UNIVERSITI PUTRA MALAYSIA

GROWTH, PLANT HEIGHT, PHYSIOLOGICAL AND QUALITY OF ROCKMELON (Cucumis melo L.) INFLUENCED BY FERTILIZER TYPES AND POLLINATED BEES (Trigona thoracica Smith) UNDER NETTED HOUSE

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By

NIK ZURAILA BINTI NIK HASSAN

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

GROWTH, PLANT HEIGHT, PYSIOLOGICAL AND QUALITY OF ROCKMELON (*Cucumis melo* L.) INFLUENCED BY FERTILIZER TYPES AND POLLINATED BEES (*Trigona thoracica* Smith) UNDER NETTED HOUSE

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Chair : Assoc. Prof. Siti Zaharah Sakimin, PhD
Faculty : Agriculture

Fertilizer is an important substance containing chemical element that improve rockmelon growth either from organic or inorganic source. To produce a good quality of rockmelon, it has to be planted in netted greenhouse to avoid pest and disease infection and irrigated using a fertigation system. However, farmers required high cost for greenhouse construction, fertilizer and labour to do assisted pollination for rockmelon production. Two experiments were carried out with the objectives of study were (i) to determine the changes on growth, yield and quality of rockmelon influenced by different types of fertilizer and (ii) to compare the successful rate of different pollination methods. The experiment was conducted in Field 2, Faculty of Agriculture, Universiti Putra Malaysia, Serdang, Selangor. In Experiment 1, five different ratio of organic (OF) and chemical (CF) fertilizer: (T1) 100% CF + 0% CF (1:0) as control, (T2) 75% CF + 25% OF (3:1), (T3) 50% CF + 50% OF (1:1), (T4) 25% CF + 75% OF (1:3) and (T5) 0% CF + 100% OF (0:1) were tested. The experiment was arranged in Randomized Complete Block Design (RCBD) with four replications. Plant height, leaf length and leaf width of rockmelon were measured at every week interval until 6 weeks after planting (WAP) of maximum growth, while physiological changes including photosynthesis, transpiration, stomatal conductance and chlorophyll content were measured at 30 and 60 days after planting (DAP). Rockmelon fruit diameter was measured at every week interval after flower bloomed. Fruit weight and postharvest quality rockmelon including soluble solid concentration (SSC), colour, firmness, sugar (sucrose, glucose and fructose) and organic acid (citric, malic, oxalic and succinic acid) as well as macronutrient content (N, P, K, Ca and Mg) in leaf tissue were measured at harvest stage. Plant height of rockmelon of T1 and T2 were significantly higher than T3, T4 and T5. The leaf length and width of rockmelon increased as plant height increased. The types of fertilizer used which has different composition of nutrient content has influenced on plant growth. Stomatal conductance, photosynthesis rate and

transpiration rate on leaf also increased as plant height, leaf length and leaf width increases. Besides, stomatal conductance, photosynthesis rate and transpiration rate were higher at 30 DAP and decreased at 60 DAP. T1 had significant higher stomatal conductance, photosynthesis rate and transpiration rate compared to other treatment. The chlorophyll content of T5 and T1 increased at 30 DAP and the reading was decreasing for T1 at 60 DAP. T1 of rockmelon showed the highest fruit diameter and fruit weight followed by T2, T3, T4 and T5. The fruit colour in term of lightness (L*) and chromaticity (Ch*) had no significant difference among treatments, while hue angle (h*) of fruit is significant higher at T1 followed by T2 to T5 with no significant difference each other and T5 has the lowest Ch*. In addition, T1 showed the significantly highest SSC (14.5%) and lowest fruit firmness than other treatment followed by T2. The fruit firmness decreases as a result of SSC increases. There were significantly different on organic acid content between the treatments. Plant treated with T5 has the highest organic acid (oxalic, malic, citric and succinic acid). The amount of fumaric acid showed a little amount and almost closed each other between all treatments. In Experiment. 2, the effect of two factors including fertilizer type (FT) and pollination method (PM) were tested on growth and yield of rockmelon. The rockmelon plant was fertilized using different FT (T1 and T2) and were subjected to three PMs (bees, human and natural). The experiment was arranged in split plot design with factorial and four replications. Plant growth of each treatment showed no significant between treatment and no interaction between PM and FT. There were significantly different on pollination rate as influenced by PM, FT and interaction between PM and FT. Results showed rockmelon plant fertilized with T2 and pollinated by human showed the highest pollination rate compared to other treatment and followed by pollinated by bees under both types of fertilizer used. There were no significant difference on fruit weight, fruit diameter between treatments with T2 exhibited the highest fruit diameter than T1. The fruit SCC and firmness had significant interaction between PM and FT. Plant fertilized with T2 had the highest SCC and firmness than T1 treatment. There were no significant differences on organic acid of rockmelon between treatments. Significant interaction was found between PM and FT on sucrose content of rockmelon fruit. Rockmelon plant pollinated by bees had the highest sucrose content than human and natural pollination. Interestingly, rockmelon plant pollinated by bee was found successfully to increase number of fruit and number of survival bees is highest in netted greenhouse treated with T2 compared to netted greenhouse treated with T1. However, the number of dead bees increases with day after placing. In conclusion, T2 improved fruit quality and give the same yield as T1 besides reducing the amount of CF. The use of OF attract the bees to pollinate the flower than the use of CF with no different on organic compound of rockmelon fruit.

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

PERTUMBUHAN, FISIOLOGI DAN KUALITI ROCKMELON (*Cucumis melo* L.) DIPENGARUHI OLEH JENIS BAJA DAN LEBAH PENDEBUNGAAN (*Trigona thoracica* Smith) DI DALAM RUMAH LINDUNGAN HUJAN

Oleh

NIK ZURAILA BINTI NIK HASSAN

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Pengerusi : Prof. Madya Siti Zaharah Sakimin, PhD
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Baja merupakan unsur kimia yang boleh membantu pertumbuhan rockmelon sama ada daripada sumber organik ataupun bukan organik. Untuk menghasilkan buah rockmelon yang berkualiti tinggi, rockmelon perlu ditanam di dalam rumah hijau untuk mengelakkan jangkitan perosak dan penyakit, serta pengairan menggunakan sistem fertigasi. Walau bagaimanapun, petani memerlukan kos yang tinggi untuk pembinaan rumah hijau, baja dan buruh untuk melakukan pendebungaan aruhan bagi penghasilan rockmelon. Dua eksperimen telah dijalankan dengan objektif kajian adalah (i) untuk menentukan perubahan terhadap pertumbuhan, hasil dan kualiti buah rockmelon dipengaruhi dari penggunaan jenis baja yang berlainan dan (ii) untuk membandingkan kadar keberjayaan kaedah pendebungaan. Eksperimen telah dijalankan di Ladang 2, Fakulti Pertanian, Universiti Putra Malaysia, Serdang, Selangor. Eksperimen 1, lima gabungan nisbah baja organik (OF) dan kimia (CF) yang berbeza: (T1) 100% CF + 0% CF (1:0) sebagai kawalan, (T2) 75% CF + 25% OF (3:1) (T3) 50% CF + 50% OF (1:1), (T4) 25% CF + 75% OF (1:3) dan (T5) 0% CF + 100% OF (0: 1) telah dikaji. Eksperimen ini disusun dalam Rekabentuk Blok Lengkap Rawak (RCBD) dengan empat replikasi. Ketinggian pokok rockmelon, panjang daun dan lebar daun diukur pada setiap minggu hingga minggu ke 6 selepas penanaman (WAP) iaitu pada pertumbuhan maksimum, sementara perubahan fisiologi termasuk fotosintesis, transpirasi, konduktiviti stomata dan kandungan klorofil diukur pada 30 dan 60 hari selepas penanaman (DAP). Diameter buah rockmelon diukur pada setiap seminggu selepas pengeluaran buah. Berat buah dan kualiti pasca tuai termasuk kandungan pepejal larut (SSC), warna, ketegaran, gula (sukrosa, glukosa dan fruktosa) dan asid organik (asid sitrik, malik, oxalic dan succinic) serta kandungan makronutrien (N, P, K, Ca dan Mg) dalam tisu daun diukur pada peringkat penuaian. Ketinggian pokok rockmelon T1 dan T2 adalah ketara berbeza lebih tinggi dari T3, T4 dan T5. Panjang dan lebar daun rockmelon meningkat apabila ketinggian pokok meningkat. Jenis baja yang digunakan mempunyai kandungan komposisi yang berbeza telah

mempengaruhi pertumbuhan pokok. Konduktiviti stomata, kadar fotosintesis dan kadar transpirasi pada daun juga meningkat apabila ketinggian pokok, panjang dan lebar daun meningkat. Di samping itu, konduktiviti stomata, kadar fotosintesis dan kadar transpirasi lebih tinggi pada 30 DAP dan menurun pada 60 DAP. T1 mempunyai konduktiviti stomata, kadar fotosintesis dan kadar transpirasi yang lebih tinggi berbanding dengan rawatan lain. Kandungan klorofil T5 dan T1 meningkat pada 30 DAP dan bacaannya telah menurun untuk T1 pada 60 DAP. T1 pokok rockmelon menunjukkan diameter buah dan berat buah yang tertinggi diikuti oleh T2, T3, T4 dan T5. Warna buah dari segi cahaya (L*) dan kromatik (Ch*) tidak mempunyai perbezaan yang signifikan di antara rawatan, manakala sudut hue (h*) buah adalah lebih tinggi pada T1 diikuti oleh T2 hingga T5 tanpa perbezaan yang signifikan antara satu sama lain dan T5 mempunyai nilai kromatik yang paling rendah. Tambahan pula, T1 menunjukkan SSC tertinggi (14.5%) secara signifikan berbanding rawatan lain diikuti oleh T2. Penurunan ketegaran buah adalah disebabkan oleh peningkatan SSC. Terdapat perbezaan ketara ke atas kandungan asid organik diantara rawatan. Pokok yang dirawat dengan T5 mempunyai asid organik tertinggi (asid oxalik, malik, sitrik dan sucsinik). Jumlah asid fumarik menunjukkan jumlah yang sedikit dan hampir sama antara satu sama lain dalam semua rawatan. Experimen 2, kesan dua faktor termasuk jenis baja (FT) dan kaedah pendebungaan (PM) telah diuji pada pertumbuhan dan hasil pada rockmelon. Pokok rockmelon yang telah dirawat menggunakan FT (T1 and T2) dan tiga PM yang berbeza (lebah, manusia dan semula jadi). Eksperimen itu disusun dalam rekabentuk plot berpecah secara berfaktor dengan empat replikasi. Pertumbuhan tanaman bagi setiap rawatan tidak menunjukkan keputusan yang ketara diantara rawatan dan tiada interaksi di antara PM dan FT. Terdapat perbezaan yang bererti bagi kadar pendebungaan yang dipengaruhi oleh PM, FT dan interaksi di antara PM dan FT. Keputusan menunjukkan tanaman rockmelon yang dibaja dengan T2 dan disenyawakan oleh manusia menunjukkan kadar persenyawaan tertinggi berbanding dengan rawatan lain dan diikuti pendebungaan oleh lebah di bawah penggunaan dua jenis baja yang berbeza. Tidak terdapat perbezaan yang ketara terhadap berat buah dan diameter buah di antara rawatan dengan T2 menunjukkan diameter buah tertinggi berbanding T1. SCC dan ketegaran buah mempunyai interaksi yang ketara diantara PM dan FT. Tumbuhan yang dibaja dengan T2 mempunyai SCC dan ketegaran tertinggi berbanding rawatan T1. Tiada perbezaan ketara ke atas asid organik buah rockmelon diantara rawatan. Interaksi yang ketara dapat dilihat di antara PM dan FT ke atas kandungan sukrosa buah rockmelon. Pokok rockmelon yang disenyaawakan oleh lebah mempunyai kandungan sukrosa tertinggi berbanding pendebungaan oleh manusia dan secara semulajadi. Menariknya, pokok rockmelon yang disenyawakan oleh lebah telah berjaya meningkatkan bilangan buah dan bilangan lebah bertahan hidup tertinggi di rumah jaring dengan T2 berbanding dengan rumah jarring yang dirawat dengan T1. Walau bagaimanapun, bilangan lebah mati meningkat dengan hari selepas diletakkan. Kesimpulannya, T2 meningkatkan kualiti buah dan memberikan hasil yang sama seperti T1 disamping dapat mengurangkan jumlah CF. Penggunaan OF menarik lebah untuk melakukan pendebungaan bunga berbanding dengan penggunaan CF tanpa perbezaan ke atas sebatian organik buah rockmelon.

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

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

%	Percentage
*	Significant at p≤ 0.05
**	Significant at p≤ 0.01
***	Significant at p≤0.001
β	Beta
^{o}C	Degree Celsius
µg	Microgram
MOA	Ministry of Agriculture
ANOVA	Analysis of variance
RCBD	Randomize complete block design
MARDI	Malaysian Agriculture Research Development Institute
cm	Centimeter
et al.	And others
g	Gram
HPLC	High-performance liquid chromatography
kg	Kilogram
LSD	Least significant different
L	Liter
mg	Milligram
ml	Milliliter
ml/L	Milliliter per liter
ml/min	Milliliter per minute
mg/g	Milligram per gram
mm	Millimeter

mmol	millimoles
NaOH	Sodium hydroxide
NS	Non-Significant
RH	Relative humidity
rpm	Rotations per minute
SSC	Soluble solids concentration
UV	Ultraviolet
DAP	Day after planting
WAP	Week after planting
PH	Plant height
LL	Leaf length
LW	Leaf width
Ps	Photosynthetic rate
g_s	Stomatal conductance
Tr	Transpiration Rate
Cc	Chlorophyll content
CF	Chemical fertilizer
OF	Organic fertilizer
IF	Integrated fertilizer
PM	Pollination method
dw	Dry weight
H_2SO_4	Sulphuric acid
H_2O_2	Hydrogen peroxide
N	Nitrogen
P	Phosphorus
K	Potassium

Ca	Calcium
Mg	Magnesium
EC	Electrical conductivity
CCD	Coconut coir dust
t/ha	Tonne per hectare
BFJ	Biomass fermentation Juice
N	Newton
µL	Microlitre
µm	Micrometre
PDA	Photodiode array detector
RI	Refractive index
L*	Lightness
C*	Chromaticity
h^o	Hue angle
m^3	Meter cubic
TA	Titratable acidity
BP	Bees pollination
HP	Human pollination
NP	Natural pollination

CHAPTER 1

INTRODUCTION

Agriculture is an important sector which contribute to the economic growth in Malaysian. As stated in 10th Malaysia Plan (RMK10), melon is one of the 16 important fruits can be grown to increase smallholder's or farmer's income (DOA, 2010). Rockmelon received high demand among consumer but the production in Malaysia is decreasing due to high initial cost in fertigation and to build a netted greenhouse. Usually, lack of knowledge among farmers and small amount of investment makes them to refuse to follow the recommended good agriculture practices for rockmelon production which then may lead to pest and disease infection (Bakar & Sum, 2020).

In Malaysia, rockmelon is one of the favourite choices among melon as compared to watermelon and honeydew because of their flesh crunchiness and juiciness (Zulkarami et al., 2011; Perkins et al., 2012). Rockmelon is almost similar to red watermelon in terms of botanical family but they are different in size, flesh color and shape according to their varieties (Maina et al., 2017). Rockmelon is a type of fast-growing fruit among other fruits. Thus, farmers can create new market opportunity and offer plenty of choices to the consumers to the high-quality fruit product. Rockmelon is also very nutritious when consumed (Blomhoff, 2010). Rockmelon fruit contain 90% of water which it can helps to prevent dehydration (Mateljan, 2014). It is also high in beta carotene (source of Vitamin A) which is good for body and also contains potassium which is important in maintaining a healthy blood pressure and kidney function (Batta, 2016). These criterias of rockmelon are superior therefore have attracted farmers to grow, especially in the local market. According to Department of Agriculture (DOA, 2019), melon production locally was reported about 166,812 metric tons. Rasmuna et al. (2015) stated that rockmelon received high demand from our local consumer however, the supply is unsufficient. In order to meet the increasing demands of domestic and international, growers had tried various methods to increase rockmelon production. To meet the demand, grower need to produce high yield to accommodate at least local demand. However, high cost for greenhouse construction, labor as well as fertilizer are among the issues and factors affecting the rockmelon production faced by farmers (Castilla & Hernandez, 2006).

There are several factors which influence plant physiological and fruit quality of rockmelon. One of the factors is type of fertilizer in order to provide necessary nutrient and improve fruit quality (Berahim et al., 2016). Rockmelon commonly fertilized using fertigation system via liquid fertilizer supplied directly to the roots in soilless media by drip irrigation (Jusoh et al., 2020). Zulkarami et al. (2010) stated this technique is efficient as it can minimize the usage of water and efficient fertilizer management. According to Malhotra (2016), crop also can absorb huge amount of nutrient by water soluble fertilizer in fertigation system.

Recently, inorganic fertilizer is a major choice of the grower in fertigation system due to its availability containing complete nutrient to the plant and increasing yield production, although can be quite costly and detrimental to the environment (Liu et al., 2014). Thus, alternative source of fertilizer can be a solution to replace the consumption of 100% chemical fertilizer (CF) in rockmelon fertigation. Organic fertilizers (OF) are available in various forms such as liquid and solid form (granule and compost). Normally, plant grown organically used soil as planting medium because the application various forms of OF can affect plant growth either by providing direct to the soil or in the liquid form (Piccolo et al., 1992; Song et al., 2009). The soluble organic content in soil is higher under organic than inorganic fertilization (Okamoto et al., 2003). However, limited information is available on suitable integration or integration of CF and OF in the liquid form to be used as nutrient solution for fertigation system. Anwar et al. (2005) had stated that the further fertilizer integration between organic and inorganic fertilizer gave the highest yield on plant production of french basil, especially through fertigation system. In addition, Savci (2012) also reported the uses of exceed CF create serious problem to our environment. Moreover, consumer preference moving toward organic product are increased due to health awareness.

Apart from fertilization factors, pollination is also the crucial aspect required to ensure the successful plant and fruit production. It can be done either naturally or via pollination agents including human, insect or wind. According to Bommarco et al. (2012), pollination can naturally occur in the presence of insects such as bees in open fertigation system while human (assistance) manually does the pollination process in close greenhouse system. Botanically, cucurbits family (rockmelon and watermelon) are notorious in term of pollination. Sidik et al. (2012) also reported the rockmelon have separate between female and male flower on the same plant. It's means that pollen must be carried from male to female flower in order to ensure the pollination to occur especially when the plant grown under netted greenhouse (Whelan et al., 2009). Thus, the pollinator types need to be investigated as well as integrated farming between crops and pollinator insect (bees). *Trigona thoracica* Smith (stingless bees) is a one importance pollinator in fruit crop production (Tandon et al., 2001). Stingless bees also called as 'lebah kelulut' is the wild bees and a natural pollinator for various plants in Asia (Robinson et al., 2012). Honey bees are the most economically valuable pollinators of worldwide. Kelulut is the dominant flower visitors, and were the only species which collected pollen and acted as potential pollinators (Wahala & Huang, 2005). Honey bees are cheap, convenient and versatile, but for some crops they are not effective to be used on a per flower basis (Kremen et al., 2002).

Based on the factors discussed, this trial aims to evaluate the related factors on the production of rockmelon under netted greenhouse system via two experiments which were carried out (i) to determine the changes in plant pysiological, yield and quality of rockmelon *(Cucumis melo* L.) using different type of fertilizer, (ii) to compare method of pollination and different types of fertilizer application on the successful fertilization rate.

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