UNIVERSITI PUTRA MALAYSIA

GROWTH, PHYSIOLOGICAL AND BIOCHEMICAL RESPONSES AS AFFECTED BY PACLOBUTRAZOL FOR FLOWERING INDUCTION ON WATER INDUCED STRESS MANGO PLANTS (Mangifera indica L. cv. HARUMANIS)

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By

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GROWTH, PHYSIOLOGICAL AND BIOCHEMICAL RESPONSES AS AFFECTED BY PACLOBUTRAZOL FOR FLOWERING INDUCTION ON WATER INDUCED STRESS MANGO (*Mangifera indica* L. cv. HARUMANIS)

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Chairman : Rosimah Nulit, PhD
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Harumanis is the most popular mango cultivar in Malaysia for local fresh market as well as for export. However, flowering of Harumanis seem to be influenced by weather changes. Thus, suitable weather condition is required for Harumanis to initiate flowering. Basically, mango plant needs a long dry period in order to produce reproductive sprouts. Hence, it is very crucial to understand the role of drought in initiating flowering. Flowering of Harumanis can also be induced chemically by using paclobutrazol, a plant growth regulator to enhance the yield. Therefore, this study was conducted to determine the effect of paclobutrazol and water stress on vegetative growth, physiological and biochemical responses, and flowering of Harumanis. The application of paclobutrazol (0.75g a.i./tree) on three-year old containerized mango (*Mangifera indica* cv. Harumanis) was investigated in the field during December 2011 until March 2012 in randomized design with seven replications. Three treatments were imposed onto the tree of which T1 as control tree and irrigated daily (soil water potential maintain at 0 to -15 kPa); T2: 0.75g a.i. of paclobutrazol was applied as soil drench followed by imposed stress for 21 days (soil water potential maintain at -40kPa); and T3: Imposed stress for 30 days (soil water potential maintain at -40 kPa). T2 and T3 trees were irrigated after the dry period. Among the treatments, paclobutrazol with water stress (T2) significantly reduced shoot length and leaf development i.e. leaf size and leaf area compared to the other treatments. The physiological and biochemical content of mango plants were affected by paclobutrazol and water stress (T2) compared to control (T1) and stressed trees (T3). Paclobutrazol significantly reduced the photosynthesis rate, stomatal conductance and transpiration rate; but it increased sucrose and starch content in mango leaves. Moreover, the trees treated with paclobutrazol and water stress (T2) produced compacted flowers with short panicles and less number of fruit set. There was a few flowering occurred in the control trees (T1), while no flowering occurred in the water stressed trees (T3) up to 12 weeks of the experimental period (Appendix F1). The physiological response i.e. photosynthesis rate, stomatal conductance, and transpiration of paclobutrazol treated trees were higher during pre-floral stage and decreased during flower bud formation, but increased during flowering bloom. The biochemical content i.e. chlorophyll content, sucrose content, and starch concentration were higher during pre-floral stage

compared to during flower initiation, flower bud and flower bloom. These results suggest that paclobutrazol and water stress could effectively enhance flowering of mango.

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

PERTUMBUHAN, TINDAKBALAS FISIOLOGI DAN BIOKIMIA TERKESAN DENGAN PAKLOBUTRAZOL UNTUK MERANGSANG PEMBUNGAAN TERHADAP TANAMAN MANGGA (*Mangifera indica* cv. HARUMANIS) YANG KEKURANGAN AIR

Oleh

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Harumanis adalah kultivar mangga yang terkenal di Malaysia terutamanya di pasaran tempatan mahupun eksport. Walau bagaimanapun, pembungaan Harumanis dipengaruhi oleh perubahan cuaca. Oleh itu, keadaan cuaca yang sesuai diperlukan untuk Harumanis memulakan pembungaan. Pada dasarnya, pokok mangga memerlukan tempoh kering yang panjang untuk menghasilkan pucuk pembiakan. Oleh itu, adalah sangat penting untuk memahami peranan kemarau dalam memulakan pembungaan. Pembungaan mangga Harumanis juga boleh diransang secara kimia dengan menggunakan paklobutrazol iaitu pengawalatur pertumbuhan untuk meningkatkan hasil. Oleh itu, kajian ini dijalankan untuk menentukan kesan paklobutrazol dan kekurangan air terhadap pertumbuhan vegetatif, tindakbalas fisiologi dan biokimia, dan pembungaan Harumanis. Aplikasi paklobutrazol (0.75g b.a./ pokok) pada pokok mangga (*Mangifera indica* cv Harumanis) berumur tiga tahun yang di tanam di dalam bekas telah dikaji di kawasan lapangan pada Disember 2011 hingga Mac 2012 secara Rekabentuk Lengkap Terawak (RLT) dengan 7 replikasi. Terdapat tiga rawatan diberikan terhadap pokok antaranya (T1): Pokok kawalan dan disirami air setiap hari (Keupayaan air tanah dikekalkan pada 0-15 kPa); (T2): 0.75g bahan aktif paklobutrazol secara siraman lencunan tanah diberikan diikuti kekurangan air selama 21 hari (Keupayaan air tanah dikekalkan pada -40 kPa); dan (T3): Kekurangan air selama 30 hari (Keupayaan air tanah dikekalkan pada -40 kPa). Pokok (T2) dan (T3) akan disiram air selepas tempoh kekurangan air. Antara semua rawatan, paklobutrazol dengan kekurangan air (T2) menunjukkan kesan secara signifikan terhadap pengurangan panjang pucuk daun dan perkembangan daun (saiz dan keluasan daun) berbanding dengan rawatan lain. Kandungan fisiologi dan biokimia pokok mangga terkesan oleh paklobutrazol dan kekurangan air (T2) berbanding pokok kawalan (T1) dan pokok kekurangan air (T3). Paklobutrazol mengurangkan secara signifikan kadar fotosintesis, konduktiviti stomata dan kadar transpirasi; tetapi meningkatkan kandungan sukrosa dan kepekatan kanji dalam daun mangga. Selain itu, pokok yang dirawat dengan paklobutrazol dan kekurangan air (T2) menghasilkan bunga yang padat serta bertangkai pendek, dan jumlah set buah yang sedikit. Terdapat sedikit pembungaan berlaku pada pokok kawalan (T1) manakala tiada pembungaan berlaku pada pokok kekurangan air (T3) sehingga 12 minggu tempoh eksperimen (Appendix F1). Tindakbalas fisiologi

(kadar fotosintesis, konduktiviti stomata, dan kadar transpirasi) pokok yang dirawat dengan paklobutrazol adalah lebih tinggi semasa peringkat pra-pembungaan dan menurun semasa peringkat pembentukan putik bunga, tetapi meningkat semasa bunga mekar. Kandungan biokimia iaitu kandungan klorofil, kandungan sukrosa, dan kepekatan kanji adalah lebih tinggi semasa peringkat pra-pembungaan berbanding semasa peringkat inisiasi bunga, putik bunga dan bunga mekar. Keputusan ini mencadangkan bahawa aplikasi paklobutrazol dan kekurangan air boleh secara efektif mempercepatkan pembungaan pokok mangga.

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Nur Afigah Aris

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

%	Percentage
µ	Micro
^oC	Degree-celcius
≤	Less than and equal to
≥	Greater than and equal to
*	Significantly different at $P \leq 0.05$
a.i	Active ingredient
ANOVA	Analysis of Variance
cm	Centimeter
CRD	Completely Randomized Design
cv.	Cultivar
et al.	And friends
FAMA	Federal Agriculture and Marketing Authority
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistical Database
FW	Fresh weight
g	Gram
g/mol	Gram per mol
H_2O	Water
Ha	Hectare
HCL	Hydrochloric Acid
Kg	Kilogram
L	Litre
LSD	Least Significant Difference
ml	milliliter
m	metre
MARDI	Malaysian Agriculture Research and Development Institute
NAOH	Sodium Hydroxide
pH	Measurement of Acidity/ Alkalinity
RM	Ringgit Malaysia
rpm	Rotation per minute
SPSS	Statistical Package for Social Science
s	Second
t	Metric Tonnes
Var	Variety
PBZ	Paclobutrazol

CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia is a producer of a wide range of tropical fruits such as pineapple, banana, mango, rambutan, durian, mangosteen, jack fruit, and star fruit. However, the entire fruit industry in Malaysia is relatively small and unable to meet the demand. Therefore, government has to import fruit from neighbouring country such as Thailand, the Philippines, and India especially on mango fruit.

Mango (*Mangifera indica* L.) is considered as one of the most popular fruits among people in the tropical area and developed countries (Lucy, 2011). Due to its wide adaptability, high nutritional value, richness in variety, delicious taste, pleasant flavour, and attractive appearance, the demand on the mango fruit is still high until today (Anon, 1998).

Malaysia has many types of mangoes cultivar such as Maha 64, Harumanis, Sala, and Telor. Among the mango cultivars, 'Harumanis' is the leading commercial cultivar on north Peninsular Malaysia, which undoubtedly has the maximum consumer demand not only in Malaysia but also in the international market. Harumanis mango can only be found in Perlis and well known as the uniqueness of Perlis among Malaysian. Besides that, Harumanis mango is also considered as the ''King of Mangoes'' (Johnson and Parr, 1997) because of its deliciousness, excellent taste, aromatic fragrance and has a very nice texture.

Harumanis mango has high commercial value in the market (Appendix A) and potential for export. Perlis exported 100 kg Harumanis to Hong Kong and 3 tonnes to Singapore in 2013 (Utusan Malaysia, 2013). Besides that, Harumanis mango is considered as an exotic fruit with high market price in Japan where the price can be as high as RM400 for two fruits (Bernama, 2013).

Some interesting facts about Harumanis, the fruit only produce nice aromatic fragrance and very sweet taste when planted in Perlis. However, in some states (Negeri Sembilan, Kedah and Perak) and farmers from neighboring countries such as Thailand have tried planting Harumanis, unfortunately, have not been successful. The quality of fruit is not similar as those planted in Perlis even though the trees grew vigorously, but producing fruits that are not sweet (Omran Hashim, Director, MARDI Negeri Sembilan, pers. comm. 20 August 2011).

Previous study has found that, Harumanis is suitable to be planted in Perlis because of the "winter wind". This phenomenon happened because of prolonged hot climate and drought season that usually occurs for 3-4 months in a year from October to December,

which triggers flowering and fruiting (Syed Ridzuwan, 2008). Following to this, the flowering season of Harumanis only occurs in January until February. Currently, flowering of Harumanis depends too much on the changes in the weather and thus, produces yield only once a year, compared to other mango cultivars that can produce flowers almost twice a year. This seasonality constraints has somehow hindered potential of higher production of Harumanis. Usually, fruit of Harumanis takes 12 weeks to fully-developed and the harvest season will take place on middle of April until May every year (Zakaria *et al*., 2012).

1.2 Problem statement and objectives

In Malaysia, the rainfall distributions vary from year to year. Different mango cultivars also differ in their nature of flowering. The abundance and frequency of flowering depends on the ability of the tree to respond to the drought conditions. Low intensity and inconsistency of flowering and fruiting are still considered as a major problem in mango cultivation in Malaysia especially Harumanis. Therefore, it is necessary to investigate the role of drought on stimulation of flowering. Currentlly, work on flowering stimulation by drought is not conclusive.

Mango flowering can also be induced chemically to enhance early flowering and the fruit production. Growth substances such as paclobutrazol (PBZ), a gibberellin biosynthesis inhibitor, had been found to be very effective in promoting flowering in mango (Kulkarni, 1988; Shinde *et al*., 2000)

Induction of flowering in mango has been widely reported for matured trees under field conditions in Indonesia. However, work on trees less than three-year-old has not been sufficiently documented (Husen *et al*., 2012).

Study on Harumanis in Malaysia is still lacking especially on flowering manipulation. Therefore, this study is carried out as an attempt to stimulate flowering of Harumanis outside Perlis. The growing environment that similar to Perlis weather which has dry period was developed and the use of growth substances particularly PBZ and combine with drought stress were imposed to stimulate profuse flowering and fruiting of Harumanis.

Therefore, this study is very important to determine the effect of PBZ and water stress on vegetative growth and reproductive of Harumanis. In order to meet the above objective, two experiments were carried out in container under field condition as follows:

1. The effect of PBZ and water stress on vegetative growth (leaf sizes and flush length), physiological responses and biochemical content of mango leaves cv. Harumanis plants.
2. The effect of PBZ on flowering of mango cv. Harumanis under water stress condition.

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