UNIVERSITI PUTRA MALAYSIA

EFFECTS OF GENOTYPES, TERRAIN, AND IRRIGATION ON OIL PALM YIELD, AND LEAF AND RACHIS NUTRIENT CONCENTRATIONS

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2014

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By

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Thesis Submitted to the School of Graduate, Universiti Putra Malaysia in Fulfilment of the Requirements for the Doctor of Philosophy

April 2014

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for Doctor of Philosophy

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April 2014

Chairman : Professor Zaharah Abdul Rahman, PhD

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Foliar analysis is the most common diagnostic tool used to determine the nutritional status of oil palm. Thus the fertilizer requirements of palms are then inferred from these results. In Malaysia, most of the oil palm nutritional research works and their optimal leaf concentrations references were derived from DxP AVROS planting materials. The objective of this study was to evaluate the effects of different oil palm origins, subjected to irrigation and terrain on oil palm yield, leaf, rachis nutrient concentrations and contents over 8 years covering of two periods of yielding assessment i.e ascending and prime stage. An experiment was laid out on palms planted in 1999 at the Tun Razak Centre for Agricultural Services, Jerantut, Pahang, Malaysia (3° 52' 55" North, 102° 43' 41" East) to evaluate the selected genotypes under irrigation and terrain conditions.
Results over 8 years on the variations of leaf and rachis nutrient concentrations detected in four clonal oil palm genotypes from different origins i.e. AVROS, Yangambi, La Me and NIFOR and two D×P hybrid Yangambi which were planted on terraced and non-terraced fields subjected to irrigated and non-irrigated conditions were studied. Results clearly showed that rainfall pattern had a great influence on leaf nutrient concentrations and oil yield. Non irrigated palms during ascending yielding stage subjected to uneven rainfall distribution, had higher leaf nutrient concentrations as compared to irrigated palms especially on leaf K and Mg (by 10%) but with lower oil yield (by 13.6%). However, palms grown in the non-terraced area yielded almost 9% higher compared to those planted on terraced areas. The former also have higher leaf Mg and B concentrations which are 10% higher. As the palms reached the prime yielding stage and with good evenly distributed rainfall over time, the effects of terrain and irrigation had been nullified on both yield and foliar nutrient concentrations except for some of the nutrient elements. However, there are marked differences in term of both foliar and

rachis nutrient contents among the genotype studied which is attributed to the distinct differences in petiole cross section. Obviously genotypes have a great significant influence on foliar nutrient concentrations and contents for both period of yielding phases. The present study indicated that the high yielding genotypes, D×P Yangambi-DQ 8 consistently showed 15%-20% lower leaf K concentration than the clonal materials of AVROS-A122. Despite the lower leaf K concentration of the former, it retained relatively higher leaf and rachis K contents. It appears therefore that leaf concentration alone is not an adequate method to evaluate the nutritional status of the palms. Incorporation of leaf nutrient contents as well as the rachis nutrient concentrations and contents are certainly useful for better assessment. The present study revealed that fresh fruit bunch (FFB) productions were not significantly different between the genotypes tested, but the oil to bunch ratio (O:B) of the high yielding genotypes remain higher than the standard control (Yangambi D×P, SC3), resulting in a 14-17.5% higher oil yield and 6.1-13.5% more of total economic product (TEP) at the prime yielding phase. Monitoring the leaf cations (K, Ca and Mg) concentrations and contents over 12 years strongly revealed that the high yielding genotypes (Yangambi-Y103, AVROS-A122, and Yangambi-DQ8), had moderate to high leaf nutrient concentrations and consistently recorded higher total leaf cations (TLC) throughout this study and *vice-versa* for the poorer yielding palms (Yangambi-SC3 and NIFOR-N144). The correlation studies between leaf nutrient concentrations and oil yield components showed that leaf Ca and Mg concentrations are strongly correlated to oil to bunch (O:B) ratio, oil yield and TEP. The results of this study are useful for developing new strategies on oil palm nutrition and breeding programme.

Abstrak tesis yang telah dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk mendapat Ijazah Doktor Falsafah

PENGARUH GENOTIP, PENGAIRAN, DAN TOPOGRAFI TERHADAP HASIL, DAN KEPEKATAN NUTRIEN DAUN DAN RAKIS POKOK SAWIT

Oleh

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Analisis foliar merupakan kaedah yang biasa digunakan dalam penentuan status pemakanan tanaman dan menjadi asas dalam pengiraan syor keperluan pembajaan tanaman sawit. Di Malaysia, kebanyakan penyelidikan untuk penentuan kandungan pemakanan tanaman sawit serta paras kepekatan optimum di dalam daun adalah terhasil dari kajian ke atas baka tanaman DxP AVROS. Objektif kajian ini adalah untuk menilai kesan perbezaan keturunan baka sawit, tertakluk kepada pengaruh pengairan dan kelerengan muka bumi ke atas hasil, kepekatan dan kandungan nutrien daun serta rakis bagi tempoh 8 tahun meliputi dua peringkat penilaian hasil iaitu peringkat hasil menaik dan peringkat hasil puncak. Kajian ini telah dijalankan pada pokok sawit yang ditanam pada tahun 1999 di Pusat Perkhidmatan Pertanian Tun Razak, Jerantut, Pahang, Malaysia (3° 52' 55" Utara, 102° 43' 41" Timur) untuk menilai keupayaan beberapa genotip terpilih dalam keadaan berpengairan dan berteres. Kajian selama lebih 8 tahun telah dijalankan bagi mengenalpasti variasi kepekatan nutrien di dalam daun dan rakis pada empat klon yang berlainan asal-usulnya iaitu AVROS, Yangambi, La Me dan NIFOR serta dua hibrid D×P Yangambi yang ditanam pada kawasan berteres dan tidak berteres serta berpengairan dan tanpa pengairan. Keputusan kajian jelas menunjukkan corak taburan hujan menunjukkan pengaruh yang besar ke atas paras kepekatan nutrien di dalam daun serta penghasilan minyak sawit. Pada fasa umur hasil sedang meningkat, sawit yang ditanam di kawasan tanpa pengairan serta menerima taburan hujan yang tidak seragam mempunyai paras kepekatan nutrien yang lebih tinggi berbanding sawit di kawasan berpengairan terutamanya paras K dan Mg di dalam daun (melebihi 10%), tetapi memberikan hasil minyak yang rendah (kekurangan 13.6%). Walau bagaimanapun, sawit yang ditanam di kawasan tidak berteres memberi penghasilan hampir 9% lebih tinggi berbanding sawit di kawasan berteres. Pokok sawit di kawasan tidak berteres juga mempunyai paras kepekatan Mg dan B dalam daun melebihi 10% berbanding sawit di kawasan berteres. Apabila pokok sawit mencapai fasa umur

berhasil memuncak, dan disokong oleh taburan hujan yang mencukupi dan seragam sepanjang tahun, faktor kecerunan mukabumi dan pengairan ke atas hasil dan kepekatan nutrien daun tidak lagi berkesan kecuali pada beberapa nutrien tertentu. Walau bagaimanpun, terdapat perbezaan yang ketara pada kandungan nutrien di dalam daun dan rakis antara setiap genotip bahan tanaman yang digunakan dalam kajian. Ini berkemungkinan berpunca dari perbezaan pada keratan rentas petiol pada setiap satunya. Sumber bahan tanaman jelas mempunyai pengaruh yang ketara ke atas kandungan dan kepekatan nutrien daun pada kedua tempoh fasa penghasilan sawit. Kajian ini telah menunjukkan bahawa bahan tanaman berhasil tinggi, D×P Yangambi-DQ8 secara konsisten mempunyai paras K daun sebanyak 15%-20% lebih rendah berbanding bahan tanaman klon AVROS-A122. Di sebalik paras K daun yang rendah, ia masih mengekalkan kandungan relatif K daun dan rakis yang tinggi. Keadaan ini menunjukkan bahawa kepekatan daun secara bersendirian adalah tidak memadai untuk menilai status kandungan nutrien pada pokok sawit. Gabungan kandungan nutrien di dalam daun serta kepekatan dan kandungan nutrien di dalam rakis adalah sangat berguna bagi membuat penilaian yang lebih baik. Kajian ini membuktikan bahawa tiada perbezaan ketara pada penghasilan tandan buah segar (TBS) antara bahan tanaman yang dikaji tetapi nisbah minyak kepada tandan (O:B) pada bahan tanaman berhasil tinggi kekal lebih tinggi berbanding bahan tanaman yang digunakan sebagai kawalan piawai (Yangambi D×P, SC3). Bahan tanaman berhasil tinggi memberikan hasil minyak 14-17.5% lebih tinggi dan mempunyai 6.1-13.5% jumlah hasil ekonomi [*total economic product* (TEP)] pada fasa hasil memuncak. Pengawasan paras kepekatan kation di dalam daun (K, Ca and Mg) dan kandungannya bagi tempoh melebihi 12 tahun jelas menunjukkan bahawa bahan tanaman berhasil tinggi (Yangambi-Y103, AVROS-A122, dan Yangambi-DQ8) mempunyai kepekatan nutrien daun yang sederhana ke tinggi dan secara konsisten merekodkan paras jumlah kation daun [total leaf cations (TLC)] yang tinggi sepanjang tempoh kajian dan keadaan sebaliknya berlaku pada pokok sawit berhasil rendah (Yangambi-SC3 dan NIFOR-N144). Beberapa kajian korelasi antara kepekatan nutrien daun dan komponen hasil minyak menunjukkan terdapatnya korelasi kuat antara kepekatan Ca dan Mg di dalam daun dengan nisbah minyak kepada tandan (O:B ratio), hasil minyak dan TEP. Keputusan dari kajian ini amath berguna dalam merangka strategi baharu untuk program pemakanan dan biakbaka tanaman sawit.

ACKNOWLEDGEMENTS

Working on this project was an exciting journey with its challenges and discoveries. I would like to thank Professor Dr. Zaharah Abdul Rahman, Professor Dr. Hanafi Musa and Professor Madya Dr. Che Fauziah Ishak for their support and guidance in conducting this study. I gratefully acknowledge Felda Global Ventures Plantations (Malaysian) Sdn. Bhd. for allowing me the time and opportunity to complete this study. I would like to thank the contributions from Felda Agricultural Services Sdn. Bhd. (FASSB) research colleagues particularly Mr. Foong Sang Foo (former Head of Agronomy Unit), who initiated the project in collaboration with the Breeding and Tissue Culture Unit, Dr. Maheran Abu Bakar and Mr. Chin Cheuk Weng who provided the planting materials as well as staffs of the Agronomy Unit especially Mr. Ismail Hashim, Mr. Syed Kamarudzaman Syed Ibrahim, Mr. Ismail Mohammad, Hj. Rosman Rohan, the late Nga Shee Keong, Mr. Tan Choon Check, Mr. Mohd Shahkhirat Norizan, Wong Mum Keng, Mr. Mohd Salihuddin Mohd Yusof, Mr. Saipol Azmi Shamsuddin and Hj. Rosman Rohan who ensured the success of this project. Appreciation is also extended to Mr. Goh Kah Joo of Applied Agricultural Resources Sdn. Bhd for his useful comments and view. A big thank you goes to my wife, Hiew Yee Hooi, and my son Lee Cheng Earn for their support, patience and understanding.

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

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LIST OF ABBREVIATIONS

AAR	Applied Applied Research
ANOVA	Analysis of variance
Ap	Disturbed surface horizon (cultivation, pasture, forestry)
AVROS	*Algemeene Vereniging van Rubberplaters ter Oostkust van Sumatra*
B	Boron
BO1	Surface B horizon Oxides
Ca	Calcium
Cl	Chloride
cmol	centimole
Cu	Copper
D×P	*Dura* × *pisifera*
D×T	*Dura* × *tenera*
DOA	Department of Agriculture
DRIS	Diagnosis and recommendation integrated system
EPA	Eastern Plantation Agency
FAO	Food and Agriculture Organization
FASSB	Felda Agricultural Services Sdn. Bhd.
Fe	Iron
FELCRA	Federal Land Consolidation and Rehabilitation Authority
FELDA	Federal Land Development Authority
FFB	Fresh fruit bunches
GAP	Good agronomic practices
ha	Hectare
HSD	Honestly significant difference
IJM	Ipoh Jurutera Malaysia
INEAC	*the Institut National por l'Etude Agronomique du Congo*
IOI	Industrial Oxygen Incorporated
IRHO	the French Institute for oil crops Research now known as CIRAD
K	Potassium
K/B	Kernel to bunch ratio
kg/palm	kg per palm
Kies	Kieserite
Mg	Magnesium

mm	millimetre
mm/day	millimeter per day
MMS	Malaysia Metrological Services
MOP	Muriate of potash
MPOB	Malaysia Palm Oil Board
N	Nitrogen
Nalfin	National Finance
NIFOR	Nigerian Institute for Oil Palm Research
O/B	Oil to bunch ratio
p	Probability
P	Phosphorous
Palms/ha	palms per hectare
PCS	Petiole cross section
PET	Potential evapotranspiration
PNG	Papua New Guinea
PPPTR	Pusat Perkhidmatan Pertanian Tun Razak
PR	Phosphate rock
RCBD	Randomized complete block design
RSSB	Risda Semaian dan Landskap Sdn. Bhd.
S	Sulphur
SAS	Statistical Analysis Software
SC3	Standard control 3
SEU	Sasaran Edaran Utama
SIME	Sime Darby
SNLC	Single nutrient critical level
SPAD	Sarawak Plantation Agriculture Development
t	ton
t/ha/yr	ton per hectare per year
TEP	Total economic product
TLC	Total leaf cations
UP	United Plantations
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 Oil palm in general

Over the last 100 years, oil palms (*Elaeis guineensis* Jacq) a native plant from tropical Africa has been extensively planted in South East Asia, primarily in Malaysia and Indonesia. By 2011, it has become the main source of vegetable oil in the world and contributed to almost 36% of total world's production or equivalent to 55.88 million tonnes of vegetable oil (FAO, 2012). Currently, over 13.4 million hectares of land had been planted with oil palm worldwide, and grown under very diverse agro-climatic environments. The two key exporting countries of palm oil are Malaysia and Indonesia, producing over 86% of world palm oil which account for over 93% of world palm oil export.

More oil palms are planted in the marginal environment such as low rainfall and hilly conditions. There are means to overcome the shortcomings such as to implementing irrigation in a drier area and to construct a terraced in hilly area to assure that respectable yields can be achieved. In order to sustain high oil yields, selected elite planting materials and adopting good agronomic practices (GAP) are amongst the key success factors to ensure that respectable yields can be achieved. Leaf nutrient concentrations in oil palm trees indirectly provide an indicator on the status of palm health. This information has been used by the agronomists to formulate appropriate fertilizer requirements to be applied to the palms to obtain good growth and high yields. In Malaysia, most of the oil palm nutritional research was carried out in the 1960's to 1990's using palms derived from D×P AVROS planting materials. These nutritional works provided a reference for optimal leaf nutrient concentrations as a benchmark to the oil palm industry. Over the years, newer and higher yielding planting materials capable of producing high yields of > 10 tonnes ha^{-1} of total economic product (TEP, include the oil plus kernel) became available. These new materials are quite diverse in their origins and showed some differences in the leaf nutrient concentrations as compared to the older data. Therefore, to review the optimum leaf and rachis nutrient concentrations in oil palm is crucial. Thus, the general objectives of this study are:-

i) To determine the effects of oil palm genotypes planted on non-terraced and terraced areas on leaf and rachis nutrient concentrations and contents.
ii) To determine the effects of irrigation and terrain on oil palm leaf and rachis nutrient concentrations and contents, and
iii) To study the correlation between leaf and rachis nutrient concentrations of oil palm and their oil yield components.

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