UNIVERSITI PUTRA MALAYSIA

GENETIC STUDIES IN SOME OIL PALM BREEDING POPULATIONS IN MALAYSIA

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GENETIC STUDIES IN SOME OIL PALM BREEDING POPULATIONS IN MALAYSIA

by

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ABSTRACT

Five oil palm breeding populations were studied for heritability, phenotypic correlations, path coefficient analysis and yield performances involving oil yield, number of bunches, single bunch weight, percentage fruit-to-bunch, percentage mesocarp-to-fruit and percentage oil-to-wet mesocarp. The breeding populations consisted of different families of Deli Duras, Teneras and Pisiferas grown at Banting between 1968 and 1970.

Two methods, namely, parent offspring regression and combined (genotype x year) analyses were used to estimate heritabilities. Heritabilities using combined analysis were larger than those estimated using parent offspring regression. However, both methods showed that heritabilities for total bunch weight were lower than those of its component characters.

The correlation studies for oil yield and its components showed wide variation in association in both magnitude and direction. Nevertheless, number of bunches and single bunch weight negatively and significantly correlated in four of the five populations studied.

Re-examination of the correlation coefficients by path coefficient analyses indicated that number of bunches contributed significantly to oil yield in Population A. Single bunch weight and percentage fruit-to-bunch contributed significantly to oil yield in Population B. Contributions of the component characters to oil yield in Populations C, D and E were not significant.

The yield performance of the various progenies were generally good with high possibility of selecting promising genotypes from all the populations studied. The following promising Deli *Duras* were found in Populations A, C and E: UR 410/9, UR 427/28, UR 422/15, UR 444/10, BM 163/36, BM 1/42, BM 1/8, BM 1/175, BM 176/49 and BM 176/24. The promising *Pisifera* lines were BM 119/18, BM 119/16, BM 215/4, BM 390/10, BM 384/2 and BM 390/16. Nine promising Deli *Dura* progenies were identified in Population B and three *Tenera* progenies in Population D for selection and further testing.

TABLE OF CONTENTS

		Page
ACKNOWLEDGEMENTS	... ...	ii
ABSTRACT	... ...	iii
TABLE OF CONTENTS	... ...	v
LIST OF TABLES	... ...	x
LIST OF FIGURES	... ...	xi
CHAPTER I :	INTRODUCTION	1
CHAPTER II :	LITERATURE REVIEW ...	5
	2.1 Oil Palm Breeding Populations	5
	2.2 Exchange Programme	8
	2.3 Variations In The Oil Yield And Its Components	11
	2.4 Heritability Studies	15
	2.4.1 Heritability Studies Using Parent-Offspring Regression	16
	2.4.2 Heritability Studies Using Different Mating Systems	19
	2.4.3 Heritability Studies Using Combined (genotype-environment) Analysis	26
	2.5 Correlation Coefficients	28
	2.6 Path Coefficient Analysis	30
	2.7 Breeding And Selection Methods In Oil Palm	31

			Page
CHAPTER III	:	MATERIALS AND METHODS ...	36
		3.1 Plant Materials	36
		3.2 Characters Studied	40
		3.3 Statistical Analyses	42
		3.3.1 Analyses of Variance	42
		3.3.2 Components of Variance Analysis	42
		3.3.3 Inheritance Studies	43
		3.3.3.1 Heritability Estimates Using Components Of Variance	43
		3.3.3.2 Heritability Estimates Using Parent/Offspring Regression	43
		3.3.4 Correlation Coefficients	44
		3.3.5 Path Coefficient Analysis	44
CHAPTER IV	:	RESULTS	47
		4.1 Variability in The Breeding Populations	47
		4.2 Some Genetic Parameters Based on The Variability in The Breeding Populations	51
		4.3 Performance of The Progenies in The Breeding Populations	52
		4.3.1 Mean Squares For Oil Yield And Its Components	52
		4.3.2 Performance of The Breeding Lines	55

CHAPTER IV (Cont'd) Page

4.4 Correlation Studies 69

4.4.1 Phenotypic Correlations Between Oil Yield and Its Components For All The Populations 69

4.4.2 Phenotypic, Genotypic and Environmental Correlations For Oil Yield, Total Bunch Weight, Single Bunch Weight and Number of Bunches 72

4.5 Path Coefficient Analysis For Five Component Characters and Oil Yield in All The Populations 75

4.6 Inheritance Studies 85

4.6.1 Estimation of Heritability By The Parent-Offspring Regression Analysis 85

4.6.2 Estimation of Heritability By Combined Analysis of Variance 87

CHAPTER V : DISCUSSION 94

5.1 Variability and Inheritance of Oil Yield Characters in The Breeding Populations 94

5.2 Relative Association and Contribution of The Component Characters to Oil Yield 99

5.3 Yield Performance of The Parent Palms and Progenies in The Breeding Populations 102

			Page
REFERENCES		... ...	106
APPENDIX 1a	:	FRUIT AND BUNCH QUALITY DATA FOR PROGENIES OF POPULATION A (1976-77 MEAN)	113
" 1b	:	FRUIT AND BUNCH QUALITY DATA FOR PROGENIES OF POPULATION B (1975-76 MEAN)	114
" 1c	:	FRUIT AND BUNCH QUALITY DATA FOR PROGENIES OF POPULATION C (1976-77 MEAN)	115
" 1d	:	FRUIT AND BUNCH QUALITY DATA FOR PROGENIES OF POPULATION D (1974-75 MEAN)	117
" 1e	:	FRUIT AND BUNCH QUALITY DATA FOR PROGENIES OF POPULATION E (1975 DATA)	118
APPENDIX II	:	FORM OF COMBINED ANALYSIS OF VARIANCE	119
APPENDIX III	:	FORMS OF ANALYSIS OF VARIANCE AND COVARIANCE	121
APPENDIX IVa	:	MEAN SQUARE VALUES FOR COMBINED (PROGENY x YEAR) ANALYSES OF VARIANCE IN POPULATION A	123
" IVb	:	MEAN SQUARE VALUES FOR COMBINED (PROGENY x YEAR) ANALYSES OF VARIANCE IN POPULATION B	124
" IVc	:	MEAN SQUARE VALUES FOR COMBINED (PROGENY x YEAR) ANALYSES OF VARIANCE IN POPULATION C	125
" IVd	:	MEAN SQUARE VALUES FOR COMBINED (PROGENY x YEAR) ANALYSES OF VARIANCE IN POPULATION D	126
" IVe	:	MEAN SQUARE VALUES FOR COMBINED (PROGENY x YEAR) ANALYSES OF VARIANCE IN POPULATION E	127

			Page
APPENDIX V	:	MEAN SQUARE VALUES FOR OIL YIELD, TOTAL BUNCH WEIGHT, SINGLE BUNCH WEIGHT AND NUMBER OF BUNCHES	128
APPENDIX VIa	:	PHENOTYPIC AND GENOTYPIC VARIANCES AND COVARIANCES IN POPULATION A	129
" VIb	:	PHENOTYPIC AND GENOTYPIC VARIANCES AND COVARIANCES IN POPULATION B	129
" VIc	:	PHENOTYPIC AND GENOTYPIC VARIANCES AND COVARIANCES IN POPULATION C	130
" VId	:	PHENOTYPIC AND GENOTYPIC VARIANCES AND COVARIANCES IN POPULATION D	130
" VIe	:	PHENOTYPIC AND GENOTYPIC VARIANCES AND COVARIANCES IN POPULATION E	131

LIST OF TABLES

TABLE			Page
2.1	:	HERITABILITY ESTIMATES: PARENT-OFFSPRING REGRESSION	17
3.1	:	GENERAL INFORMATION ON THE FIVE BREEDING POPULATIONS	37
4.1	:	CHANGES IN THE POPULATION MEANS AND COEFFICIENT OF VARIATION (CV) IN THE BREEDING POPULATIONS	50
4.2	:	SOME GENETIC PARAMETERS FOR TOTAL BUNCH WEIGHT, SINGLE BUNCH WEIGHT AND NUMBER OF BUNCHES	53
4.3	:	MEAN PERFORMANCE OF THE DURA AND PISIFERA LINES AND THEIR PROGENIES IN POPULATION A	57
4.4a	:	MEAN PERFORMANCE OF DURA x DURA PROGENIES IN POPULATION B	60
4.4b	:	MEAN PERFORMANCE OF PROGENIES INVOLVING SELECTIONS FROM BM 8 AND BM 20 FAMILIES	62
4.5a	:	MEAN PERFORMANCE OF DURA AND PISIFERA LINES AND THEIR PROGENIES IN POPULATION C	63
4.5b	:	MEAN PERFORMANCE OF DURA AND PISIFERA LINES IN POPULATION C	64
4.6	:	MEAN PERFORMANCE OF TENERA x TENERA PROGENIES IN POPULATION D	66
4.7	:	MEAN PERFORMANCE OF DURA AND PISIFERA LINES AND THEIR PROGENIES IN POPULATION E	68
4.8	:	PHENOTYPIC CORRELATION COEFFICIENT OF OIL YIELD AND ITS COMPONENTS	70
4.9	:	PHENOTYPIC, GENOTYPIC AND ENVIRONMENTAL CORRELATIONS FOR OIL YIELD AND ITS COMPONENTS: (ALL POPULATIONS)	74

TABLE			Page
4.10	:	PATH COEFFICIENT ANALYSES FOR DIRECT AND INDIRECT EFFECTS OF FIVE CHARACTERS IN OIL YIELD (POPULATION A)	76
4.11	:	PATH COEFFICIENT ANALYSES SHOWING THE DIRECT AND INDIRECT EFFECTS OF FIVE CHARACTERS ON OIL YIELD (POPULATION B)	78
4.12	:	PATH COEFFICIENT ANALYSES SHOWING DIRECT AND INDIRECT EFFECTS OF FIVE CHARACTERS ON OIL YIELD (POPULATION C)	80
4.13	:	PATH COEFFICIENT ANALYSES SHOWING DIRECT AND INDIRECT EFFECTS OF FIVE CHARACTERS ON OIL YIELD (POPULATION D)	82
4.14	:	PATH COEFFICIENT ANALYSES SHOWING DIRECT AND INDIRECT EFFECTS OF FIVE CHARACTERS ON OIL YIELD (POPULATION E)	84
4.15	:	ESTIMATES OF HERITABILITY FOR VARIOUS CHARACTERS IN FOUR POPULATIONS OF OIL PALM USING THE PARENT-OFFSPRING REGRESSION METHOD	86
4.16a	:	ESTIMATES OF VARIANCE COMPONENTS AND HERITABILITY : POPULATION A	88
4.16b	:	ESTIMATES OF VARIANCE COMPONENTS AND HERITABILITY : POPULATION B	89
4.16c	:	ESTIMATES OF VARIANCE COMPONENTS AND HERITABILITY: POPULATION C	90
4.16d	:	ESTIMATES OF VARIANCE COMPONENTS AND HERITABILITY : POPULATION D	91
4.16e	:	ESTIMATES OF VARIANCE COMPONENTS AND HERITABILITY : POPULATION E	92
FIGURE I	:	PATH DIAGRAM SHOWING FACTORS INFLUENCING OIL YIELD IN OIL PALM	46

CHAPTER I

INTRODUCTION

Oil palm is an important source of vegetable oil, highly in demand for culinary and industrial purposes. The contribution of palm oil to the world's oils and fats output is increasing rapidly. In 1960, the world palm oil production was only 1.3 million metric tons making up 4.7 percent of the total production of the world's edible oils and fats, but in 1977, the world palm oil production increased to 3.6 million metric tons taking 6.7 percent of the total vegetable oil production (I.T.C. 1978).

The oil palm industry contributes significantly in various ways to the national economy and to the welfare of the people of the producing countries. Malaysia is currently the single largest world producer and exporter of palm oil; earning a substantial amount of hard currency needed to pay for essential imports. In 1971, Malaysia exported 0.5 million metric tons of palm oil valued at $356.1 million. In 1977, the palm oil export increased to 1.5 million metric tons gaining $1,651 million in foreign exchange (I.T.C. 1978). In the past few years, the oil palm plantations in

Malaysia have been expanding to meet the high palm oil demand (Tam, 1976). Hence, it is of utmost importance to step up systematic research into the breeding and other improvement aspects to sustain the industry.

In the past, the breeding materials in most palm oil producing countries were phenotypically selected within the available populations of narrow genetic base. Later, more comprehensive breeding programmes were initiated by the Institut National pour l'Etude Agronomique du Congo Belge (INEAC) in Zaire in 1950 (Hardon, 1976), by the Nigerian Institute For Oil Palm Research (NIFOR) in 1957 (Sparnaaij *et al*, 1963), by Institut de Recherches pour les Huiles et Oleagineux (IRHO) in Ivory Coast in 1957 and by the various oil palm research stations [such as Chemara Research Station (CRS) and Oil Palm Research Station (OPRS)] in Malaysia around 1950 (Hardon and Thomas, 1968).

Preliminary results of some of these programmes established the superiority of the *Tenera* hybrids from crosses between *Dura* (D) as female and *Pisifera* (P) as male, for commercial palm oil production. Due to some success in this approach, the objective of modern oil palm breeding has been to develop through breeding and selection improved *Duras* and *Pisiferas* which are artificially pollinated to produce D x P (_Tenera_) planting materials with high oil production potential. Towards this end, and in order to increase the genetic variability of the breeding materials, oil palm breeders have introduced the necessary parent stocks of _Dura_, _Tenera_ and _Pisifera_ materials from oil palm breeding stations in Nigeria, Malaysia, Ivory Coast, Angola and Zaire. Selected palms from these stocks are crossed in various combinations to create _Dura_ x _Dura_, _Tenera_ x _Tenera_, _Dura_ x _Tenera_ and _Dura_ x _Pisifera_ progenies for evaluation and exploitation. Expected genetic progress and efficient selection, however, depend on the presence, magnitude and the identification of genetic variability in the important economic characters and the interrelationship of these characters. In addition, palm oil is made up of a number of measurable components, viz., number of bunches, single bunch weight, fruit-to-bunch ratio, mesocarp-to-fruit ratio and oil-to-wet mesocarp ratio. However, there are differences in the genetic variation of these component characters from population to population and various environments may cause differences in phenotypic variation in the components and the final yield. Consequently, it is desirable to evaluate the relative effects of these characters on the oil yield in the various populations under different environments in order to estimate heritabilities of the characters.

The objectives of the present studies are, therefore, to examine the oil yield and its components of five oil palm breeding populations in Malaysia with respect to the progeny and population means, heritabilities and correlation coefficients. These genetic parameters are discussed in relation to the various yield characters of the parent breeding lines and their progenies in the light of selection for improved oil yield. It is hoped that the findings may be used to improve the breeding methods of oil palm.

CHAPTER II

LITERATURE REVIEW

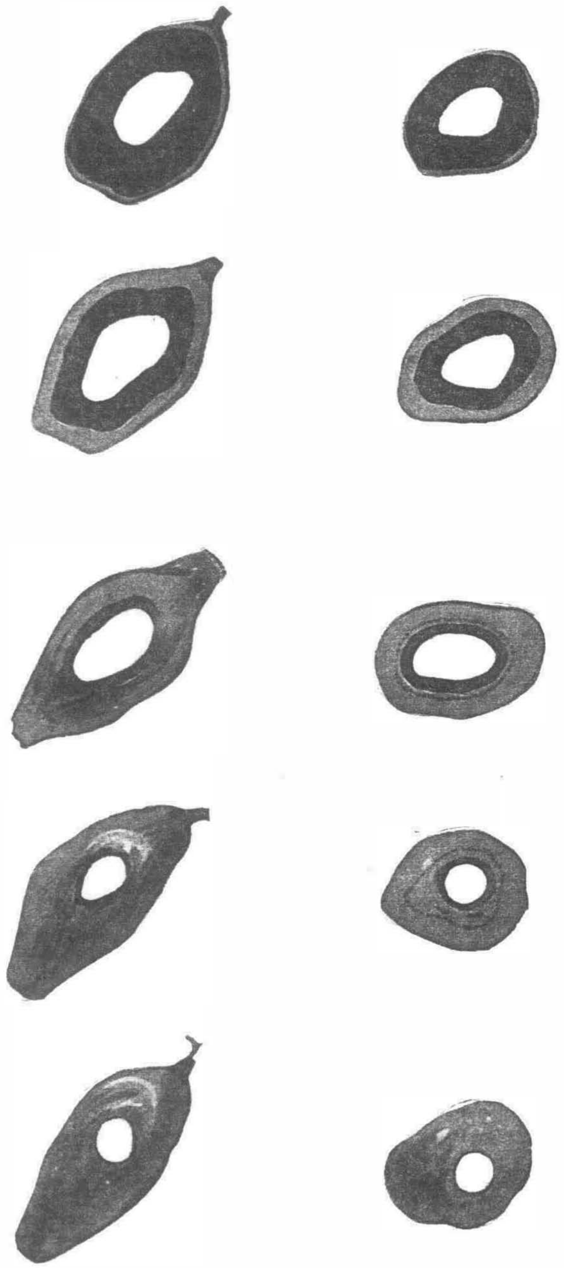
2.1 Oil Palm Breeding Populations

The oil palm (*Elaeis guineensis Jacquin*) is native to West and Central Africa from where introductions have been made to other parts of the tropics (Zeven, 1967). Oil palm was introduced to South East Asia, as four ornamental palms and planted in the Bogor Botanical Gardens (Indonesia) in 1848 (Jagoe, 1952). Hartley (1967) tracing the development of oil palm plantations in Africa and South East Asia noted that the first oil palm plantations were established in Sumatra in 1911 and in Zaire in 1920. Other countries like Malaysia, Nigeria, Ivory Coast, Republic of Benin, and Ghana followed later with plantations of various sizes.

In the past, unsystematic phenotypic mass selections were made from the natural palm groves in Africa and the ornamental avenue palms in South East Asia, to establish the early commercial plantations. However later, it was discovered that oil palm breeding populations were made of the three basic fruit forms, *Dura*, *Tenera* and *Pisifera*. These fruit forms are distinguished by the variation in their shell thickness. The *Dura* fruit form has a thick shell; the *Tenera* has a thin shell with a characteristic fibre ring around the shell; and the *Pisifera* is shell-less.

The approach to oil palm breeding to establish the early plantations differed in Africa and South East Asia, because of the differences in the available basic breeding materials. In Zaire, the breeding objective of the Institut National pour l'Etude Agronomique du Congo Belge (INEAC) was to develop good *Tenera* fruit form palms only, since the *Dura* palms were found to be of poor quality (Van der Vossen, 1974). Some of the *Teneras* developed from these programmes have contributed substantially to the improvement of bunch and fruit component characters of the materials in the breeding programmes in Ivory Coast, Indonesia and Malaysia (Hardon *et al*, 1976). In Nigeria, the *Dura* and *Tenera* fruit forms were of comparable quality and the materials of the two forms were developed simultaneously by the Nigerian Institute For Oil Palm Research (NIFOR). Consequently, the Nigerian *Dura* palms and/or Deli *Dura* palms (Bogor origin) are utilised as *Dura* mother palms in the NIFOR and Ghana's Oil Palm Research Centre, for the *Dura* x *Pisifera* (Tenera) seed production programmes

OIL PALM FRUIT FORMS



The principal "forms" of oil palm fruit, distinguished by their ***internal*** *appearance.*

(Sparnaaij *et al*, 1963; Van der Vossen, 1969; Hartley, 1977). In Malaysia, on the other hand, selections for the early plantations were limited to the Deli *Dura* populations of Bogor origin because they were the only available planting material at the time. Later, with the planting of *Dura* x *Pisifera* (*Tenera*) hybrids in the plantations, the Deli *Dura* palms remained the only source of *Dura* component of the hybrid in Malaysia and also in Ivory Coast seed production programmes (Hardon and Thomas, 1968; Hardon 1972). *Teneras* are preferred to *Duras* because they have relatively more oil bearing mesocarp tissues and therefore can produce more oil per bunch (Hardon, 1976). On the other hand, *Pisiferas* are not planted in commercial plantations because they are in most cases female sterile due to early abortion of the developing fruits.

Further prospections in the African oil palm groves and subsequent selections from the established plantations resulted in the development of a number of local breeding populations with characteristic features. But these populations have been conveniently grouped according to the thickness of the shell and the source of the material (Hardon and Thomas, 1968; Hartley, 1977). The *Dura* group is characterised by a small number of large bunches with thick shelled fruits. Those originating from the Bogor palms are known as Deli *Duras* and are identified in the breeding populations as ex-Serdang, ex-SOCFIN or ex-Guthrie etc. The Deli Duras (ex-SOCFIN) were selected in the breeding programme of the Societe Financiere de Caoutchoucs (SOCFIN) with characteristics of high yields, low sex-ratio (ratio of female to total inflorescence) and heavy bunches. In a separate selection programme, Guthrie Ltd, also created a distinct Deli Dura population (ex-Guthrie) with high yields and high sex-ratio (Sparnaaij et al, 1963). Those Duras developed in the African breeding programmes are identified as Duras from the Cameroons, Angola, Dabou, or NIFOR (Aba, Calabar or Ufuma) Van der Vossen, 1978; Sparnaaij et al, 1963; Meunier and Gascon, 1972). The Tenera and Pisifera populations constitute the other group which is characterised by a large number of small bunches. Some of the breeding materials identified under this group are conveniently referred to as coming from the following sources: Yangambi, Sibiti, La Me, Pobe, Yocoboue, AVROS, Angola and NIFOR. (Meunier and Gascon, 1972; Van der Vossen, 1974; Hardon et al, 1976; Hartley, 1977).

2.2 Exchange Programme

As breeding and selection in oil palm advanced, the need for international and national co-operative efforts became necessary. Thus, between 1945 and 1973, extensive Joint International Exchange Programmes and National Co-operative Breeding Schemes were organised to exchange information and the various locally developed breeding materials. In 1946, on the initiative of the Institut de Recherches pour les Huiles at Oleagineux (IRHO), an international breeding project known as the "International Experiment" was inaugurated. Five oil palm breeding countries, namely, Zaire (INEAC), Malaysia (SOCFIN), Ivory Coast (IRHO), Republic of Benin (IRHO) and Congo (Brazzaville) participated in this international breeding project (Haddon and Tong, 1959).

Within Malaysia, the Ministry of Agriculture initiated a Co-operative Breeding Scheme in 1956 to avail itself of land from the participating estates to redistribute promising Deli _Dura_ breeding materials. The participants were, Harrisons and Crosfield Sdn. Bhd., Kumpulan Guthrie Sdn. Bhd., SOCFIN and United Plantations Ltd. The scheme was extended to include comparative studies in the "Dumpy" and _Tenera/Pisifera_ populations too (Haddon and Tong, 1959). Between 1963 and 1972, four private oil palm producing companies in Malaysia, namely, Dunlop Estate Bhd., Kumpulan Guthrie Sdn. Bhd., Harrisons and Crosfield Sdn. Bhd., and Unilever Ltd., contributed to organise an Oil Palm Genetic Laboratory (OPGL) to encourage "the development of a fundamental basis for oil palm research in South East Asia" (Corley _et al_, 1976).

In addition to the various multilateral exchange programmes, many oil palm breeding organisations have been involved in bilateral exchange programmes too. A special exchange programme started in 1970 between the Oil Palm Research Centre (OPRC) in Ghana and the Chemara Research Station in Malaysia. Some *Tenera* x *Tenera* seeds, *Tenera* pollen and *Dura* x *Pisifera* seeds were specially bred and exchanged with a quantity of Malaysian Deli *Dura* x Deli *Dura* seeds and pollen. (OPRC: Ghana Annual Report, 1970). In 1973, Nigerian Institute For Oil Palm Research (NIFOR) and Malaysian Agricultural Research and Development Institute (MARDI) organised a joint prospection to Eastern Nigeria oil palm groves to obtain new genetic materials and to conserve them for future breeding work. The genetic materials collected have been duplicated and grown in replicated trials and progeny blocks in Nigeria and Malaysia (Arasu and Rajanaidu, 1977). The objectives of the various prospections and subsequent exchange and crossing programmes have been to create genetic variation in the oil palm breeding populations for further improvement. Through active participation in the various exchange programmes, Kumpulan Guthrie Sdn. Bhd., and Harrisons and Crosfield Sdn. Bhd., have acquired and established a wide range of variable oil palm genetic materials for evaluation and exploitation.

2.3 Variations In The Oil Yield And Its Components

Oil yield is a product of component characters, namely, number of bunches, single bunch weight, percentage fruit-to-bunch, percentage mesocarp-to-fruit and percentage oil-to-wet mesocarp. Studies have shown that wide variations exist for these characters with respect to the individual palms, progenies and fruit forms (Sparnaaij, 1969; Hartley, 1977). The observed variations are reported to be partly genetic and partly environmental (Blaak, 1965; Sparnaaij, 1969). Progress in improving these characters would be influenced by the relative magnitude of the genetic and non-genetic components of the total variation of each of the characters and their interrelationships.

Due to the large spacing requirement and the soil heterogeneity encountered in oil palm growing areas, the greater part of the variation in the bunch yield per palm is environmental (Sparnaaij, 1969). In view of this situation it has been recommended to use progeny data to study genetic variation in oil palm instead of individual palm data. A well-planted