UNIVERSITI PUTRA MALAYSIA

GENETIC PERFORMANCE OF OIL PALM (*Elaeis guineensis Jacq.*) PROGENIES FROM DIFFERENT *DURA* SOURCES IN CROSSES WITH AVROS *PISIFERA*

NOH BIN AHMAD

FP 2007 16

GENETIC PERFORMANCE OF OIL PALM (*Elaeis guineensis Jacq.*) PROGENIES FROM DIFFERENT *DURA* SOURCES IN CROSSES WITH AVROS *PISIFERA*

NOH BIN AHMAD

MASTER OF SCIENCE
UNIVERSITI PUTRA MALAYSIA
2007

GENETIC PERFORMANCE OF OIL PALM (*Elaeis guineensis Jacq.*) PROGENIES FROM DIFFERENT *DURA* SOURCES IN CROSSES WITH AVROS *PISIFERA*

by

NOH BIN AHMAD

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

June 2007

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

GENETIC PERFORMANCE OF OIL PALM (*Elaeis guineensis Jacq.*) PROGENIES FROM DIFFERENT DURA SOURCES IN CROSSES WITH AVROS PISIFERA

By

NOH BIN AHMAD

June 2007

Chairman: Assoc. Prof. Mohd. Rafii bin Yusop, PhD

Faculty: Agriculture

A total of 40 oil palm (*Elaeis guineensis* Jacq.) *Dura x Pisifera* (DxP) progenies derived from the North Carolina Mating Design 1 (NCM1) were evaluated at the MPOB Research Station, Keratong, Pahang in inland soils predominantly of Serdang Series. The *Dura* sources in this study originated from the Sabah Breeding Programme (SBP) and were crossed with male parents of AVROS *Pisifera* materials, the descendant of BM119 of Oil Palm Research Station (OPRS) (now Golden Hope), Banting, Selangor. They were laid down in a Randomised Complete Block Design (RCBD) with three replicates, with 16 palms/progeny/replicate in 1994. The materials were evaluated for bunch yield, bunch quality and vegetative traits. The objectives of the study were to evaluate the performance of different *Dura* sources for bunch yield, bunch quality components and vegetative traits, to estimate genetic variability and heritability, and to assess the phenotypic correlation among the traits. Potential genotypes with high yield were selected for breeding and seed production. Analysis of variance (ANOVA) showed that the *Dura* sources were not significantly different for bunch yield and yield components, indicating the lack of genetic variability for these

characters. However, ANOVA showed greater variability in the bunch quality components of the *Dura* sources such as mesocarp to fruit ratio (M/F), shell to fruit ratio (S/F), kernel to fruit ratio (K/F) and kernel yield (KY). Significant differences among the *Dura* sources were also observed in the vegetative traits *viz* petiole cross-section (PCS), rachis length (RL) and leaflet number (LN). The results indicate that there was still genetic variability among the *Dura* sources for those traits, even though the materials had undergone many cycles of selection. Three *Dura* sources DS1 (Banting x Banting), DS2 (Elmina x Elmina) and DS4 (H.Est x H.Est) were identified to be good candidates for further breeding and seed production with FFB yield of more than 130 kg/p/yr and oil yield (OY) of more than 31 kg/p/yr or more than 4.5 tons/ha/yr. ANOVA showed that the *Pisifera* item in the half-sib families was not significant for most of the traits studied except fruit to bunch ratio (F/B), kernel to bunch ratio (K/B), kernel yield (KY), leaflet length (LL), leaf area (LA) and leaf area index (LAI). This was expected as the AVROS *Pisiferas* used as males were derived from a small population and they were highly inbred. However, greater variation was observed in the *dura within pisifera* item. Heritability estimates for bunch yield and its components were generally low, with h_p^2 of 0-14% and h_d^2 of 3-32%. Higher estimates were observed in some of the bunch quality components with h_p^2 of 0-36% and h_d^2 of 0-64%. Generally, vegetative characters had high heritability values, with h_p^2 of 0-45% and h_d^2 of 9-72%. Phenotypic correlations among the bunch yield components indicate that there exist strong and positive correlation between fresh fruit bunch (FFB) and bunch number (BNO), thus selecting for one character will also improve the other. However, there was also strong negative correlation between BNO and average bunch weight (ABW), indicating that increasing ABW would decrease the BNO and vice versa. This can be an obstacle in the effort to increase bunch yield as the traits cannot be improved simultaneously in the same palm. In this study, it was noted that high FFB yield can be obtained through high BNO and medium ABW. Correlations among bunch quality components and vegetative characters were also observed in this study. Oil yield (OY) correlated positively with bunch yield and its components and also with trunk height (HT). Selecting palms for high OY would also select for vigorous growing palm. Reasonably good general combining ability (GCA) for FFB was observed in three *Pisiferas*, P1 (0.174/211), P3 (0.174/498) and P11 (0.12/308). For oil to bunch (O/B), the good combiners were P1 (0.174/211), P10 (0.182/305) and P11 (0.12/308). The good combiners for vegetative traits were P6 (0.182/30), P8 (0.182/230) and P9 (0.182/297). For breeding, selection for good combiners can be considered for a single trait or in combination with the others. For instance, P1 (0.174/211) and P11 (0.12/308) were good candidates in selecting for *Pisiferas* with good GCA for FFB yield and oil to bunch O/B but high GCA values for vegetative characters. *Pisiferas* P6 (0.182/30), P8 (0.182/230) and P9 (0.182/297) were the right choice to select for less vigorous growing palms since they have good GCA values for lower trunk height (HT), lower trunk diameter (DIA), small petiole cross-section (PCS) and short rachis length (RL). The advantages of having palms with these characters are that they can be planted in higher density and may also increase yield per hectare. The low variability in the materials can be overcome through introgression with other materials. Malaysian Palm Oil Board (MPOB) is actively involved in introgressing newly selected oil palm materials prospected from Africa with the Deli *Dura* and AVROS *Pisiferas* to broaden the genetic base. The oil palm germplasm from Nigeria, Cameroon and Zaire after undergoing systematic evaluation and selection were being used to introgress with Deli *Dura* and AVROS *Pisifera* as part of the improvement programme. The progenies of the materials were evaluated in a number of field trials in various MPOB Research

Stations. It is expected that these materials will be able to contribute to the progress and advancement of the oil palm industry in the future.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PRESTASI GENETIK PROGENI KELAPA SAWIT (*Elaeis guineensis Jacq.*) DARI SUMBER DURA YANG BERBEZA DIKACUKKAN DENGAN *PISIFERA AVROS*

Oleh

NOH BIN AHMAD

Jun 2007`

Pengerusi: **Prof. Madya Mohd. Rafii bin Yusop, PhD**

Fakulti: **Pertanian**

Sejumlah 40 progeni *Dura* x *Pisifera* (DXP) yang dihasilkan melalui kacukan North Carolina Mating Design 1 (NCMI) telah di tanam di tanah bersiri Serdang di Stesen Penyelidikan MPOB Keratong, Pahang pada 1994. Sumber *Dura* yang digunakan sebagai induk betina didalam kajian ini berasal dari Sabah Breeding Programme (SBP) manakala induk jantan (AVROS *Pisifera*) pula dari keturunan BM119, Oil Palm Research Station (OPRS) (sekarang dikenali sebagai Golden Hope). Rekabentuk percubaan yang digunakan ialah rekabentuk blok rawak lengkap (RCBD) menggunakan tiga replikasi dengan 16 pokok/progeni/replikasi. Objektif khusus kajian ini adalah untuk menilai pencapaian bahan tanaman tersebut dari segi hasil tandan, komposisi mutu tandan dan ciri vegetatif. Kajian ini juga bertujuan untuk menganggar kebolehwarisan dan korelasi fenotip antara ciri-cirinya disamping mengenalpasti genotif tertentu untuk tujuan pembiakbakaan dan pengeluaran bijibenih. Analisis varians (ANOVA) menunjukkan tiada perbezaan bererti bagi sumber *Dura* untuk hasil berat tandan segar (FFB) dan komponen hasilnya iaitu purata berat tandan (ABW) dan bilangan tandan (BNO). Keputusan ini juga menunjukkan tiada variasi di dalam ciri-ciri tersebut. Walau bagaimana pun terdapat perbezaan bererti untuk ciri-ciri komponen

tandan seperti nisbah mesokarpa ke buah (M/F), nisbah tempurung ke buah (S/F) dan hasil isirong (KY). Perbezaan bererti juga dikesan diantara sumber *Dura* untuk ciri-ciri vegetatif seperti keratan rentas petiol (PCS), panjang rachis (RL) dan bilangan lai daun (LN). Keputusan ini juga menunjukkan masih terdapat variasi untuk ciri-ciri yang dikaji walaupun sumber *Dura* tersebut telah melalui beberapa pusingan pemilihan yang menyebabkan variasinya makin berkurangan. Tiga sumber *Dura* DS1 (Banting x Banting), DS2 (Elmina x Elmina) and DS4 (H.Est x H.Est) telah dikenalpasti sebagai calon yang baik untuk pembiakbakaan dan pengeluaran bijibenih. Ketiga-tiga sumber Dura tersebut menghasilkan BTS melebihi 130 kg/pokok/tahun dan hasil minyak (OY) melebihi 31 kg/pk/tahun atau 4.5 tan/ha/tahun. Analisis varians (ANOVA) juga mendapati tiada perbezaan bererti untuk *Pisifera* AVROS yang digunakan sebagai induk jantan didalam famili 'half-sib' kecuali nisbah buah ke tandan (F/B), nisbah isirong ke tandan, hasil isirong (KY), panjang lai daun (LL), luas daun (LA) dan indeks keluasan daun (LAI). Keputusan ini adalah dijangkakan kerana *Pisifera* AVROS yang digunakan didalam kajian ini diperolehi dari populasi yang kecil dan telah melalui beberapa pusingan penginbredan dan menyebabkan variasi didalam ciri-ciri yang dikaji semakin berkurangan. Walau bagaimana pun, analisis varian (ANOVA) menunjukkan terdapat lebih variasi untuk komponen *Dura*-dalam-*Pisifera* berbanding *pisifera*. Secara umumnya anggaran heritabiliti untuk hasil tandan dan komponennya adalah rendah, h_p^2 (0-4%) dan h_d^2 (3-32%). Anggaran heritability yang lebih tinggi dicerap disesetengah cirri mutu tandan, h_p^2(0-36%) dan h_d^2 (0-64%). Ciri vegetatif merekodkan anggaran heritabiliti tertinggi dengan h_p^2 (0-45%) dan h_d^2 (9-72%). Korelasi fenotif diantara hasil tandan dan komponennya menunjukkan terdapat korelasi positif yang kuat diantara FFB dengan BNO, memberikan implikasi bahawa memilih salah satu ciri akan secara automatik memilih yang lain. Walau bagaimana pun, terdapat korelasi negatif yang kuat diantara BNO and ABW, yang boleh menjadi penghalang di dalam usaha meningkatkan hasil tandan. Memilih untuk meningkatnya ABW akan mengurangkan BNO dan disebalik. Di dalam kajian ini didapati untuk mendapatkan hasil tandan yang tinggi ialah melalui BNO yang tinggi dengan ABW yang sederhana. Selain dari itu terdapat juga korelasi antara komponen mutu tandan dan ciri vegetatif. Hasil minyak (OY) didapati berkorelasi positif dengan hasil tandan dan ketinggian batang pokok. Keputusan ini mencadangkan memilih hasil yang tinggi secara tidak langsung akan juga memilih pokok yang cepat membesar. Tiga *pisifera* P1 (0.174/211), P3 (0.174/498) dan P11 (0.12/308) telah menunjukkan keupayaan bergabung (GCA) yang baik untuk hasil tandan (FFB) manakala *pisifera* P1 (0.174/211), P10 (0.182/305) dan P11 (0.12/308) untuk minyak/tandan (O/B). *Pisifera* P6 (0.182/30), P8 (0.182/230) dan P9 (0.182/297) pula telah dikenalpasti mempunyai GCA yang baik untuk ciri vegetatif. Untuk tujuan pembaikbakaan, ciri-ciri tersebut boleh dipilih secara berasingan atau bersama ciri-ciri yang lain. Sebagai contoh, *pisifera* P1 (0.174/211) dan P11 (0.12/308) merupakan calon terbaik untuk memilih induk jantan yang mempunyai keupayaan bergabung yang baik untuk ciri FFB dan O/B tetapi kurang sesuai untuk ciri-ciri vegetatif. *Pisifera* P6 (0.182/30), P8 (0.182/230) dan P9 (0.182/297) pula merupakan calon terbaik jika ingin memilih pokok-pokok yang lambat membesar kerana induk jantan berkenaan mempunyai GCA yang baik untuk ketinggian batang (HT) yang perlahan, keratan rentas petiole (PCS) yang kecil dan pelapah yang pendik (RL). Pokok renek boleh ditanam pada ketumpatan yang tinggi dan berupaya meningkatkan hasil sehektar. Kekurangan variabiliti bahan tersebut boleh diatasi melalui pengabungan dengan bahan yang lain. Lembaga Minyak Sawit Malaysia (MPOB) sedang bergiat secara aktif mengabungkan bahan germaplasma kelapa sawit yang terpilih dari Afrika dengan bahan AVROS dan Deli d*ura* untuk melebarkan dasar genetik bahan tersebut. Germplasma kelapa sawit dari Nigeria, Cameroon dan Zaire setelah melalui penilaian dan pemilihan yang sistematik telah digabungkan dengan Deli *Dura* dan AVROS *Pisifera* sebagai sebahagian dari program penambahbaikan bahan tanaman yang sedia ada. Progeni hasil gabungan tersebut telah ditanam dibeberapa Stesen Penyelidikan MPOB. Bahan tersebut diharapkan dapat menyumbang kepada kemajuan industri sawit di masa akan datang.

ACKNOWLEDGEMENT

I wish to express my sincere appreciations to my supervisors Assoc. Prof. Dr. Mohd Rafii Yusop, Prof. Dr. Ghizan Saleh and Dr. A. Kushairi Din for their guidance, criticism, encouragement and suggestions during the course of this study.

I am indebted to Director General, Deputy Director General, Director of Biology and Head of Advanced Biotechnology and Breeding Centre of MPOB for their involvement in granting me the study leave and their continuous advice and support.

My gratitude also goes to the breeding staff and workers at MPOB Keratong Station for assisting me in the data collections. My thanks also due to the data processing staff at MPOB Kluang for their help in the data analyses.

I would also like to express my deepest gratitude to my parents (the late Ahmad bin Husin and Puan Che Yah bte Said) and my brothers and sister.

Last but not least, my deepest love and affections to my wife (Pn. Hijah bte Mohamed) and my sons (Ahmad Mazni, Ahmad Tarmizi, Ahmad Sabri and Ahmad Nazri) for their continuous support and patience, without which the study would have not been successfully completed.

I certify that an Examination Committee has met on **16th June, 2007** to conduct the final examination of Mr. Noh bin Ahmad on his **Master of Science** thesis entitled **"GENETIC PERFORMANCE OF OIL PALM (*Elaeis guineensis Jacq.*) PROGENIES FROM DIFFERENT *DURA* SOURCES IN CROSSES WITH AVROS *PISIFERA*"** in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Zakaria Wahab, PhD
Associate Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Chairman)

Dato' Idris Abdol, PhD
Associate Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Internal Examiner)

Mohd Said Saad, PhD
Associate Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Internal Examiner)

Mohamad Osman, PhD
Associate Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(External Examiner)

____

HASANAH MOHD GHAZALI, PhD
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date :

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Mohd Rafii Yusop, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Ghizan Salleh, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

A.Kushairi Din, PhD
Malaysian Palm Oil Board (MPOB)
(Member)

AINI IDERIS, PhD
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date :

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or at other institutions.

____

NOH BIN AHMAD

DATE:

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

ABW	Average bunch weight
ASD	Agriculture Service and Development, Costa Rica
AVROS	Algemene Vereniging van Rubber-planters ten Oostkust van Sumatra (now known as Balai Penelitian Pekebun Medan)
BNO	Bunch number
BPRO	Breeding Populations of Restricted Origin
Cov	Covariance
df	Degree of freedom
DIA	Diameter
EMS	Expected mean squares
F/B	Fruit to bunch
FFB	Fresh fruit bunch
FP	Frond Production
GCA	General combining ability
GCV	Genotypic coefficient of variation
h^2_B	Broad-sense heritability
h^2_N	Narrow-sense heritability
HMPB	Harison Malaysia Plantations Berhad
HRU	Highlands Research Unit
HT	Trunk Height

K/B	Kernel to bunch
K/F	Kernel to fruit
kg/p/yr	Kilogram per palm per year
KY	Kernel yield
LA	Leaflet Area
LAI	Leaf Area Index
LL	Leaflet Length
LN	Leaflet Number
LW	Leaflet Width
M/F	Mesocarp to fruit
MARDI	Malaysia Agricultural Research and Development Institute
MPOB	Malaysian Palm Oil Board
MS	Mean squares
NCM 1	North Carolina Model 1
NIFOR	Nigerian Institute for Oil Palm Research
O/B	Oil to bunch
O/DM	Oil to dry mesocarp
O/WM	Oil to wet mesocarp
OPM	Oil Palm of Malaya
OPRS	Oil Palm Research Station, Banting, Selangor (Golden Hope Group)
OY	Oil yield
PCS	Petiole cross-section

PCV	Phenotypic coefficient of variation
PORIM	Palm Oil Reasearch Institute of Malaysia
PORLA	Palm Oil Registration and Licensing Authority
r	Correlation coefficient
RISPA	Research Institute of the Sumatran Planters Association
RL	Rachis Length
s.e	Standard error
S/F	Shell to fruit
Socfin	Societe Financiere de Cauotchouces
SPB	Sabah Breeding Program
TEP	Total economic product
UPB	United Plantations Berhad

CHAPTER 1

INTRODUCTION

The oil palm, *Elaeis guineensis* Jacq. is indigenious to the wild and semi wild groves of tropical West Africa, stretching from Senegal to Angola (Zeven, 1967). It was introduced to the Far East through Indonesia. The famous four Bogor Palms (planted in Bogor Botanical Garden, 1848) can be considered as the original source of the present oil palm planted in Indonesia and Malaysia. Descendants of these four palms have then spread throughout the world (Rajanaidu and Jalani, 1999).

Oil palm materials were imported into Malaysia through a number of sources including through Rantau Panjang, Kuala Selangor in 1911/12. Informal mass selection of these palms was carried out. These palms were found to be highly productive and bred true-to-type (Hartley, 1988). The seeds from these palms were later used to plant the first oil palm estates in Malaysia, Tenamaran Estate in 1917 followed by Elmina Estate in 1920. Informal and formal selection in Indonesia and Malaysia gave rise to an oil palm planting materials known as the "Deli *dura*". They were used as planting materials in Indonesia and Malaysia up to late 1950's (Rajanaidu, 1985). After the discovery of the monofactorial inheritance of the three fruit forms by Beirnaert and Vanderweyen (1941), the *tenera*s or DxP which is the hybrid between *dura* and *pisifera* was used as planting materials up till now. The thin-shelled *tenera*s are preferred to *dura*s since *tenera* fruits have more oil–bearing mesocarp (75-85% per fruit weight) than *dura*s (20-65% per fruit weight) (Kushairi and Rajanaidu, 2000).

The Deli type is still considered the best *dura* for breeding (Hartley, 1988). In view of its superiority over African *duras*, the dura parent worldwide is usually Deli *dura* (Kushairi and Rajanaidu, 2000). They produce fewer but heavier bunches as compared with those of *tenera*s and the African *dura*s (Hartley, 1988). Generally, fruits of the Deli *dura*s are darker coloured, larger and have high mesocarp content and higher oil to bunch compared to African *dura*s (Hartley, 1988).

The Department of Agriculture (DOA) of Malaysia initiated oil palm breeding programme in1920s. Later, other companies such as the Oil Palm of Malaya (OPM) of Kumpulan Guthrie Berhad, Socfin (Societe Financiere de Cauotchouces) started their own breeding programmes in 1933. Through their programmes, the Serdang Avenue, Elmina, Ulu Remis and Johore Labis breeding populations of restricted origin (BPRO) were formed (Rosenquist, 1985). The United Plantations Berhad (UPB) imported oil palm materials from Sumatra and Africa in 1927 and formally formed the United Plantation Research Department in 1964 (Sharma and Tan, 1999). The progress of oil palm breeding and selection in Malaysia was partly due to the joint research programme between research centers in Malaysia and Africa since 1950's (Hardon *et al.*, 1976). One of the programmes was the Sabah Breeding Programme (SBP). The programme was initiated by Hartley, a consultant to Sabah Government, with the objective to produce high yielding oil palm materials suitable for the Sabah agroclimatic conditions (Rajanaidu *et al.*,1985). The breeding materials for the programme were obtained through exchange scheme, organized between four Malaysian and three African participants. The Malaysian participants were Chemara, Harrison Malaysia Plantation Berhad (HMPB), Socfin and DOA. The West African participants were the Nigerian Institute for Oil Palm Research (formerly WAIFOR),