	5
CND-Me 8120	42	263	478	165	120.5	5.35	4	7
CND-Me 8121	23	214	502	196	129.5	5.25	3	12

general observations, it would appear that this section of the leaf is particularly responsive (etiolation) to shaded conditions. The leaflet number is moderate but like the other characters show a wide range of values from 128 to 196. Leaflet characteristics are also variable, some with thin long leaflets while others have moderately long leaflets but with very wide leaf blades.

The palms generally show good growth, with dark green leaves and no visible deficieny symptoms or evidence of disease infection. Together with this good vegetative vigour is the high bunch production. In one of the sampled palms, nine bunches were recorded but this is by no means the highest possible. Among several of those palms not sampled were those with well in excess of 15 well developed bunches.

Male flower production is also high and in 2 of the sampled palms, 12 male flowers were recorded.

Bunch characteristics

Some bunch characteristics are shown in Table 4. Mean bunch weight of the sampled bunches is 5.99 kg but they vary from extremelly small bunches of 1.68 kg to moderately large bunches, in excess of 10 kg.

Of particular interest is the rather small peduncle (bunch stalk) size. This is in contrast to the situation in Central America and Columbia where, as will be seen later, large bunch stalks are a regular feature of palms from the region. In the present study, only 1 sample reach an exceptionally high level of 26%. In general, the peduncle forms only slightly in excess of 10% of the bunch weight. However, in several samples, the peduncle content of the bunch is very low indeed, only between 6% to 7%, much better than even for *E. guineensis* species.

Fruit set in the samples range from moderate to well-set bunches. In general, fruit set among the natural occurring palms are good although in several instances, failure of the anthesised bunches was observed, especially at one location but whether this is due to lack of pollination or other factors cannot be established. However, general observation on male inflorescence production would suggest that while inadequacy of pollen is not likely to be a factor timing could be a problem.

Of interest is the pattern of fruit set in the bunch (Table 5). Much of the developed fruits occur within the lower parts of the individual spikelets. This is in contrast to the situation in *E. guineensis* where much of the fruit set is at the apices of the spikelets (Ooi & Tam 1975). While data has been presented only for two samples, this appears to be a general phenomenon. This is most apparent during bunch analysis where the presence of well developed fruits interfered several with the separation of the spikelets. The pattern of fruit set in *E. oleifera* appears not to be consistent with what would be expected with pollination.

It is highly probable that insects have an important role in the pollination of these bunches. It is generally observed that the male and female inflorescence of *E. oleifera* palms in Brazil tend to have a higher density and more varied types of insects associated with them including ants, termites, bees, a curculionidae, and very many other tiny insects yet to be identified, than oil palm in Malaysia.

Parthenocarpic fruit development is extremely variable with some palms having a high proportion of well developed parthenocarpic fruit while others are very poor in this characteristics. To some extent, it would appear that development of parthenocarpic fruit is associated with the level of fertile fruit set. Where the fruit set is reduced, much more parthenocarpic fruit development occurs. However, excessively low fruit set normally would result in failure of the bunch.

Fruit characteristics

Fruit characteristics of some sampled bunches are shown in Table 6. It is clear from these data that fruit characteristics of these samples are very outstanding indeed.

The fruits are generally large, mean fruit weight is 7.91 g but ranging from less than 5 g to close to 13 g. The latter is clearly very large fruit size indeed for *E. oleifera*.

Mesocarp content of these fruits are also very

TABLE 4. Bunch characteristics.

Sample number	Bunch wt (kgs)	Peduncle (%)	Spikelet number	Fruit bunch (%)	Dev. fruits (%)	Parthenocarpic * fruits (%)	Undeveloped * fruits (%)
CND-Ca 8004	7.22	6.38	115	-	36.78	34.31	28.93
CND-Ca 8005	2.77	6.55	85	-	13.00	26.90	60.10
CND-Ca 8006	3.75	9.60	120	-	41.72	29.80	28.48
CND-Ca 8010	7.86	7.35	89	-	good	good	-
CND-Me 8112	9.73	11.41	137	44.30	good	poor	-
CND-Me 8113	4.10	15.12	119	41.22	good	good	-
CND-Me 8115	10.00	12.00	151	63.00	very good	very good	-
CND-Me 8117	4.00	15.75	133	58.75	very good	good	-
CND-Me 8118	7.41	11.61	103	68.69	excellent	good	-
CND-Me 8119	4.98	11.04	92	52.01	26.41	54.72	18.87
CND-Me 8120	1.68	26.19	83	54.76	poor	poor	-
CND-Me 8121	10.86	12.89	131	67.31	51.77	11.17	37.06
CND-Me 8122	3.59	8.64	90	56.27	good	poor	-
Mean value	5.99	11.89	111	56.25	33.93	31.88	34.69

* By number

TABLE 5. Pattern of fruit set (%) *in the bunch.

Sample number	Regions within the bunch			Regions within the spikelet		
	Basal	Middle	Apical	Basal	Middle	Apical
CND-Ca 8004	23.61	33.33	43.06	41.76	38.46	19.78
CND-Ca 8005	32.26	32.26	35.51	38.46	41.02	20.52

* By number

TABLE 6. Fruit characteristics.

Sample number	Fruit wt (g)	Pulp/fruit (%)	Kernel/fruit (%)	Shell/fruit (%)
CND-Cm 8001	12.90	45.83	18.01	36.16
CND-Cm 8002	11.77	42.78	19.31	37.91
CND-Cm 8003	8.89	55.36	16.92	27.72
CND-Ca 8004	8.61	44.50	15.09	40.41
CND-Ca 8005	8.32	35.74	19.65	44.61
CND-Ca 8006	6.58	35.76	24.30	39.94
CND-Ca 8008	5.36	36.29	17.07	46.64
CND-Ia 8010	7.28	41.59	22.93	35.48
CND-Ia 8011	10.91	49.61	17.09	33.30
CND-Me 8112	6.52	53.83	16.62	29.55
CND-Me 8113	7.16	53.67	14.15	32.18
CND-Me 8115	6.07	57.95	11.20	30.85
CND-Me 8116	6.16	61.99	10.51	27.50
CND-Me 8117	4.98	60.10	9.80	30.10
CND-Me 8118	5.60	51.32	16.58	32.10
CND-Me 8119	9.76	58.91	12.43	28.66
CND-Me 8120	11.10	57.03	13.83	29.14
CND-Me 8121	5.77	54.07	11.68	34.25
CND-Me 8122	6.62	49.22	17.67	33.11
Mean value	7.91	49.77	16.04	34.21

good, with several samples exceeding 50% and 2 samples exceeding 60%.

Similarly, shell content ranged from fairly poor to extremely good, with several samples having less than 30%, i.e. almost as good as a good dura parent.

Kernel content is not particularly large with one sample having less than 10%.

Comparison with *E. oleifera* genetic materials from other sources

Data on *E. oleifera* genetic materials collected from various sources in South and Central America are presented in Table 7 to provide a comparison on the relative merits of the *E. oleifera* genetic materials occurring in Brazil.

The outstanding features of the Brazilian populations are apparent from the data shown.

While bunch weight is not particularly high, they are nevertheless, not as small as those from Surinam. However, more important is the fact that the peduncle is extremely small. On average, these are about half of that for the materials from Central American and Colombian populations. The latter is particularly unsatisfactory in this respect. As may be recalled from Table 4, only 1 sample among the Brazilian populations showed poor peduncle characteristics while several had peduncle contents of less than 1/3 of those for the Colombian populations.

Fruit set in the Brazilian populations is fairly good but not particularly exceptional. However, of particular importance is the high percentage of well developed (2 to 3 g) parthenocarpic fruits. No comparative figures are available for the other populations but as will be discussed later, high parthenocarpy is a useful breeding characteristics and one which can contribute greatly to increased oil yield in the bunch.

However, it is the fruit characteristics which make the Brazilian populations particularly outstanding. Fruit size of the samples are on average twice as large as the materials from Central and South America. Together with this large fruit size is the high mesocarp content and low shell content. While the mesocarp content of the Central and South American populations seldom exceed 35%, the average Brazilian population is close to 50% with two samples exceeding 60%. All being equal, this would mean a higher oil content of between 40% to 70%. Similarly, while in the case of the Central and South American populations, shell

TABLE 7. Bunch and fruit characteristics of *E. oleifera* from different sources.

Population	Bunch wt. (kg)	Peduncle (%)	Fertile fruits (%)	Parthenocarpic fruits (%)	Fruit wt. (g)	Pulp/fruit (%)	Kernel/fruit (%)	Shell/fruit (%)
1. Sinu, Columbia[1]	12.6	-	42	19	3.4	38	17	45
2. San Alberto, Columbia[1]	17.7	-	46	15	3.4	33	14	53
3. Surinam[1]	1.5	-	65	0	3.0	44	17	39
4. Quepos, Costa Rica[2]	10.3	19.5	61.4	-	4.03	36.6	16.4	47.0
5. Limon, Costa Rica[2]	14.1	19.7	60.3	-	3.90	32.7	17.7	49.6
6. Golfito, Costa Rica[2]	12.7	17.8	62.2	-	3.00	30.8	20.7	48.5
7. Palmar, Costa Rica[2]	15.0	16.4	63.7	-	3.38	32.3	19.2	48.5
8. Armuelles, Costa Rica[2]	14.5	19.0	61.5	-	2.96	34.9	18.0	47.1
9. Chiriqui, Costa Rica[2]	12.0	19.3	61.6	-	2.92	33.0	17.9	49.1
10. Guabala, Costa Rica[2]	11.8	21.7	57.4	-	3.42	35.6	16.7	47.7
11. Santiago, Costa Rica[2]	12.0	18.5	61.6	-	3.44	38.3	15.4	46.3
12. Penonome, Costa Rica[2]	11.1	17.6	57.9	-	3.74	37.5	17.2	45.3
13. Bocas, Costa Rica[2]	10.7	21.0	59.5	-	3.73	31.9	17.3	50.8
14. Turbo, Columbia[2]	9.5	20.8	60.1	-	3.55	31.2	15.9	52.9
15. San Alberto, Columbia[2]	9.9	22.6	57.5	-	3.06	33.1	17.3	49.6
16. Monteiria, Columbia[2]	9.9	21.0	59.6	-	3.23	34.1	17.2	48.7
17. KLM[3]	-	-	3.5	60.20	7.36	47.3	10.1	42.6
18. Central America (mixed)[3]	-	-	23.1	26.67	3.67	32.5	17.7	49.2
19. Brazil[4]	6.0	11.89	56.26	31.38*	7.91	49.77	16.04	34.21

* By number

Source [1] IRHO, unpublished, Meunier, 1975 as reported in Meunier and Hardon (1976).
[2] SIATSA, Costa Rica, as reported in Ooi (1975). Report on visit to South America, MARDI, unpublished.
[3] Ooi (1979). Unpublished, MARDI.
[4] Mean of materials recently sampled.

content is well in excess of 45%, the average for the Brazilian population is only 34.21% with several samples being well within the range of good *E. guineensis* dura materials.

In terms of bunch and fruit characteristics, there is no doubt regarding the superiority of the Brazilian populations over those from other Central and South American areas. Only the materials from Surinam and KLM appear to come within the range of the Brazilian materials. However, fruit size of the Surinam population is small. The material "KLM" from Malaysia has satisfactory fruit size and fairly good fruit characteristics. This material has also outstanding features relating to the level of parthenocarpic fruit set. The origin of this material is not known for certain but various records available would suggest that its origin may also be Brazil (via Belém) and introduced through INEAC during the early fifties.

However, a disadvantage of the Brazilian population is the extreme vegetative vigour. The Panama and Colombian populations are already considered to be vigorous leaf length of between 4 meters to 4.5 meters. The average of the samples examined had a total leaf length close to 5 meters with several well in excess of 7 meters. However, much variation exist for this parameter and recent studies reveal that vegetatively less vigorous materials are available from other populations.

BREEDING IMPLICATIONS

As has been indicated earlier, the most promising immediate strategy for achieving the optimum combination of high oil yield and high level of unsaturation lies with the F_1 hybrid between the two species. Accodingly, of imediate concern is the way in which various characteristics of the two parents are transmitted to the F_1 hybrids, in particular, the dominance relationship and the presence of epistastic interactions. Some generalizations may be made relating to this from existing data and on the linear scale, these are as follows:

1. Vegetative vigour: The F_1 hybrid is generally more vigorous than the larger parent, *E. guineensis,* (as is reflected by leaf size) i.e. overdominance (hybrid vigour) for this characteristic.

2. Height: The height of the F_1 hybrid follows that of shorter parent, *E. oleifera,* but dominance for short height is incomplete.

3. Fruit bunch production: The F_1 hybrid shows hybrid vigour for this characteristics and production is higher than *E. guineensis* parent. The high F.F.B. is due to over-dominance for bunch number. Fruit bunch weight follows that of the lower parent, *E. oleifera* and low bunch weight is completely dominant over high bunch weight in the hybrid.

4. Fertile fruit set: The F_1 hybrid shows ever lower fruit set than the *E. oleifera* parent. There appears to be reduced fertility in the F_1 hybrid and there is therefore over-dominance for low fruit set in the hybrid.

5. Parthenocarpic fruit set: The parthenocarpic fruit set in the F_1 hybrid is higher than the *E. oleifera* parent i.e. over-dominance (hybrid vigour) for high parthenocarpic fruit set. Is is likely that the higher parthenocarpic fruit set compensates for the reduced fertility and fertile set of the hybrid.

6. Mesocarp content: The mesocarp to fruit percentage of the hybrid approaches that of *E. guineensis* but dominance for high mesocarp content is incomplete. Table 1 shows the mesocarp content of the hybrid to be fairly close to *E. guineensis* parent but it should be noted that the parent used for production of the hybrid is a pisifera while the data quoted in Table 1 is for tenera. Accordingly, the dominance level is much lower than what is reflected by the data presented.

7. Shell content: The shell content of the hybrid approaches that of the *E. guineensis* parent. For the same reasons as stated for mesocarp, the degree of dominance for reduced shell content is lower than what is reflected in the data shown in Table 1. It is quite likely that a no dominance relationship exist for this parameter in the hybrid.

8. Oil content: The oil content of the hybrid approaches that of the *E. guineensis* parent, i.e. incomplete dominance for high oil content.

9. Fatty acid composition: The level of unsaturation shows a slight degree of dominance in favour of high saturation.

The pattern of inheritance is summarised in Fig. 2.

Given this pattern of inheritance, the advantages that may acrue from some of the outstanding

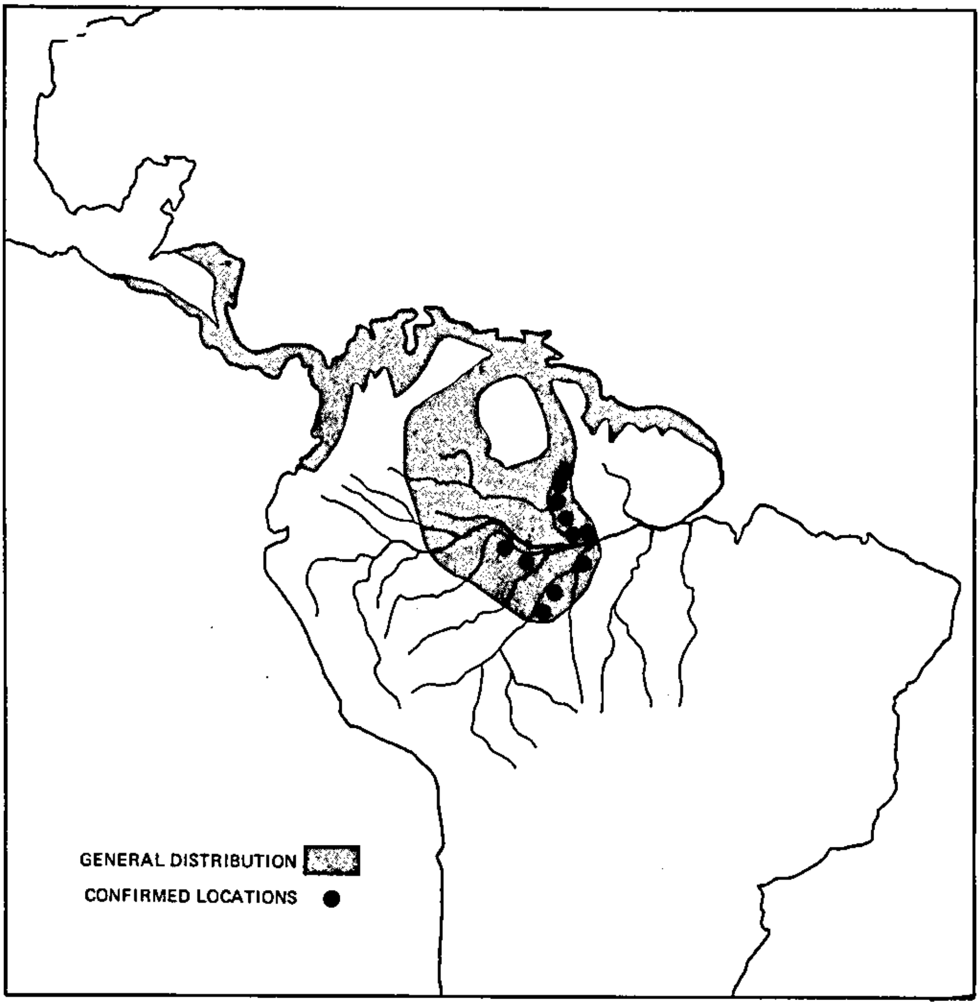

FIG. 2. Inheritance of some characteristics in the F_1 hybrid progenies.

features of the Brazilian population are obvious.

No data has been presented for the peduncle content of the bunch but the advantage of having a very small peduncle in *E. oleifera* requires little explanation.

In terms of fruit bunch production, high production in the hybrid appears to depend on the bunch number of the *E. oleifera* parent and data collected would suggest that this source of variation is present among the Brazilian population. However, also important is the fact that bunch weights in the Brazilian populations are good. Since, the bunch weight of the *E. oleifera* parent is dominant over the *E. guineensis* parent, high bunch weight is an important factor determining overall yield of the hybrids.

However, in the hybrids evaluated so far, fruit bunch yield has not presented a serious problem and in fact, the main limitation to achieving high yield in the hybrid has been the low oil content of the bunch.

Improvement in the oil content of the bunch depends on raising the overall mesocarp content of the bunch and the oil content in the mesocarp and this depends very much on the characteristics of the *E. oleifera* parent.

Mesocarp content in the *E. oleifera* depends not only on the mesocarp content of the fruit but also on the level of parthenocarpy.

With a mesocarp content in fruit of some of the

Brazilian populations exceeding 60%, the F_1 hybrid progenies derived from these parents may be expected to have a mesocarp content close to 85% i.e. almost equivalent to a good tenera.

However, it is felt that in the long term, the parthenocarpic fruit set is likely to have a more important role in raising the overall mesocarp content, and can offer the possibility of achieving an oil yield higher than even *E. guineensis*. Another advantage of exploiting the parthenocarpic fruit level as a means of raising the mesocarp content is the possibility of using tenera instead of pisifera as the parent. The use of tenera instead of pisifera would certainly increase the selection efficiency and acclerate the selection progress. In terms of parthecocarpy level, a wide range is exhibited within the Brazilian populations with several palms having extremely high parthenocarpy levels and these parthenocarpic fruits are well developed.

The other important parameter of oil yield is the oil content of the mesocarp. Facilities are only now being developed as such no data is as yet available on the Brazilian populations. However, the oil content of the mesocarp is clearly a very important factor and for which the Brazilian populations need to be evaluated.

Similarly, no data has yet been collected on the fatty acid composition and no assessment can be made for this property.

One disadvantage of the Brazilian population is its extreme vegetative vigour in respect of leaf size. If the inheritance for this character follows that given earlier, this may mean that the hybrids may have to be planted at an extremely low density, clearly a disadvantage. However, sufficient variation exists to allow selection to be made for smaller plant size. Possibilities, of course, also exist for interpopulation crosses to be made, particularly with the extremely small plant types available in Surinam.

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