EFFECTS OF ROOT RESTRICTION AND WATER STRESS ON GROWTH PERFORMANCE, AND PHYSIOLOGICAL AND BIOCHEMICAL RESPONSES OF MANGO (Mangifera indica cv. CHOKANAN)

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 Science

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Specially Dedicated To:
Haji Sakimin Bin Sakidin
Hajjah Poriah Binti Haji Mokti
and
Ismail Iberahim
Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman : Associate Professor Mohd. Razi Ismail, PhD
Faculty : Agriculture

The effects of restricted root volume (10, 30 and 50-litre of soil) on growth, stomatal conductance and photosynthesis rate of mango (Mangifera indica) cv. Chokanan trees were investigated under a rain shelter condition. Root restriction (10-litre of soil) significantly (P≤0.05) reduced all growth parameters and leaf gas exchange of plants. However, stem and root dry weight, root:shoot ratio, number of branches and stem diameter were not significantly (P>0.05) different between the 10 and 30-litre of soil. There were a linear relationships between root and total leaf dry weight; diameter of stem and plant height; and between photosynthesis rate and stomatal conductance.

Similarly, growth of mango plants was significantly affected by root restriction in a 24-litre volume of soil compared to control roots (unrestricted) under field condition. Root restriction reduced the number of fruits by 56.3% in the first season, but it increased the total number of fruits and total fruit weight in the second season.
compared to the control. Average fruit weight per plant was not affected by the root restriction treatment in the second season.

Root restriction in combination with water stress was also studied. Root restriction inhibited the growth of mango trees as reflected in the reduction of leaf expansion with greater reduction under water stress conditions. Under well-watered condition, restricted root resulted in a considerable reduction in stomatal conductance and leaf water potential compared to the control root growth. Decreases in stomatal conductance and leaf water potential were rapid under restricted root and water stress condition compared to the control. On the other hand, leaf proline and abscisic acid (ABA) accumulation increased as a result of root restriction and water stress. Re-watering of mango trees increased stomatal conductance, leaf water potential and peroxidase accumulation in plants with both restricted and control root growth. However, proline and ABA accumulation decreased with re-watering. Anatomical studies of cross section of secondary branch of mango also showed that root restriction and water stress brought about various changes, such as smaller and compacted cell size (as estimated by epidermis thickness and area, as well as by cortex thickness), but increased the size of some of the cells (as measured by schlerenchyma, phloem and xylem thickness, schelenchyma and pith area and pith diameter). These results suggest that reduction of soil volume and water stress could effectively control tree size by physiological and morphological changes and trigger reproductive development of fruit trees like mango.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN PEMBATASAN AKAR DAN KEKURANGAN AIR TERHADAP PRESTASI PERTUMBUHAN, DAN TINDAKBALAS FISIOLOGI DAN BIOKIMIA TANAMAN MANGGA (Mangifera indica cv. CHOKANAN)

Oleh

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Kesan pembatasan akar (10, 30 dan 50-liter tanah) terhadap pertumbuhan, konduktiviti stomata dan kadar fotosintesis pokok mangga (Mangifera indica) kultivar Chokanan telah dikaji di bawah keadaan lindungan hujan. Pembatasan akar (10-liter tanah) secara bererti (P≤0.05) merendahkan kesemua parameter pertumbuhan dan pertukaran gas daun tanaman. Bagaimanapun, berat kering batang dan akar, nisbah akar ke pucuk, bilangan cabang dan garispusat batang tidak berbeza secara bererti (P>0.05) antara 10 dan 30-liter tanah. Terdapat perkaitan secara linear di antara berat kering akar dan daun; garispusat batang dan tinggi pokok; dan antara kadar fotosintesis dan konduktiviti stomata.

Dalam keadaan yang sama, terdapat kesan secara bererti terhadap pertumbuhan pokok mangga dengan menggunakan pembatasan akar di dalam 24-liter isipadu tanah berbanding akar kawalan (tanpa pembatasan) di kawasan ladang. Pembatasan akar mengurangkan bilangan buah sebanyak 56.3% dalam musim
pertama, tetapi meningkatkan jumlah bilangan buah dan jumlah berat buah dalam musim ke dua berbanding kawalan. Purata berat buah sepokok tidak di pengaruhi oleh rawatan pembatasan akar

Pembatasan akar dengan kombinasi pengurangan air juga dikaji. Pembatasan akar mempengaruhi pertumbuhan pokok mangga seperti mana ditunjukkan dengan pengurangan pemanjangan daun dengan pengurangan yang jelas dalam keadaan kekurangan air. Dalam keadaan pengairan air yang baik, pembatasan akar menyebabkan penurunan yang banyak pada konduktiviti stomata dan potensi air daun berbanding pertumbuhan akar kawalan. Penurunan konduktiviti stomata dan potensi air daun di percepatkan dalam keadaan pembatasan akar dan kekurangan air berbanding kawalan. Pembatasan akar dan kekurangan air juga menyebabkan peningkatan pengumpulan proline dan asid absisik (ABA). Pengairan semula pokok mangga meningkatkan konduktiviti stomata, potensi air daun dan pengumpulan peroksidase pada kedua-dua pertumbuhan akar dengan pembatasan dan pertumbuhan akar kawalan. Bagaimanapun, pengumpulan proline dan ABA menurun dengan pengairan semula. Kajian anatomi terhadap keratan rentas cabang kedua mangga menunjukkan bahawa pembatasan akar dan pengurangan air membawa kepada pelbagai perubahan seperti pengecilan dan pemadatan saiz sel (yang dianggarkan dari ketebalan dan keluasan epidermis, dan juga ketebalan korteks), tetapi meningkatkan beberapa saiz sel (yang diukur dari ketebalan sklerenkima, floem dan xilem, keluasan sklerenkima dan empulur dan diameter empulur). Keputusan ini mencadangkan bahawa pengurangan isipadu tanah dan pengurangan air boleh secara efektif mengawal saiz pokok melalui perubahan
fisiologi dan morfologi dan merangsang pembentukan reproduktif pokok buahan seperti mangga.
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Last but not least, I would like take this point to dedicate this Master thesis to my beloved husband Ismail Iberahim, for his encouraging and moral support, which made life easy throughout my studies. Finally, my special appreciation and gratitude go on particularly to my family and all friends for being source of encouragement, and always ready to offer a helping hand.
I certify that an Examination Committee has met on 29th March 2006 to conduct the final examination of Siti Zaharah Sakimin on her Master of Science thesis entitled “Effects of Root Restriction and Water Stress on Growth Performance, and Physiological and Biochemical Responses of Mango (Mangifera indica cv. Chokanan)” 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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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.

SITI ZAHARAH SAKIMIN

Date:
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