EFFECTS OF WATER STRESS ON THE PHYSIOLOGICAL PROCESSES AND WATER USE EFFICIENCY IN OIL PALM

By

MOHD ROSLAN BIN MD NOOR

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

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Special dedicated

To

My beloved wife and children

"He who finds a way in searching for knowledge,
God finds him a way to paradise"

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

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Chairman: Professor Mohd Razi Ismail, PhD

Faculty: Agriculture

Malaysia is currently the major producer of palm oil in the world with a total production of crude palm oil of about 15 million tonnes in 2005. This major commercial crop in Malaysia covers an area of about 4 million hectares of agricultural land. Due to its important role, various research and development are still on going to improve and to ensure the sustainability of this industry. In this physiological study of oil palm, focus was given to two different environments and palm age.

In the first experiment, physiological evaluation was done on two different planting materials namely the commercial DxP and PS1.1 dwarf palms. This PS1.1 planting material is expected to be shorter, higher yielding, more compact and with desirable fruit qualities. The seedlings were raised in large polybags filled with topsoil. Experiments were initially done at Green House I that was located near the UPM Hydroponics and later, at Green House II situated at the

UPM Agriculture Park. Various physiological parameters were studied to compare the performance of both genotypes and their responses to soil drying. Four replicates of ten seedlings per treatment were used. Among the parameters studied were gas exchange, chlorophyll fluorescence, vegetative growth, chlorophyll content, root:shoot ratio, soil moisture and leaf sugar analysis. Based on vegetative measurements, DxP seedlings had 34% longer rachis length than PS1.1 and were 29% taller. The leaves of DxP seedlings had higher relative water content and moisture content as compared to PS1.1. As water is essential for cell growth, this may be one of the factors that enable the DxP seedlings to grow faster. The leaf chlorophyll content was slightly higher in the DxP as compared to PS1.1 seedlings. Fluctuations in leaf sugar contents were found in both genotypes in response to soil drying. DxP seedlings had significantly higher water use efficiency (WUE) ($p<0.05$) and showed vigorous growth as compared to PS1.1. The PS1.1 seedlings showed higher photosynthetic rate and higher evapotranspiration rate as compared to DxP. PS1.1 seedlings had similar root:shoot ratio as DxP. Both photosynthetic rate and stomatal conductance were reduced in response to soil drying.

In the second experiment, the study was carried out at the ESPEK Tanjung Genting, Sintuk located in North Kedah. The site was chosen because of the seasonal dry period that occurred at the end of the year and ends in the first quarter of the following year (Dec to Mac). Comparisons of physiological responses were done between irrigated and non-irrigated palms. Two treatments

with three replicates of 16-recorded palms per replicate were used. A total of 96 DxP oil palms planted in July 2000 were involved in this study. Irrigation was done using the drip system, where the Netafim drip tape was aligned at one side of the planting rows. A higher photosynthetic rate or gas exchange response to CO_2 concentration was observed in the irrigated palms as shown by the ACi curve. But there was no significant response of both irrigated and control palms to the different light intensities. The leaf moisture content of irrigated palms was higher than the control, but the relative water content and chlorophyll content were lower than control. No statistically significant difference was found in the canopy study, such as the leaf area index and light interception. The instantaneous WUE in the field study showed better response in the irrigated palms as compared to control. Based on chlorophyll fluorescence, palms in the control plots showed lower PSII efficiency. In the first year harvesting, the FFB yield in the irrigated plots was 10% higher than control.

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

KESAN KETEGASAN AIR TERHADAP PROSES-PROSES FISIOLOGI DAN KECEKAPAN PENGGUNAAN AIR DALAM SAWIT

Oleh

MOHD ROSLAN BIN MD NOOR

Oktober 2006

Pengerusi : Profesor Mohd Razi Ismail, PhD

Fakulti : Pertanian

Malaysia buat masa ini adalah pengeluar utama minyak sawit dunia dengan penghasilan minyak sawit sebanyak 15 juta metrik tonne dalam tahun 2005. Tanaman komersil utama ini merangkumi kawasan seluas 4 juta ha tanah pertanian. Oleh kerana peranan ini, berbagai penyelidikan danpembangunan masih dijalankan bagi memastikan kebolehupayaan industri ini. Dalam kajian fisiologi ini, fokus diberikan keatas dua keadaan persekitaran dan umur pokok sawit.

Dalam ujikaji pertama, penilaian fisiologi dibuat ke atas dua bahan tanaman yang berbeza iaitu DxP komersil dan pokok renek PS1.1. Bahan tanaman PS1.1 dijangkakan lebih rendah, mengeluarkan hasil yang tinggi, padat dan mempunyai kualiti buah yang diinginkan. Anak benih dibesarkan dalam polibeg besar. Ujikaji pada mulanya dijalankan di rumah hijau I yang terletak berdekatan dengan

Hidroponik UPM dan kemudiannya dipindahkan ke rumah hijau II, Taman Pertanian UPM. Berbagai parameter fisiologi telah diukurkan bagi membandingkan prestasi kedua genotip dan tindakbalas terhadap kekeringan tanah. Empat replikat setiap satunya sepuluh pokok telah digunakan. Diantara parameter yang dikaji adalah pertukaran gas, pengukuran tampang, kandungan klorofil, nisbah akar:pucuk, kelembapan tanah dan kandungan gula. Berdasarkan pada pengukuran tampang, panjang rakis bagi anak benih DxP adalah 34% lebih panjang dari PS1.1 dan 29% lebih tinggi. Anak benih DxP mempunyai kandungan air relatif yang lebih tinggi dari PS1.1. Memandangkan air adalah keperluan asas bagi pertumbuhan sel, ini mungkin salah satu faktor membolehkan DxP tumbuh dengan cepat. Kandungan klorofil dalam daun adalah sedikit tinggi dalam DxP. Perubahan turun naik aras kandungan gula dalam daun anak benih juga mempunyai nilai WUE yang bererti pada aras $p<0.05$ dan menunjukkan kadar fotosintesis dan evapotranspirasi yang tinggi berbanding DxP. PS1.1 menunjukkan nisbah akar:pucuk yang sama dengan DxP baik dalam kawalan dan juga selepas mengalami ketegasan air. Ini menunjukkan PS1.1 dan DxP mempunyai sistem akar yang serupa bagi menyerap air dan nutrien. Kadar fotosintesis dan stomata konduktans didapati menurun apabila tanah mengering.

Dalam ujikaji kedua, kajian dijalankan di estet yang dimiliki oleh Espek Tanjung Genting, Sintuk yang terletak di utara Kedah. Kawasan ini dipilih kerana ujudnya kemarau bermusim setiap tahun lazimnya bermula pada hujung tahun sehingga tiga bulan pertama tahun berikutnya. Perbandingan tindakbalas diantara pokok-

pokok sawit kawalan dan pengairan dijalankan berasaskan beberapa parameter. Dua rawatan dengan tiga replikat yang mengandungi 16 pokok berekod setiap replikat digunakan. Sejumlah 96 pokok sawit DxP yang ditanam pada Julai 2000 terlibat dalam kajian ini. Sistem pengairan yang digunakan adalah sistem titis Netafim yang dipasangkan sebaris sepanjang barisan pokok sawit. Tindakbalas yang tinggi terhadap kepekatan CO_2 diperhatikan dalam lekuk ACi. Namun begitu tiada kesan bererti bagi kedua kawalan dan pengairan terhadap lekuk cahaya. Kandungan kelembapan daun adalah tinggi dalam daun pengairan berbanding kawalan tetapi disebaliknya dalam kandungan relatif air dan klorofil. Tiada perbezaan bererti pada kajian kanopi sepertimana ditunjukkan oleh indeks luas daun dan cahaya pintasan. WUE yang dibuat secara spontan di ladang menunjukkan tindakbalas yang lebih baik dari pokok pengairan. Berasaskan klorofil floresens, pokok dalam kawalan menunjukkan keefisienen PSII yang rendah berbanding pokok pengairan. Dalam tahun pertama penuaian, hasil tandan sawit kawasan pengairan adalah lebih 10% berbanding kawalan.

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I certify that an Examination Committee met on 13th October 2006 to conduct the final examination of Mohd Roslan Bin Md Noor on his Master of Agricultural Science thesis entitled 'Effects of Water Stress on the Physiological Processes and Water Use Efficiency in Oil Palm' 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:

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

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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 UPM or other institutions.

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MOHD ROSLAN BIN MD NOOR

Date: 9 JANUARY 2007

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