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Performance of Oil Palm (*Elaeis Guineensis* Jacq.) DxP Progenies from Different Agencies under Various Planting Densities

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Performance of Oil Palm (*Elaeis Guineensis* Jacq.) DxP Progenies from Different Agencies under Various Planting Densities

By

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

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Agricultural Science

Performance of Oil Palm (*Elaeis Guineensis* Jacq.) DxP Progenies from Different Agencies under Various Planting Densities

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Chairman: **Mohd Rafii Hj. Yusop, PhD**

Faculty: **Agriculture**

Fifteen *dura* x *pisifera* (DxP) bi-parental crosses from six Malaysian seed producers (agencies) were studied for yield, bunch quality, vegetative characters and physiological traits in four planting densities. Analysis of variance indicated significant differences among the fifteen progenies that were obtained from six agencies and planted under four planting densities. However, all the progenies and agencies were considered responding similarly across planting densities for all the 34 traits studied by showing no significant difference in genotype x planting density interaction, pooled over years. Broad-sense heritability estimates (h^2_B) using intra-class correlation varied between 13.3% and 47.6%. Generally, the genetic variations and heritability estimates were low, which may restrict further improvements of the parental stocks. On the other hand, uniform performance for yield is advantageous in commercial plantings. The difference in yield among progenies and among agencies reflected the different genetic background and selection pressure. The low genetic variability could be due to the narrow genetic base. The fresh fruit bunch (FFB) yield of the six agencies ranged from

18.41 to 21.46 t/ha/yr. The highest FFB yield in agency A2 was attributed to its high bunch number (BNO). Oil to bunch (O/B) varied from 25.93 to 28.21% with the latter extreme observed in agency A1. Heights (HT) of the 21-year old palms were between 8.97m and 10.02m with the height increment of between 47cm and 53cm among agencies, while the HT among densities were between 8.73m and 10.43m with the height increment of between 46cm (density D1) and 55cm (density D4). Agencies A1 and A6 had the lowest HT increment reflecting the dumpy ancestry. Oil yield (OY), which ranged from 5.11 t/ha/yr to 6.03 t/ha/yr was highest in agency A2, due its high FFB. Bunch index (BI) ranged between 0.39 and 0.43 with agency A2 was the highest. Agency A2 produced the best total economic product (TEP) at 6.93 t/ha/yr. Minimum TEP of 5.80 t/ha/yr was produced by agency A3. Density D2 (148 palms/ha) recorded the highest FFB and OY with 21.74 and 6.0 t/ha/yr, respectively. Densities D3 (170 palms/ha), D4 (215 palms/ha) and D1 (120 palms/ha) was the second, third and fourth (lowest) respectively, in FFB and OY productions. Density 2 (148 palms/ha) was the ideal planting density for maximum oil yield per unit land area. This density (148 palms/ha) is the current planting density used in commercial oil palm cultivation on inland soil.

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

Prestasi Progeni Kelapa Sawit (*Elaeis Guineensis* Jacq.) DxP daripada Agensi yang Berbeza di Berbagai Kepadatan Tanaman

Oleh

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Lima belas progeni *dura* x *pisifera* (DxP) kacukan dwi-induk dari enam pengeluar benih kelapa sawit di Malaysia (agensi) telah dikaji dari segi hasil buah tandan segar, kualiti tandan, sifat vegetatif dan ciri fisiologi di empat kepadatan tanaman. Analisis varians antara lima belas progeni, enam agensi dan empat jarak tanaman menunjukkan perbezaan yang bererti di antara progeni, agensi dan kepadatan tanaman. Bagaimanapun, kesemua 34 ciri yang kaji tidak menunjukkan perbezaan yang bererti terhadap kesan interaksi antara progeni atau agensi dengan kepadatan tanaman. Anggaran heritabiliti luas (h^2_B) menggunakan korelasi intra-kelas adalah pada julat 13.3% hingga 47.6%. Secara umumnya, variasi genetik dan anggaran nilai heritabiliti adalah rendah yang mungkin menghadkan usaha penambahbaikan. Sebaliknya, keseragaman di dalam progeni memudahkan pemilihan bagi penghasilan bahan tanaman komersil. Prestasi hasil yang berbeza di antara progeni dan antara agensi mencerminkan kesan pemilihan dan sumber genetik yang berbeza. Variabiliti genetik yang rendah bagi hampir semua ciri mungkin disebabkan bahan tanaman yang mempunyai asas genetik yang sempit. Hasil buah tandan segar (FFB) dari semua agensi adalah di antara 18.41 dan 21.46 tan/hektar/tahun. Hasil tertinggi yang direkodkan oleh agensi A2 adalah disebabkan bilangan tandan (BNO) yang banyak. Nisbah minyak ke tandan (O/B) adalah di antara 25.93 dan 28.21% dengan nilai tertinggi pada agensi A1. Ketinggian pokok (HT) di kalangan agensi selepas 21 tahun penanaman adalah di antara 8.97m dan 10.02m dengan purata pertambahan ketinggian di antara 47cm dan 53cm, manakala di kalangan kepadatan tanaman pula di antara 8.73m dan 10.43m dengan pertambahan ketinggian di antara 46cm (kepadatan D1) dan 55cm (kepadatan D4). Agensi A1 dan A6 mempunyai pokok paling rendah yang mencerminkan pewarisan sifat renek. Jumlah penghasilan minyak (OY) berjulat di antara 5.11 dan 6.03 tan sehektar dengan nilai tertinggi dicatat oleh agensi A2. Julat indeks tandan (BI) adalah di antara 0.39 dan 0.43 dengan nilai tertinggi pada agensi A2. Agensi A2 juga mencatatkan penghasilan ekonomi total (TEP) yang tertinggi (6.93 tan sehektar), manakala Agensi A3 adalah yang terendah (5.80 tan sehektar). Jarak tanaman D2 (148 pokok sehektar) merekodkan FFB dan OY tertinggi, dengan masing-masing 21.74 dan 6.0 tan sehektar. Kepadatan tanaman D3 (170 pokok/hektar), D4 (215 pokok/hektar) dan D1 (120 pokok/hektar) adalah masing-masing mengikut susunan kedua, ketiga dan keempat (terendah) dari segi penghasilan FFB dan OY. Kepadatan tanaman D2, yang banyak diamalkan secara komersil di tanah pedalaman, didapati paling ideal untuk pulangan hasil yang maksimum per unit kawasan.

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I certify that an Examination Committee has met on 29th August 2007 to conduct the final examination of Mohd Isa bin Zainol Abidin on his Master of Science thesis entitled "Performance of Oil Palm (*Elaeis guineensis* Jacq.) DxP Progenies from Different Agencies under Various Planting Densities" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the degree of Master of Science.

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Date: 21 February 2008

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 other institutions.

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MOHD ISA ZAINOL ABIDIN

Date: 28 December 2007

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FFB	fresh fruit bunch
BNO	bunch number
ABW	average bunch weight
BWT	bunch weight
MFW	$\bar{x}$ fruit weight
P/B	parthenocarpic/bunch
M/F	mesocarp/fruit
K/F	kernel/fruit
S/F	shell/fruit
O/DM	oil/dry mesocarp
O/WM	oil/wet mesocarp
F/B	fruit/bunch
O/B	oil/bunch
K/B	kernel/bunch
OY	oil yield (kg/palm/yr)
KY	kernel yield kernel/palm/year
TEP	total economic product (kg/palm/yr)
FP	frond production
PCS	petiole cross-section
RL	rachis length
LL	leaflet length

LW	leaflet width
LN	leaflet number
HT	palm height
LA	leaf area
LAI	leaf area index
DIA	diameter
LDW	leaf dry weight
TDW	trunk dry weight
FDW	frond dry weight
LAR	leaf area ratio
VDM	vegetative dry matter
BDM	bunch dry matter
TDM	total dry matter
BI	bunch index
NAR	net assimilation rate
SD	standard deviation
CV	coefficient of variation
ANOVA	analysis of variance
FS	full-sib
BIPS	bi-parental
r	correlation coefficient of variation
df	degree of freedom
h^2_B	broad-sense heritability

MS	mean squares
EMS	expected mean squares
D1	density 1 (120 palms/ha/year planted at 9.79m distance)
D2	density 2 (148 palms/ha/year planted at 8.81m distance)
D3	density 3 (170 palms/ha/year planted at 8.22m distance)
D4	density 4 (215 palms/ha/year planted at 7.31m distance)
AVROS	Algemene Vereniging van Rubber-planters ten Oostkust van Sumatera (now known as Balai Penelitian Pekebun Medan)
MPOB	Malaysian Palm Oil Board

CHAPTER 1

INTRODUCTION

The oil palm (*Elaeis guineensis*) is comparatively the highest oil bearing plant. The increase in yield performance of superior planting materials through proper plantation management and agronomic practices has further enhanced productivity of the crop.

Oil palm development in Malaysia has been phenomenal. Starting off as an ornamental plant, the crop has developed into a multi billion ringgit industry. Malaysia is currently the largest producer and exporter of palm oil in the world supplying 51% of the total world production with 13.4 million tonnes of oil in 2005 (MPOB, 2006). However, the national average of oil palm yield, 3.80 t/ha/yr in 2005 (MPOB, 2006), was about 75% lower than the maximum theoretical potential yield of 18.2 t/ha/yr (Corley, 1996). Thus, efforts towards increasing oil productivity are necessary to reduce this gap.

Increasing oil yield remains the primary objective of oil palm breeding programmes. In order to get optimum oil yield per unit area, options to emphasize on the planting density may be more attractive. Genetic and physiological researches are possible avenues towards this goal by producing planting materials with high FFB yield and high oil yield with high planting density. The optimum planting density will enable optimum growth and economic yield production of oil palm through its life span.

Oil palm planting density has been a topic of interest since the 1970's. Results have been reported from trials testing various spacing and planting patterns, thinning of existing stands as well as variable density planting *i.e.* deliberately planting at high initial density for future thinning (Mohd Nazeeb *et al.*, 1989). High optimal densities, leading to higher early yields, are possible in areas where palms grow relatively slow or if suitable planting materials are used.

Sly and Chapas (1963) reported that FFB yield decline at 180 palms/ha occurred only after the eighth year in Ghana while such decline was observed in Nigeria after the seventh year of planting (Hartley, 1988).

Corley (1973a) observed that the general increase in yield with age during the early bearing years was reversed with increasing density. Mok *et al.,* (1971) recorded a decrease in bunch weight after the fourth year, especially at densities greater than 225 palms/ha. They also noted apparently greater frond length from the third year in palms the very high densities of 227 and 334 palms/ha. In the very fertile environments at Dami, Papua new Guinea, the rachises of palms at the comparatively lower stand of 148 palms/ha were very significantly longer from the fifth year compared to those grown at 56 or 110 palms/ha (Breure, 1977). On coastal clay soil soils of Peninsular Malaysia, Tan and Ng (1976) observed rachis etiolation in palms at the highest density of 185 palms/ha in the sixth year of planting. Tanipura *et al*., (1985) observed significantly longer rachises from the fifth year in palms grown at 160 and 180 palms/ha on reddish yellow podsols in North Sumatera.

Ramachandran *et al.,* (1973) studied the long term effects of density on yield for the period of seven to eighteen years and noted a consistent reduction in FFB, bunch number and bunch weight at the highest density of 183 palms/ha. They concluded that bunch weight decreases by about one kg for every 25 palms/ha increase in density.

Corley *et al.,* (1973b) found that the optimum density for costal clay soils was 151 palms per hectare, 158 palms per hectare for well-fertilized inland soils and 166 palms per ha for poorer inland soils. Based on equilateral triangular plantings with 111, 136, 161 and 185 palms per hectare, Tan and Ng (1976) observed that on per hectare basis in coastal soils, early yields of the higher density plantings were significantly higher but trend lasted only until the fifth year of harvest, when all treatments gave similar yields. Within the next two years, the density of 136 palms/ha out-yielded 185 palms/ha by 9% or 5 tonnes FFB/ha.

Density effects on eleven years old of ten open-pollinated Nigerian germplasm planted in Kluang in 1976 under three spacings of approximately 125, 175 and 225 palms per hectare gave drastic reduction in FFB yield with increasing density due to reduced bunch number and also reduced bunch weight from fewer and smaller spikelets (Rao *et al*., 1993). The study showed no significant effect of planting density on oil/bunch (O/B) ratio at the 5% level. Corley (1976) also reported no significant change in O/B with planting density besides no significant difference in fruit/bunch (F/B) ratio.

Hardon *et al.,* (1969) and Corley *et al*., (1971a) suggested that increasing the leaf area index by high density planting might be a promising way of improving yield of oil palm. It has also been suggested that selection for high harvest index might be a more effective way of increasing oil yield per hectare than selection for individual palm yield. (Rees, 1963; Corley *et al.,* 1971b).

Results based on 13 years yield record of commercial DxP (or 16 years planting) of a spacing trial (120, 160 and 200 palms/ha) at MPOB's peat area in Teluk Intan showed continued significant increase in FFB yield and O/B with increase in planting densities (Mohd Tayeb *et al*., 2002).

Two oil palm spacing trials evaluating a range of planting densities on riverine alluvial and organic muck soil in Sabah using four DxP progenies of Oil Palm Research Station, Banting, revealed the strong indications of positive effect of increased planting density on oil and kernel extraction rates, through improved fruit to bunch ratio (Donough and Betty Kwan, 1991). The palm height increment was unaffected by density until seven to eight years after planting. Thereafter, increasing density increased height increment. Donough and Betty Kwan, (1991) estimated that every ten palms per hectare increase in planting density would necessitate earlier replanting by four to six months.

Although various studies were carried out to determine the effect of planting density on oil palm productivity, there has been no known information on interaction between various genotypes and planting densities in oil palm.

This study has the following objectives:

1) To evaluate the agronomic performance of different genotypes of different source of origins planted in four different planting densities.
2) To estimate and quantify the genetic control and heritabilities of various agronomic traits.
3) To estimate the correlation among the agronomic traits i.e. yield, bunch quality and vegetative characters of the different progenies planted in different planting densities.
4) To identify and select high yielding and stable oil palm genotypes with respect to planting density.