

COCONUT BREEDING: IDENTIFICATION OF PARENTS IN MALAYAN YELLOW DWARF AND TALL CULTIVARS FOR THE PRODUCTION OF PROMISING DWARF FEMALE x TALL MALE HYBRIDS

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ABSTRACT

Results of a study made on the nut and copra characters of Malayan Yellow Dwarf palms and of the local Tall cultivars to select the parents which could combine well, when Malayan yellow Dwarf palms as pistillate parents are crossed with Tall cultivars as pollen parents are presented in this paper. In this study Malayan yellow Dwarf palms were classified into four groups based mainly on nut characters like shell and copra content which are fairly stable characters. The Tall cultivars were classified into five groups based mainly on the copra content per nut. Correlation studies made on the important characters of the nut in the Dwarf and Tall cultivars indicated significant correlations between the stable characters shell, kernel and copra. Based on this relationship it may be possible to identify palms in both which could combine well when Malayan Yellow Dwarf as pistillate parent is crossed with the Tall as pollen parent. The study has indicated that it may be preferable to select Malayan Yellow Dwarf palms which produce nuts which have a low shell content (less than 17 percent of husked nut weight) and yield a copra content of more than 150g per nut as pistillate parent and Tall palms which yield nuts of low husk content (less than 50 percent of the weight of fruit) and a high copra content of 200g or more per nut as pollen parent. The combining ability of the parents could be ascertained from xenia studies before taking up crossing work. Individual palms from both the cultivars which can combine well can be identified and utilized for the production of a large number of hybrid seedlings in a short time.

INTRODUCTION

Sustained and continuous work done in improving the Tall variety of coconut by selection of mother palms, selection of seednuts and selection of vigorous growing seedlings in the nursery based on seedling characters does not seem to have improved the yield of coconut to the desired extent in the countries where coconut breeding work has been in progress ever since coconut improvement work was started. Identification of a large number of genetically superior or prepotent palms from the high yielders based on progeny studies as suggested by Harland (1957) has been a long process. The progress made by this method has been very slow. Hence there has been no substantial genetic improvement in the yield of coconut in these countries. The yield stability improvement in coconut by breeding is slow and time consuming as was predicted by Haldane (1957) who had stated that coconut improvement is not a simple problem. He had stated that though high yield is not expected to be at all strongly inherited, the yield could be improved but the process might be disappointingly slow.

Breeding work done on the production of Tall female x Dwarf male hybrids in India and elsewhere also has not given the expected results. The merits and demerits of these hybrids and the limitations confronted in producing them have indicated that production of a large number of Tall female x Dwarf male hybrids involved considerable labour and expenditure. Optimum parental combination had to be fixed for producing promising hybrids. Each female flower on the inflorescence of the Tall female parent had to be hand pollinated which was time consuming since all the female flowers on the inflorescence would not be ready for pollination on the same day. Besides there was no genetic marker to identify the hybrid seedlings in the nursery unlike in the case of the reciprocal combination in which the hybrid seedlings could be identified by the colour of the seedling.

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Therefore current research in coconut breeding in various countries is now centered around the Dwarf variety of coconut for the production of promising Dwarf female X Tall male hybrids utilizing the local cultivars of the two varieties. According to de Nuce de Lamothe and Rognon (1977), the Dwarf coconut is valued for the coconut improvement work for the production of hybrids of high yield potential. These only can increase the production of coconut in a short time. They have also reported that all dwarfs are not the same as they do not have the combining ability with the Talls. The same problem of combining ability of the parents is also met with here. Hence a critical study of the different forms of Dwarf is essential for utilizing them for the production of promising hybrids. Results of a critical study made on the Malayan Yellow Dwarf palms introduced in India by analyzing the nut and copra characters of the palms and those of the Tall cultivars which produce nuts of different sizes to identify both the female and male parents respectively which when crossed would combine well to produce high yielding hybrids are discussed in this paper. The hybrids obtained should be superior to both the parents in yield of nuts and copra outrun.

Malayan yellow Dwarf

Malayan Yellow Dwarf palms have been introduced in most of the coconut growing countries because of their short stature, early bearing nature and easy accessibility for harvest. They are generally planted for ornamental purposes because of their different distinct colour forms like green, yellow and orange or red and also for the nuts which give a refreshing sweet drink. Except for their initial early bearing character, all other characters like irregular bearing, poor quality copra and easy susceptibility to drought and water logged conditions and attack of pests and diseases have made this variety an uneconomic one. Hence this variety was not recommended for growing on a plantation scale. Cooke and Jagoe (1933) had reported that it was difficult to prepare hard copra from dwarf coconuts as usually a large proportion of wrinkled, distorted rubbery copra was produced and stated that in raising coconut estates it was advisable to plant only tall palms. Malayan Yellow and Orange or Red dwarf palms grown in most of the coconut growing countries are now used by research workers in these countries to produce Malayan Yellow or Red female X Tall male hybrids utilizing the local Tall as pollen parents. In some of these countries production of promising hybrids has not been successful to the extent desired because of the incompatible parent combination resulting in poor combining ability. This has indicated the need for identifying the parents based on their combining ability. Otherwise the hybrids produced may not be promising as they may not be superior to the local Tall cultivar which is used as the pollen parent. The need for selection of palms among the two varieties as parents for the production of promising hybrids was stressed by Satyabalan (1982) who compared the fruit component analysis data of the parents and hybrids of Dwarf female X Tall male combinations reported from Ivory Coast, India, Sri Lanka, Malaysia and Jamaica.

The palms of the Malayan Yellow Dwarf which are mainly used for the production of hybrids are generally believed to be highly self-pollinated. Jack and Sands (1922) reported that out of 500 nuts of Malayan Yellow Dwarf sown in the nursery, 406 seedlings were true to type accounting for 96.2 percent. This observation might have been made on the basis of the colour of the seedlings. According to Le Saint et al (1983), Malayan Yellow Dwarf exhibits direct auto gamy wherein the long female phase is overlapped by the male phase of the same inflorescence. Later studies have indicated that though the palms look similar in stature and colour, the constituents of their fruits vary in their proportion indicating phenotypic uniformity concealing genetic variability. Though the nuts show similarity in colour and size, the constituents, husk, kernel, water, shell and the dried kernel copra vary in their ratios in the nuts of the palms. Though the palms are believed to be highly self pollinated, there seems to be some heterozygosity present in them. Perhaps this may necessary for their continued survival under progressive inbreeding. The heterozygosity could be the result of gradual evolution of the Dwarf from the ancestral wild type due to combined action of inbreeding and out crossing. The same situation can be expected to exist in different forms of Dwarf reported from different countries.

Variation in the nut and copra characters of Malayan Yellow Dwarf palms

Data on the fruit components of four nuts on a bunch of 12 Malayan Yellow Dwarf palms studied are presented in Table 1. The data indicate slight variation in the characters of nuts on a bunch of each palm and high variation in the nut characters between the palms. Based on the data collected, the palms have been classified into four groups based on the shell and copra characters which are fairly stable. The data in the Table indicate that in the first group which comprises three palms the mean shell content in the nut is less than 17 percent of the husked nut weight. The mean copra content is less than 140g per nut. The second group comprises three palms which produce nuts the mean shell content of which is less than 18 percent of the husked nut weight. But the mean copra content in these palms is above 150g per nut. The third group comprises three palms which produce nuts the mean shell content of which is more than 20 percent of the husked nut weight. The mean copra content in these palms varied between 80.8 to 113.0g per nut. The three palms in the fourth group produce nuts the shell content of which is also more than 20 percent of the husked nut weight. The mean copra content in these palms varied between 157 to 182.5g per nut. Based on the findings of this study, the Malayan Yellow Dwarf Palms in the garden were classified into four groups. The first group of palms produced fruits the weight of which varied from 367 to 995g per fruit while the weight of husked nut varied from 205 to 730g per nut. The variation in the weight of kernel was from 112 to 317g per nut, while that of water was from 27 to 320g per nut and that of shell from 37 to 140g per nut. The weight of copra per nut varied from 70 to 150g per nut. In the palms of the second group the weight of fruit varied from 705 to 1180g while that of the husked nut varied from 515 to 895g per nut. The weight of kernel ranged from 310 to 430g per nut while that of water from 50 to 340g per nut. The weight of shell varied from 80 to 170g per nut and the weight of copra from 152 to 215g per nut. In the palms of the third group the weight of fruit ranged from 253 to 870g per fruit while that of the husked nut from 180 to 445g per nut. The weight of kernel per nut varied from 117 to 281g. The variation in the weight of water was from 3 to 125g per nut while that of shell was from 38 to 100g per nut. In the palms of the fourth group the weight of fruit varied from 635 to 970g per fruit while that of husked nut from 260 to 354g per nut. The weight of water ranged from 50 to 290g while that of shell from 100 to 155g per nut. The weight of copra per nut varied from 150 to 235g. The mean values of the characters of the palms in the four groups are presented in Table 2a. Among the components of the fruit, kernel, shell and copra are found to be fairly stable characters than husk and water. The percentage of the components in the fruit and in the husked nut has been worked out and presented in Table 2b.

Correlation studies were made on the nut and copra characters of the palms in the four groups to determine the magnitude of association between the characters mainly between the stable characters shell, kernel and copra. Coefficient of correlation between the weights of the characters are presented in Table 3. Among the correlations worked out, highly significant correlations were obtained between the stable characters kernel, shell and copra in the palms of the first three groups separately and in the combination of all palms in the four groups. The correlation indicated that any increase or decrease in the weight of shell resulted in the increase or decrease in the weight of kernel and copra.

Variation in the nut and copra characters of the Tall cultivars

There is considerable variation in the yield of nuts and nut and copra characters of the Tall cultivars as they are highly cross pollinated, and heterozygous, yielding nuts of different sizes and shapes. These palms are used as pollen parents in the production of hybrids. The study of the Tall cultivars has indicated that they can be classified into five groups based mainly on the copra content per nut. The palms in the first group produced very large sized nuts the copra content of which was more than 300g per nut. The fruit had 30 percent of its weight as husk content. The mean copra content per nut varied from 303 to 376g in the palms of this group. The palms in the second group produced large sized nuts the mean copra content of which varied between 200 to 300g per nut. The copra content of the palms varied from 205 to 296g between the palms. The palms in the third group also produced large sized nuts the copra content of which varied between 200 to 300g per nut. The copra content of the palms varied from 200 to 265g between the palms. The palms in the fourth

group produced nuts which were medium sized the copra content of which was below 200g per nut. It ranged from 117 to 195g between the palms. The palms in the fifth group also produced medium sized nuts the mean copra content of which was also below 200g per nut. This ranged from 108 to 195g between the palms. In the palms of was the first group the husk content was 30 percent of the weight of fruit whereas in the palms of the remaining groups the husk content was less than 50 percent of the weight of fruit. In the case of palms in the first, second and fifth groups the copra content was less than 30 percent of the weight of husked nut whereas in the case of palms in third and fourth groups it was 30 percent and above the weight of husked nut. The mean values are presented in Table 4a. The data on the percentage of the components namely the weight of husked nut in the weight of fruit and those of kernel, shell and copra in the weight of the husked nut are presented in Table 4b.

Correlation studies made on the nut and copra characters of the palms in the five groups have also indicated significant correlation between the stable characters shell, kernel and copra. The data are presented in Table 5.

Identification of promising combinations for the production of high yielding Malayan Yellow Dwarf x Tall male hybrids

Malayan Yellow Dwarf female x Tall male hybrids have been produced in some countries utilizing the local Malayan Yellow Dwarf palms and the local Tall cultivars. In some countries the attempt has succeeded because of the good combining ability of the parents selected for crossing while in some countries it has not been successful because of the incompatibility of the parents resulting in the poor performance of the hybrids. In Table 6 are presented the fruit analysis data of Malayan Yellow Dwarf palms, of the Tall cultivars and of the hybrids Malayan Yellow Dwarf x Tall produced in the countries Malaysia, Ivory Coast and Jamaica. The data indicate that the hybrid produced in Ivory Coast now known as MAWA in which selected Malayan Yellow Dwarf palms were used as pistillate parents with selected West African Tall palms as pollen parents were found to very promising as the copra content of the hybrid was more than of the parents used in the cross. In the hybrids produced in Malaysia and Jamaica the copra content in the nuts of the hybrids was only more than those of the pistillate parents namely Malayan Yellow Dwarf used in Malaysia and Jamaica and not to those of the pollen parents namely Malayan Tall and Jamaica Tall. This indicates that the combination of the parents utilized in Ivory Coast only has clicked because of the compatibility or the combining ability of the parents. In Indonesia the nut and copra characters of the hybrid Malayan Yellow Dwarf x West African Tall planted in Medan, North Sumatra do not seem to be as high as those reported from Ivory Coast. Perusal of the data of the combination reported from Ivory Coast has indicated that the shell percentage by weight in the nuts of selected Malayan Yellow Dwarf palms was only 16 percent of the husked nut weight whereas in was 20 percent in Malayan Yellow Dwarf used in Malaysia and 22 percent in the Malayan Yellow Dwarf palms used in Jamaica. The copra content per nut of Malayan Yellow Dwarf palms used in Ivory Coast was 166g whereas it was 108g in Malaysia and 185g in Jamaica. The selected Malayan Yellow Dwarf palms which produced nuts having a low shell content of 16 percent of the husked nut weight and yield a high copra content of 166g were crossed with selected West African Tall palms as pollen parent which produced medium sized nuts having a low husk content of 39 percent of the fruit weight and gave a copra content of 193g per nut. This combination has been successful because the shell content in the nut of the hybrid increased from 16 percent in the pistillate parent to 19 percent resulting in the increase of the copra content from 166g per nut in the pistillate parent to 226g in the nut of the hybrid. The weight of copra per nut in the hybrids exceeded those of the parents utilized in this combination. In the case of hybrids produced in Malaysia and Jamaica the copra content per nut in the hybrid was superior to those of the pistillate parents only because of the poor combining ability of the parents which may perhaps be due to the high shell content and low copra content in the nuts of the Malayan Yellow Dwarf utilized in Malaysia and high shell content and high copra content in the nuts of the Malayan Yellow Dwarf palms utilized in Jamaica. Besides the husk content in the fruit of the Jamaica Tall which was used as the pollen parent was also very high resulting in the high husk content in the nut of the hybrid. The Malayan Yellow Dwarf palms utilized as pistillate parents in

Ivory Coast, Malaysia and Jamaica were different in their composition of nut and copra characters. Similarly West African Tall, Malayan Tall and Jamaica Tall utilized as pollen parents were also entirely different in the composition of nut and copra characters. The contribution of the different components of the husked nut to the total in the fruits of the parents and their hybrids has indicated the difference in their composition. A comparison of the increase in the weight of husked nut of the hybrid with those of the parents showed that the increase was due to the weight of kernel and shell when compared to those of the Malayan Yellow Dwarf which was the pistillate parent. But when compared to those of the West African Tall pollen parent which was the superior parent the data indicated that the increase was mainly due to increase in the weight of nut water and kernel only; the shell did not contribute anything. This had resulted in the increase in the kernel content which naturally resulted in more copra content than that of the superior pollen parent namely West African Tall. This indicates the importance of low shell content in the pistillate parent. In Table 7 are presented the data of the different components of the husked nut to indicate their contribution to the total in the parents and hybrids. The data indicate that the hybrid Malayan Yellow Dwarf x West African Tall was superior to both the parents in all characters whereas the hybrid Malayan Yellow Dwarf x Malayan Tall was superior to its female parent Malayan Yellow Dwarf only and not to its superior male parent Malayan Tall while the hybrid Malayan Yellow Dwarf x Jamaica Tall was neither superior to its female parent Malayan Yellow Dwarf nor to its superior male parent, Jamaica Tall.

The observation reported by Fremond and de Nuce de Lamothe (1971) that the combination of Malayan Yellow Dwarf x West African Tall in Ivory Coast gave a high copra content of 226g per nut in the hybrid and the observation reported by Chan (1979) that the combination of Malayan Yellow Dwarf in Malaysia pollinated with West African Tall pollen obtained from Ivory Coast and with Rennell Tall pollen obtained from New Hebrides gave a copra content of 199g per nut and 191g per nut respectively (vide Table 6) have indicated the importance of the combining ability of the parents. This is mainly due to the differences in the nut and copra characters of the parents. Earlier studies on different combinations of Dwarf female x Tall male had indicated that it is preferable to select Dwarf palms which yield nuts having a low shell content of less than 20 percent of the husked nut weight as pistillate parents and Tall palms which yield fruits which have less husk content (less than 50 percent of the weight of fruit) and yield a copra content of more than 150g per nut as pollen parents to obtain in a large number of hybrid seedlings (Satyabalan and Rajagopal 1987). On the basis of the results obtained from earlier studies and based on the data presented in Table.7. Malayan Yellow Dwarf palms in group II which produce nuts having a shell content of 17 percent and below of the husked nut weight and yield copra content of 150g. or more per nut may be identified as pistillate parents and Tall palms in group II which produce fruits which have a husk content of less than 50 percent of the weight of fruit and yield a copra content of 200g and above per nut may be identified as pollen parents. It may be possible to identify individual palms from both the parent groups which when combined, can throw a very high percentage of hybrids.

Xenia effect and combining ability of the parents.

Studies made on the effect of pollen of the male parent on the copra content of the female parent in India and Ivory Coast have shown that hybrid vigour may possibly manifest in nuts derived from cross pollination. Haldane (1958) had stated the possibility of hybrid vigour showing in nuts derived by cross pollination since hybrid vigour in some species is largely due to increased seed weight. This may be due to inherent ability of certain trees or due to hybrid vigour of nuts resulting from certain combinations. Hybrid vigour manifestation in nut characters between palms producing medium and small sized nuts resulting in high copra outturn has been reported (Satyabalan,1995). The observations reported from a trial in Ivory Coast from a combination of Cameroon Red Dwarf as seed parent with West African Tall and Tahiti Tall as pollen donors had shown that the copra content per nut was much greater than that of either of the parents when pollen of West African Tall was used whereas it was intermediary when Tahiti Tall pollen was used which has been explained as an expression of better combining ability between Cameroon Red Dwarf and West African Tall (Rognon and de Nuce de Lamothe 1983). Their studies have shown that the influence of pollen was

on the shell weight and not on the quantity of husk. This combining ability of the parents was reflected in the manifestation of hybrid vigour in PB 111 released from Ivory Coast (Sangare et al 1983). Similar xenia effect was observed in the combination of Malayan Yellow Dwarf with West African Tall when the nuts of selected Malayan Yellow Dwarf palms pollinated with the pollen of selected West African Tall palms received from Ivory Coast were studied for their nut characters (vide Table No.8)

The observations reported and the results obtained from the studies made so far indicate the possibility to identify palms from the different Dwarf forms and Tall cultivars as pistillate and pollen parents respectively for their better combining ability. Such identified palms should be utilised for the production of promising hybrids in a short time and in large numbers which when planted, will go a long way to improve the yield of future plantations. Research workers should study the palms in the Dwarf and Tall cultivars available in their countries and identify the parental combinations for producing promising hybrids for their countries.

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Table 1							
Fruit component analysis data of four nuts on a bunch in each of the 12 Malayan Yellow Dwarf Palms classified into four groups							
Tree No	Nut No	Husked Nut Fruit	Kernel Nut	Water Nut	Shell Nut	Copra Nut	Copra per Nut
(Percentage by weight)							
Group I							
1	1	60.7	56.8	25.9	17.5	27.2	125
	2	64.7	54.2	27.9	17.9	27.5	123
	3	64.7	57.2	28.3	14.5	27.3	135
	4	65.2	53.1	28.7	18.2	28.1	142
		64.2	55.2	27.7	17.1	27.7	131.3
2	1	63.3	54.3	28.4	17.3	27.4	111
	2	64.5	55.1	28.2	16.7	29.5	115
	3	65.5	53.1	30.1	16.8	27.3	127
	4	63.3	55.3	27.9	16.8	28.0	130
		64.0	54.5	28.7	16.9	28.0	120.8
3	1	62.5	50.9	29.0	20.0	19.0	105
	2	67.4	49.5	34.9	15.6	23.0	145
	3	53.1	51.9	32.1	16.0	23.0	145
	4	64.3	53.8	30.2	16.0	27.0	146
		64.4	51.4	31.8	16.9	24.1	135.3
Group II							
1	1	73.4	48.0	32.9	19.1	26.9	205
	2	74.4	46.6	35.6	17.8	25.2	205
	3	73.2	45.8	36.6	17.6	24.8	190
	4	74.8	45.9	35.9	18.2	23.6	180
		74.0	46.6	35.3	18.1	25.1	195.0
2	1	75.9	48.4	33.5	18.1	24.2	195
	2	76.9	45.3	35.9	18.8	22.3	190
	3	76.5	49.4	32.0	18.6	23.7	187
	4	75.9	50.9	31.1	18.0	26.1	215
		76.3	48.5	33.2	18.4	24.2	196.3
3	1	72.1	50.4	33.1	16.5	24.0	160
	2	58.5	52.5	30.5	16.9	27.4	162
	3	57.4	54.9	27.6	17.5	27.2	143
	4	79.5	47.5	36.0	16.5	25.1	171
		65.9	51.0	32.2	16.9	25.8	159.0
Group III							
1	1	60.5	65.9	11.4	22.7	28.4	100
	2	62.6	69.6	5.2	25.2	33.8	130
	3	61.4	64.9	8.6	24.5	31.7	110
	4	63.2	64.8	11.3	23.9	31.5	112
		62.1	66.9	9.1	24.1	31.4	113.0
2	1	60.5	65.9	11.4	22.7	28.4	80
	2	71.8	31.8	48.3	19.9	30.4	107
	3	70.2	63.8	14.0	21.3	31.2	105
	4	72.0	64.9	14.6	20.5	29.2	100
		70.4	55.5	23.4	21.3	29.4	98.0
3	1	66.8	61.8	17.3	20.9	32.4	85
	2	67.4	62.4	17.1	20.5	34.2	90

	3	66.2	61.3	18.3	20.4	29.8	70
	4	64.9	65.6	13.7	20.7	35.8	78
		67.0	62.7	16.7	20.6	33.3	80.8
Group IV							
1	1	71.7	56.6	20.2	23.2	32.3	160
	2	72.6	61.1	17.1	21.8	33.8	158
	3	73.0	65.8	11.4	22.8	30.8	135
	4	76.1	60.4	18.3	21.3	34.3	188
		73.3	60.8	17.0	22.3	32.7	160.3
2	1	71.2	63.8	14.4	21.8	36.9	205
	2	66.9	62.7	13.6	23.4	34.7	151
	3	64.8	62.6	11.4	26.0	34.3	122
	4	64.6	63.9	11.7	24.4	36.6	150
		67.3	63.2	13.2	23.7	35.8	157.0
3	1	79.9	42.6	37.4	20.0	23.8	185
	2	77.4	43.6	33.1	23.3	23.6	150
	3	77.2	44.7	36.3	18.9	24.0	215
	4	79.1	47.9	31.9	20.2	25.0	180
		78.3	44.7	34.8	20.5	24.2	182.5

Table 2a

Fruit component analysis data of Malayan Yellow Dwarf palms in the four groups

Group	Fruit weight (g)	Wt. of husked nut (g)	Wt. of kernel (g)	Wt. of water (g)	Wt. of shell (g)	Wt. of copra (g)
I	714.6	470.4	247.9	142.1	80.4	124.3
II	961.6	709.6	353.8	235.2	120.6	170.1
III	407.9	257.1	167.5	32.7	56.9	90.4
IV	763.0	567.1	303.6	138.0	122.5	169.2
	653.5	445.1	232.9	119.4	82.8	125.8

Table 2b

Fruit component analysis data (percentage by weight) in the palms of the four groups

Group	Fruit weight (g)	Percentage by weight					
		H.N. Fruit	K/N	W/N	S/N	C/N	Copra per nut (g)
I	714.6	65.7	52.7	30.3	17.0	26.4	123.3
II	961.6	73.8	49.9	33.2	16.9	25.2	179.1
III	407.9	63.0	65.1	12.8	22.1	35.1	90.4
IV	763.0	74.0	53.8	24.5	21.7	29.9	169.2
	653.5	68.0	54.6	26.8	18.6	28.3	125.8

Table 3
Coefficients of correlation between the weights of different nut and characters of the Malayan Yellow Dwarf Palms in the four group

Group I	2	3	4	5	6
1	0.9275	0.8584	0.8099	0.8587	0.7727
2		0.8550	0.9154	0.9347	0.7767
3			0.5931	0.7654	0.8163
4				0.8553	0.6123
5					0.7082
Group II					
1	0.8199	0.3350	0.7678	0.8594	0.6676
2		0.5940	0.8662	0.9399	0.8122
3			0.1288	0.5163	0.6799
4				0.7915	0.5780
5					0.7692
Group III					
1	0.8759	0.8095	0.6248	0.8842	0.5364
2		0.9425	0.7123	0.9702	0.7153
3			0.4735	0.9373	0.7823
4				0.5838	0.3287
5					0.7231
Group IV					
1	0.9877	0.6408	0.9423	0.9411	0.4954
2		0.6370	0.9585	0.9541	0.4782
3			0.3965	0.4997	0.9549
4				0.9364	0.2207
5					0.3526
Group I to IV					
1	0.9676	0.9161	0.9202	0.8932	0.8557
2		0.9426	0.9482	0.9376	0.9087
3			0.7985	0.8861	0.9299
4				0.8464	0.7917
5					0.8806

Correlation Matrix	
Characters	1. Fruit Weight 2. Weight of husked nut 3. Weight of Kernel 4. Weight of Water 5. Weight of shell 6. Weight of copra
Groups	
I	≤ 150g of copra ≤ 20 shell percentage in husked nut weight
II	≥ 150g of copra ≤ 20 “ “
III	≤ 150g of copra ≥ 20 “ “
IV	≥ 150g of copra ≥ 20 “ “
Shell percentage in husked Nut weight	Copra content per nut
≤ 20	≤ 150 > 150
≤ 20	I II
	III IV

Table 4a Fruit component analysis data of the Tall cultivars which are classified into five groups					
Group	Fruit weight (g)	Wt. of husked nut (g)	Wt. of kernel (g)	Wt. of shell (g)	Wt. of copra (g)
I	2,132.0	1,519.4	632.2	275.3	331.9
II	1,537.8	913.2	434.1	220.8	234.7
III	1,360.4	730.0	389.0	184.7	226.9
IV	970.1	544.1	292.3	147.3	174.2
V	1,254.3	657.5	329.6	182.4	168.8
	1,466.6	864.6	419.9	204.4	228.9

Table 4b Fruit component analysis data (percentage by weight) of the palms in the five groups of Tall cultivars						
Group	Fruit weight (g)	Percentage by weight				
		Husked Nut Fruit	Kernel Nut	Shell Nut	Copra Nut	Copra / nut (g)
I	2,132.0	71.2	41.6	18.1	21.8	331.9
II	1,537.8	59.4	47.5	24.2	25.5	234.7
III	1,360.4	53.7	53.3	25.3	31.1	228.9
IV	970.1	56.1	53.6	27.0	32.0	174.2
	1,254.3	52.2	50.2	27.7	25.7	168.8
	1,466.6	58.9	48.6	23.6	26.5	228.9

Table 5

Coefficients of correlation between the weights of different nut and copra characters in the palms of the five groups of the Tall cultivars

Group I	2	3	4	5
1	0.892242	0.928507	0.692175	0.641477
2		0.943081	0.855942	0.676517
3			0.759025	0.723311
4				0.650319
Group II				
1	0.404974	0.424529	0.447861	0.405805
2		0.872512	0.634240	0.776866
3			0.659390	0.758976
4				0.524759
Group III				
1	0.597881	0.631378	0.908356	0.331326
2		0.920678	0.808641	0.608833
3			0.759489	0.525092
4				0.492656
Group IV				
1	0.595197	0.503452	0.807270	0.495350
2		0.876800	0.812721	0.938128
3			0.626573	0.964272
4				0.736244
Group V				
1	0.477872	0.428087	0.560602	0.218779
2		0.893588	0.779147	0.697371
3			0.768077	0.714631
4				0.578625
Group I to V				
1	0.867525	0.869077	0.847204	0.781342
2		0.983707	0.888416	0.933646
3			0.875544	0.948366
4				0.817188

Group I - comprises cultivars which produce very large sized nuts the mean copra content of which is more than 300g per nut which is less than 30 percent of the husked nut weight.

Group II - comprises cultivars which produce large sized nuts the mean copra content of which varies between 200 to 300g per nut which is less than 30 percent of the husked nut weight

Group III - comprises cultivars which also produce large sized nuts the mean copra content of which varies between 200 to 300g per nut which is more than 30 percent of the husked nut weight

Group IV - comprises cultivars which produce medium sized nuts the copra content of which is less than 200g per nut which is 20 percent and above of the husked nut weight.

Group V - comprises cultivars which also produce medium sized nuts the copra content of which is less than 200g per nut which is less than 30 percent of the husked nut weight.

Group I to V - comprises all the palms in the five groups.

- Characters :
1. Fruit weight
 2. Weight of husked nut
 3. Weight of kernel
 4. Weight of shell
 5. Weight of copra

Table 6
Fruit component analysis data of Malayan Yellow Dwarf, Tall cultivars and the Malayan Yellow Dwarf female x Tall male hybrids reported from some countries

Country	Parents Hybrids	Fruit weight (g)	Percentage by weight				Weight of copra (g)
			Husked Nut Fruit	Kernel Nut	Shell Nut	Copra Nut	
Malaysia	MYD	634.0	65.0	54.0	20.0	26.0	108 (1)
Ivory Cost	MYD	806.1	69.0	60.0	16.0	30.0	166 (2)
Jamaica	MYD	1,100.0	62.0	49.0	22.0	27.0	185 (3)
Malaysia	MT	1,336.0	68.0	48.0	20.0	24.0	214 (1)
Ivory Cost	WAT	893.0	61.0	64.0	24.0	35.0	193 (2)
Jamaica	JT	1,700.0	43.0	50.0	29.0	31.0	227 (3)
Malaysia	MYD x MT	951.0	70.0	49.0	20.0	27.0	176 (1)
“	MYD x WAT*	946.0	61.0	55.0	28.0	34.0	199 (1)
“	MYD x RT**	982.0	71.0	51.0	19.0	27.0	191 (1)
Ivory Cost	MYD x WAT	1,060.0	67.0	57.0	19.0	32.0	226 (2)
Jamaica	MYD x JT	1,360.0	46.0	51.0	23.0	30.0	192 (4)
Indonesia	MYD x WAT	1,108.0	68.0	47.0	22.0	28.0	201 (5)

* WAT pollen imported from Ivory Coast

** RT pollen imported from New Hebrides

MYD - Malayan Yellow Dwarf

MT - Malayan Tall

WAT - West African Tall

RT - Rennell Tall

JT - Jamaican Tall

Reference :

1. Chan (1979)
2. Fremond and de Nuce de Lamonthe (1971)
3. Harries (1971)
4. Anonymous (1971)
5. Taniputra (1978)

Table 7 Percentage share of different components of husked nut to the total in the different hybrids and their parents reported from the three countries Ivory Coast, Malaysia and Jamaica.					
Parent / Hybrids	Wt. of husked nut (g)	Husked Nut Fruit %	Wt. and percentage weight (in parenthesis) of		
			Nut Water	Kernel	Shell
Ivory Coast					
Malayan Yellow Dwarf (Female)	564	63	141 (25%)	333 (50%)	91 (16%)
Malayan Yellow Dwarf (Female) x West African Tall (Male)	713	67	175 (24%)	405 (57%)	133 (19%)
Increased Weight of the hybrid over female parent	+149	+4	+34 (22%)	+72 (48%)	+43 (30%)
West African Tall (male)	133 (25%)	544	61	66 (12%)	345 (63%)
Malayan Yellow Dwarf (Female) x West African Tall (Male)	713	67	175 (24%)	405 (57%)	133 (19%)
Increased weight of the hybrid over male parent	+169	+6	+109 (65%)	+60 (35%)	0
Malaysia					
Malayan Yellow Dwarf (Female)	413	65	108 (26%)	224 (54%)	81 (20%)
Malayan Yellow Dwarf (Female) x Malayan Tall (Male)	664	70	205 (30%)	326 (50%)	133 (20%)
Increase Weight of the hybrid over the female parent	+251	+5	+97 (39%)	+102 (41%)	+52 (20%)
Malayan Tall (Male)	902	68	282 (32%)	437 (48%)	183 (20%)
Malayan Yellow Dwarf (Female) x Malayan Tall (Male)	664	70	205 (30%)	328 (50%)	133 (20%)
Decreased Weight of the hybrid over the male parent	-258	+2	-77 (-32%)	-111 (-47%)	-50 (21%)
Jamaica					
Malayan Yellow Dwarf (Female)	681	62	196 (29%)	334 (49%)	151 (22%)
Malayan Yellow Dwarf (Female) x Jamaica Tall (Male)	626	46	164 (26%)	318 (50%)	144(23%)
Decreased weight of the hybrid over the male parent	-55	-16	-32 (-58%)	-16 (-29%)	-7 (-13%)
Jamaica Tall (Male)	731	43	154 (21%)	365 (50%)	212 (29%)
Malayan Yellow Dwarf (Female) x Jamaica Tall (Male)	626	46	164 (26%)	318 (50%)	144 (23%)
Decreased weight of the hybrid over the male parent	-105	+3	+10 (+10%)	-47 (-45%)	-68 (-65%)

Table 8 Fruit component analysis data of Malayan Yellow Dwarf reported from Ivory Coast and that of the nuts of selected Malayan Yellow Dwarf Palms pollinated with the pollen of selected West African Tall Palms received from Ivory Coast indicating xenia effect in the combination.									
Nuts	Fruit weight	Husked nut weight	H.N. Fruit	Kernel Weight	$\frac{K}{N}$	Water Weight	$\frac{W}{N}$	Shell Weight	$\frac{S}{N}$
	(g)	(g)		(g)		(g)		(g)	
MYD	806	558	69	333	60	14	25	90	16
MYD nuts Pollinated with WAT pollen	772	572	74	358	63	113	20	101	18
				Copra weight (g)	$\frac{C}{N}$				
				166	30				
				198	35				

References:

Fremont and de Nuce de Lamothe (1971)
(Unpublished)