



UNIVERSITI PUTRA MALAYSIA

**EFFECTS OF SOURCE AND RATES OF CALCIUM APPLICATION ON GROWTH,
QUALITY AND ANTHRACNOSE CONTROL IN PAPAYA (*Carica papaya* L.)**

BABAK MADANI

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papaya* L.)**

By

BABAK MADANI

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

July 2014

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DEDICATION

This thesis is dedicated to all I love specially

To my parents, my beloved mother and father

Who were sponsors of my study and sold some of their asset for me to be able to finish my P.hD. and I was not able for four years to see them



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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

EFFECTS OF SOURCE AND RATES OF CALCIUM APPLICATION ON GROWTH, QUALITY AND ANTHRACNOSE CONTROL IN PAPAYA (*Carica papaya* L.)

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BABAK MADANI

July 2014

Chairperson: Mahmud Tengku Muda Mohamed, PhD
Faculty: Agriculture

Papaya (*Carica papaya* L.) is the third most important fruit after durian and banana in Malaysia. 'Eksotika II', a high yielding F₁ hybrid, is a well-liked papaya cultivar in Malaysia for its good quality. Although, 'Eksotika II' has gained much popularity in the domestic and export markets, the harvested fruits are susceptible to anthracnose infection that limits its acceptability. Calcium plays a key role in enhancing plant growth and increasing fruit quality and storage life. It could be used as an alternative to fungicides to reduce disease incidence and hence to increase post-harvest quality. So far, little attention has been paid to investigate the effect of calcium pre-harvest application on post-harvest quality of papaya, especially with respect to 'Eksotika II' papaya. Four experiments were conducted in Agro technology Unit, University Agriculture Park, Universiti Putra Malaysia, Serdang, Selangor during 2011-2013 in order to evaluate the effect of pre-harvest calcium application on plant growth, fruit calcium content, post-harvest quality, anthracnose disease incidence and some enzymatic activities in papaya fruits.

In the first experiment, papaya seedlings were established in pots and irrigated with a standard nutrient solution in a net house. Papaya plants were sprayed with three different sources of calcium (calcium chloride, calcium nitrate and calcium propionate) at four different concentrations (0, 60, 120 and 180 mg L⁻¹). Results showed that calcium content in leaves of plants was not affected significantly by the different sources of calcium. However, increased calcium concentrations applied to the leaves enhanced calcium concentration in papaya leaves. In addition, increased concentrations of calcium enhanced stem height and diameter. Another experiment was carried out to find out the suitable source of calcium for better post-harvest qualities of papaya in the field. Different concentrations of calcium (0, 34, 67, 100 mM) in the form of calcium chloride and calcium nitrate were sprayed at 21 days after flower anthesis to the fruits and leaves. Spray applications were repeated every two weeks for six times. Results revealed that calcium content in fruit peel and pulp was higher for calcium chloride compared to calcium nitrate. Also, calcium chloride caused significantly smaller lesion diameter compared with those found in plants treated with calcium nitrate. Increased calcium concentration decreased ethylene production and increased ascorbic acid content in fruits. Thus, calcium chloride was

found better as a calcium source for increasing calcium content in fruits and decreasing anthracnose lesion diameter. In the third experiment, various concentrations of calcium chloride (0, 0.5, 1.0, 1.5 and 2.0%) were sprayed to different sites of papaya (leaves, fruits, leaves plus fruits). Fruits of uniform size and shape were harvested at index 2 and stored at $12 \pm 2^\circ\text{C}$ and 85-90% relative humidity. Fruit samples for each treatment were used for measurement 21 days after storage. It was found that there were considerable increases in peel and pulp calcium content, firmness, titratable acidity, ascorbic acid storage life and overall quality of fruits when calcium was applied in fruits and fruits plus leaves compared to calcium application in leaves only. In addition, ethylene production, respiration rate, soluble solids concentrations, disease incidence, and disease severity were considerably lower in fruits when calcium was applied in fruits and fruits plus leaves compared to calcium application in leaves only. In the fourth experiment, 0, 1.5 and 2% calcium chloride was sprayed in leaves plus fruits. Results showed that polygalacturonase (PG) and pectin methyl esterase (PME) activities decreased with increasing calcium concentrations. Microscopy images confirmed that cell wall structures of fruit peel and pulp were preserved more in the middle lamella of calcium chloride-treated fruits compared to control. Also, results indicated that at 1.5% calcium chloride respiration rate, ethylene production, soluble solids concentrations, disease incidence and severity significantly decreased compared with control. In contrast, at 1.5% calcium chloride ascorbic acid, titratable acidity, firmness, storage life and overall quality markedly increased compared with control. Therefore, spraying with 1.5% calcium chloride to the leaves and fruits is suitable for better post-harvest quality, higher calcium content in fruits and lower anthracnose disease in papaya.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**KESAN SUMBER DAN KADAR APLIKASI KALSIMUM KE ATAS
PERTUMBUHAN, KUALITI DAN KAWALAN BINTIK BERPUSAR
POKOK BETIK (*Carica papaya L.*)**

Oleh

BABAK MADANI

Julai 2014

Pengerusi : Mahmud Tengku Muda Mohamed, PhD

Fakulti : Pertanian

Betik (*Carica papaya L.*) merupakan buah ketiga terpenting selepas durian dan pisang di Malaysia. 'Eksotika II', hybrid F₁ yang berpengeluaran tinggi, merupakan kultivar yang digemari di Malaysia kerana kualitinya yang baik. Walaupun, 'Eksotika II' telah mendapat tempat dalam pasaran domestik dan eksport, buah yang dituai mudah terdedah kepada jangkitan antraknos yang menghadkan penerimaannya. Kalsium memainkan peranan penting dalam meningkatkan pertumbuhan pokok dan meningkatkan kualiti serta hayat simpanan buah. Ia boleh digunakan sebagai alternatif kepada racun kulat bagi mengurangkan jangkitan berlaku dan seterusnya meningkat kualiti lepas tuai. Sehingga kini, perhatian yang diberikan untuk menyiasat kesan penggunaan kalsium pra-tuai ke atas kualiti lepas-tuai betik masih kurang, terutamanya ke atas betik 'Eksotika II'. Empat kajian telah dijalankan di Unit Agro Teknologi, Taman Pertanian Universiti, Universiti Putra Malaysia, Serdang, Selangor pada 2011-2013 bagi mengenalpasti kesan penggunaan kalsium pra-tuai ke atas pertumbuhan pokok, kandungan kalsium buah, kualiti lepas-tuai, kejadian jangkitan antraknos dan beberapa aktiviti enzim dalam buah betik.

Dalam kajian pertama, anak pokok betik ditanam di dalam pasu dan diairkan dengan larutan nutrien standard dalam rumah jaring. Pokok betik kemudiannya disemur dengan tiga sumber kalsium berbeza (kalsium klorida, kalsium nitrat dan kalsium propionat) pada empat kepekatan berbeza (0, 60, 120 dan 180 mgL⁻¹). Keputusan menunjukkan bahawa kandungan kalsium dalam daun tumbuhan tidak dipengaruhi secara signifikan oleh sumber kalsium yang berbeza. Walaubagaimanapun, peningkatan kepekatan kalsium yang diberikan kepada daun meningkatkan kandungan kalsium dalam daun betik. Selain itu, peningkatan kepekatan kalsium merangsang ketinggian batang dan diameter pokok. Kajian seterusnya dijalankan bagi mengenalpasti sumber kalsium sesuai bagi mendapatkan kualiti lepas tuai betik yang lebih baik di ladang. Kepekatan kalsium berbeza (0, 34, 67, 100 mM) bagi kalsium klorida dan kalsium nitrat telah disemur pada hari ke 21 selepas bunga mekar ke atas buah dan daun. Penyemburan diulang setiap dua minggu sebanyak enam kali. Keputusan menunjukkan kandungan kalsium dalam kulit dan isi buah adalah lebih tinggi pada kalsium klorida berbanding kalsium nitrat. Selain itu, kalsium klorida

juga menyebabkan pengurangan diameter saiz jangkitan secara signifikan berbanding dengan tumbuhan yg dirawat dengan kalsium nitrat. Peningkatan kepekatan kalsium mengurangkan penghasilan etilena dan meningkatkan kandungan asid askorbik dalam buah. Oleh itu, kalsium klorida dikenalpasti sebagai sumber kalsium yang lebih baik bagi meningkatkan kandungan kalsium dalam buah dan mengurangkan diameter jangkitan antraknos. Dalam kajian ketiga, pelbagai kepekatan kalsium klorida (0, 0.5, 1.0, 1.5 dan 2.0%) telah disembur pada bahagian berbeza di pokok betik (daun, buah, daun serta buah). Buah dengan saiz dan bentuk yang seragam telah dituai pada indeks kematangan 2 dan disimpan pada suhu $12 \pm 2^{\circ}\text{C}$ dengan kelembapan relatif 85-90%. Sampel buah bagi setiap rawatan diuji 21 hari selepas simpanan. Didapati bahawa peningkatan yang jelas dapat dilihat dari segi kandungan kalsium pada kulit dan isi, kekerasan, asid tertitrat, asid askorbik, hayat penyimpanan dan kualiti keseluruhan buah apabila kalsium diberikan pada buah dan daun serta buah berbanding penyemburan pada daun sahaja. Disamping itu, penghasilan etilena, kadar respirasi, kepekatan pepejal terlarut, kejadian jangkitan dan keterukan jangkitan adalah lebih rendah pada buah apabila kalsium diberikan pada buah dan daun serta buah berbanding dengan pada daun sahaja. Dalam kajian ke empat, 0, 1.5 dan 2% kalsium klorida disembur pada daun serta buah. Keputusan menunjukkan bahawa aktiviti enzim poligalakturonase (PG) dan pectin methyl esterase (PME) menurun dengan peningkatan kepekatan kalsium. Imej mikroskopi mengesahkan bahawa struktur dinding sel kulit dan isi buah lebih dilindungi dalam lamela tengah bagi buah yang dirawat dengan kalsium klorida berbanding kawalan. Di samping itu, keputusan menunjukkan bahawa penyemburan kalsium klorida pada kepekatan 1.5% menunjukkan penurunan yang signifikan untuk kadar respirasi, penghasilan etilena, kandungan pepejal terlarut, kejadian dan keterukan jangkitan penyakit berbanding rawatan kawalan. Oleh itu, semburan 1.5% kalsium klorida pada daun serta buah adalah sesuai bagi mendapatkan kualiti lepas-tuai yang lebih baik, tinggi kandungan kalsium dalam buah dan mengurangkan jangkitan antraknos pada buah.

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The members of the Supervisory Committee were as follows:

Mahmud Tengku Muda Mohamed, PhD

Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Yahya Awang, PhD

Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Jugah Kadir, PhD

Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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