UNIVERSITI PUTRA MALAYSIA

SALINITY AND NUTRIENT EFFECTS ON PLANT GROWTH, PHYSIOLOGY AND FRUIT QUALITY OF ROCKMELON (*Cucumis melo* L.) CULTIVATED UNDER SOILLESS SYSTEM

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FP 2018 106

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By

YAQOOB ALI NASSER AL-MAHROUQI

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

October 2018

DEDICATION

THIS THESIS IS ESPECIALLY DEDICATED TO MY FAMILY, WITHOUT THEIR CARING SUPPORT IT WOULD NOT HAVE BEEN POSSIBLE, AND OTHER LOVED ONCE

TO ANYONE WHO HAS SHOWN ME FRIENDSHIP AND KINDNESS DURING THE TIME IT TOOK ME TO COMPLETE THIS RESEARCH AND WRITE THE THESIS

Abstract of thesis presented to the Senate of Universiti Putra Malaysia In fulfillment of the requirement for the degree of Master of Science

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October 2018

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Salinity possesses challenges for agriculturalist to obtain optimum crop productions, yet could be employed as one of management strategies to modulate better quality of produce. In most cases, salinity potentially restricts nutrients balance, growth and production in many crops due to poor major nutrients availability and macronutrients deficiencies. Therefore, the overall objective of this study was to investigate the interactive effects of salinity and macronutrients on plant growth, physiology and fruit quality of melon (*Cucumis melo* L.) grown under soilless media system.

Three (3) experiments were conducted to study the effects, best management of salinity, and macronutrients fortification in order to enhance the yield and quality of *Cucumis melo L*. In the first study, the effects of salinity from sodium chloride (NaCl) were assessed on the growth, physiology, and yield of *(Cucumis melo* L.) cultivar MG 9. The crop was grown in a substrate soilless culture using coco peats as medium from transplanting until harvest. Salinity treatment was imposed at 4.0 mS/cm whilst nutrient solution at 1.5 mS/cm acts as control set under completely randomized design (CRD) with four (4) replicates. Stem height, fresh fruit weight, fruit texture, total soluble solid, stomata conductance, transpiration rate, and net photosynthetic rate parameters were evaluated. The results imply that, no significant effects of salinity on the growth, physiology and yield of *C. melo*. Since, no significant difference were indicated, the rate of salinity imposed potentially to be used for further studies to elevate quality produce.

The second (2) and third (3) experiments were conducted to evaluate the influence salinity sources in enhancing yield and fruits quality of *C. melo*. Sodium chloride (NaCl), potassium nitrate (KNO_3) and macronutrients fortifications were used as the salinity sources at control concentration of 4.0 mS/cm each. The water (H_20) and basic solution were used as control. All treatments were supplied with the same nutrients solution with completely randomized design (CRD) experiments in four (4) replicates. Parameters such as stem height, leaf area index (LAI), plant fresh and dry weight, fruit texture, total soluble solids, fruit dry weight, titratable acidity, stomata conductance, transpiration rate, net photosynthetic rate, leaf water potential and nutrient accumulations were evaluated. Results demonstrated that, the parameters studied were independent of salinity sources except for relative water content, leaf water potential, fruit diameter, and plant fresh weight. These parameters were recorded to be reduced if 4.0 mS/cm macronutrients in the nutrient solution were used.

Macronutrients reduced water potential 57.5 % over control set. Similarly, it too reduced plant fresh weight by 38.4 %, 37.4 %, and 34.3 % over the control, NaCl, and KNO_3 treatments respectively. On the other hand, KNO_3 treatment reduced the RWC and leaf water potential but no significant effect on Ca, plant fresh weight and fruit diameter were recorded.

Overall conclusion indicated that, *C. melo* cultivar of MG 9 was moderately tolerant to 4.0 mS/cm NaCl salinity. The treatments of sodium chloride (NaCl), potassium nitrate (KNO_3), and macronutrients at the rate of 4.0 mS/cm were not effective in enhancing yield and overall fruit quality of *C. melo*.

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

KESAN KEMASINAN DAN PENGAMBILAN NUTRIENT TERHADAP PERKEMBANGAN TUMBUHAN, FISIOLOGI DAN KUALITI BUAH ROCK MELON (*Cucumis melo L.*) YANG DITANAM MENGGUNAKAN SISTEM KULTUR TANPA TANAH

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Keasinan medium tanaman memberi cabaran kepada ahli pertanian bagi memperoleh hasil tanaman yang optimum. Meskipun begitu, ia dapat diolah sebagai salah satu strategi bagi meningkatkan kualiti produk tanaman. Keasinan secara amnya berpotensi merencatkan keseimbangan nutrien, pertumbuhan dan pengeluaran dalam kebanyakkan tanaman disebabkan kekurangan zat tumbuhan yang utama dan kekurangan makronutrien. Disebabkan itu, keseluruhan kajian ini memberi fokus kepada kesan keasinan dan zat makro kepada pertumbuhan tumbuhan, fisiologi dan kualiti buah melon (*Cucumis melo L.*) yang ditanam di media tanpa tanah.

Tiga (3) eksperimen dijalankan untuk mengkaji kesan, pengurusan keasinan yang terbaik berserta penambahan zat makro bagi meningkatkan hasil dan kualiti *Cucumis melo L*. Dalam kajian pertama, kesan keasinan dari natrium klorida (NaCl) telah dinilai terhadap pertumbuhan tanaman, fisiologi, dan hasil tanaman (*Cucumis melo L.*) varieti MG 9. Ia ditanam menggunakan serabut kelapa sebagai medium tanaman. Rawatan keasinan telah dikenakan pada kadar 4.0 mS/cm sementara rawatan nutrien pada kadar 1.5 mS/cm bertindak sebagai set kawalan di dalam reka bentuk secara rawak (CRD) berserta empat (4) replikasi. Ketinggian batang, berat buah segar, tekstur buah, jumlah pepejal larut, konduktansi stomata, kadar transpirasi, dan kadar fotosintesis telah dinilai. Keputusan menunjukkan bahawa, tiada kesan yang signifikan dari segi pertumbuhan tumbuhan, fisiologi dan hasil pada semua peringkat pertumbuhan *C. melo*. Ini menunjukkan keasinan berpotensi untuk diolah sebagai sebahagian daripada pengurusan bagi menghasilkan hasil yang lebih baik dan berkualiti tinggi.

Eksperimen kedua (2) dan ketiga (3) telah dijalankan bagi menilai pengaruh sumber-sumber keasinan dalam meningkatkan hasil dan kualiti buah *C. melo*. Natrium klorida (NaCl), kalium nitrat (KNO_3) dan zat makro digunakan sebagai rawatan berkepekatan 4.0 mS/cm. Air (H_20) dan larutan asas telah digunakan sebagai set kawalan. Semua rawatan dibekalkan dengan larutan nutrien yang sama di didalam reka bentuk eksperimen secara rawak (CRD) berserta empat (4) replikasi. Parameter-parameter seperti ketinggian batang, indeks kelebaran daun (LAI), berat basah dan kering tumbuhan, tekstur buah, pepejal larut total, berat kering buah, keasidan titratable, konduktiviti stomata, kadar transpirasi, kadar fotosintesis, potensi air daun dan pertambahan nutrien telah dinilai. Keputusan menunjukkan bahawa, parameter yang dikaji adalah bebas daripada sumber saliniti kecuali kandungan air relatif, potensi air daun, diameter buah, dan berat segar tanaman. Parameter tersebut mencatatkan pengurangan jika zat makro pada kadar 4.0 mS/cm berserta larutan nutrien digunakan. Zat makro juga mengurangkan potensi air sebanyak 57.5% berbanding set kawalan. Begitu juga, pengurangan berat segar tanaman sebanyak 38.4 %, 37.4 %, dan 34.3% berbanding set kawalan, NaCl, dan KNO_3. Manakala, rawatan KNO_3 mengurangkan RWC dan potensi air daun meskipun tiada kesan yang ketara kepada kepekatan kalsium (Ca), berat segar dan diameter buah telah direkodkan.

Kesimpulannya, *C. melo* cultivar MG 9 yang digunakan menunjukkan kadar toleransi terhadap keasinan yang agak sederhana pada kadar 4.0 mS/cm NaCl. Rawatan NaCl, KNO_3, dan zat makro pada kadar 4.0 mS/cm tidak menunjukkan kesan dalam meningkatkan hasil dan kualiti buah *C. melo* secara keseluruhan.

ACKNOWLEDGEMENTS

First of all I am sincerely thankful to the Almighty ALLAH for His protection, guidance, provision and for seeing me through. Surely, His grace is sufficient and His promises are sure. I give Him all the glory and honor.

The completion of my Master's degree would definitely assisted and help lend via some people. My deeply appreciations towards my supervisor Associate Professor Dr. Yahya Bin Awang for his infectious enthusiasm, encouragement and advice support, suggestions, patience, invaluable advice and guidance throughout the period of this study.

My gratitude also goes to the Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia (UPM), for providing the seed, pots and media used in this study, and to the technical and support staff for their assistance during the performance of experiments.

Finally, I want to express my sincere gratitude to my wife and kids for their understanding and support especially their love and care. I also would like to thank Dr Mumtaz Khan for his help, guidance and support, and to my entire classmate and my friends for their willingness to help me in completing my thesis.

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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LIST OF ABBREVIATIONS

NaCl	Sodium Chloride
KCl	Potassium Chloride
mS	Millisiemens
Ca	Calcium
°C	Degree celsius
%	Percentage
FAO	Food and agriculture organisation
K_2SO_4	Potassium sulphate
dS	Decimal
TSS	Total soluble sugar
CO_2	Carbon dioxide
Chl	Chlorophyll
RWC	Relative water content
N	Nitrogen
K	Potassium
Mg	Magnesium
NO_3	Nitrate
mM	milliMole
DAT	Day after transplanting
KNO_3	Potassium nitrate
g	Gram
h	hour
cm	centimetre
DW	Dry weight
TA	Titratable acidity
FTA	Fruit texture analyser

Mm	Millimetre
NaOH	Sodium hydroxide
P_N	Net photosynthesis
gs	Stomatal conductance
E	Transpiration rate
FW	Fresh weight
DAS	day after sowing
Mn	Manganese
Zn	Zinc
Fe	Iron
P	Phosphorous
µL	Microliter
µm	Micrometer
µmoles	Micromoles
EC	Electrical Conductivity
EDTA	Ethylene-diamine-tetraacetic acid
Kb	Kilobase
L	Litre
M	Molar
%	percent
^0C	degree celcius
AA	ascorbic acid
ANOVA	analysis of variance
CA	citric acid
CRD	completely randomized design
LSD	least significant difference
HSD	High significant difference

CHAPTER 1

INTRODUCTION

Salinity poses a serious and growing challenge to crop production in many regions of the world. Amiras and Qados (2011) noted that salinity is one of the main factors limiting the dispersal of plants in natural habitats. It is a major occurrence in arid and semi-arid regions which are estimated to constitute about 40% of the earth's area. According to an FAO (2011) report about 34 million hectares of irrigated land are now impacted by salinity. In some arid areas (Iraq for example) it is estimated that close to 50% of agricultural land has been degraded by salinity (FAO, 2003).

Gray (2014) estimated the financial implication (at a daily salinity figure of 2000 hectares), to be around 27.3 billion dollars lost to salinity annually. It is therefore both a food security and economic threat. With growing world hunger and the possibility of area expansion in agriculture becoming less probable, the need to conserve and crop marginal land and improve the efficiency of available resources has become more pertinent. A number of avenues are available for dealing with these stresses, including irrigation to flush or leach salts in saline soils, breeding of tolerant crop varieties, reclamation of saline soils etc. However, it must be noted that breeding and reclamations are, sometimes slow and painstaking processes that may take a long time to actualize. Even then, it is possible that some soils may not be fully reclaimable due to limited natural and economic resources. In some places there is the possibility that full irrigation may not be economically viable or the competition for water may be so serious that the only available source may be brackish or any other low-quality water.

Salinity limits crop growth and yield via its effects on plant water relations and metabolism. Khan *et al*. (2013) showed that salinity adversely affected the morphology, physiology and biochemical characteristics of cucumber. They argued that salinity remained one of the most deleterious factors limiting the yield of the highly popular cucumber in Oman due to the intrusion of seawater. Yasmeen *et al*. (2012) observed that most crops subjected to high salinity stress presented with smaller leaf area and markedly decreased chlorophyll content and suggested that this may be due to reduced water uptake and nutritional imbalance which lead to toxicity.

Although salinity has a largely negative effect on crop production, it is sometimes employed as a tool for the enhancement of certain crop attributes such as fruits quality. Medlinger (1994) had reported that the application of salinity enhanced the total soluble solids of Muskmelon. According to Lester *et al*. (2010), fruit marketability and quality attributes can be improved significantly by treatments with potassium sulphate (K_2SO_4). Jones *et al*. (1989) in their own work found no significant effect of salinity on the fruit quality of *Cucumis sativus*. Considering the growing incidence of salinity, the increasing scarcity of quality water for irrigation and the variable effects of salinity on crops, it is pertinent to determine the response of different crops or cultivars to salinity treatments.

Rock melon also known as cantaloupe *(Cucumis melo* L.*)* has become one of the popular fruits that are traditionally a desert plant with a variety of shapes and flesh colour often cultivated in arid or semi-arid regions. It's also cultivated in all temperate regions of the world due to its good adaptation to soil and climate and belongs to cucurbitaceae family. Fruits are consumed in the summer period and are popular because the pulp of the fruit is very refreshing, high nutritional and sweet with a pleasant aroma. In agreement with the Maas and Hoffman (1977) classification, most reports defined melons as a moderately sensitive crop having a salinity threshold of 1.0 dS m^{-1} and 8.4% yield decline/dS m^{-1} (Shannon and Francois, 1978; Mangal *et al.*, 1988).

Although salinity generally depresses melon vegetative growth and fruit development and quality, some melon cultivars can continue to grow in high saline soils. Actually, the fruit quality of some melon cultivars can be improved by irrigation with mildly saline water during fruit set, and the ability of salt tolerance melon ranks second in the Cucurbitaceae (Sivritepe *et al*., 2005). Several reports indicated that salt stress brought about an increase in parameters of fruit quality, such as total soluble sugars (TSS) (Meiri *et al*., 1995; Mendlinger, 1994), and fruit appearance (Mendlinger and Fossen, 1993). However, the salinity-induced increase in fruit quality has always been accompanied by a significant reduction in yields and the decrease in yield under saline conditions was a direct consequence of reduced fruit size, attributed to the effect of the osmotic component of soil water potential on the plant (Meiri *et al*., 1995; Shani and Dudley, 2001).

In Malaysia, rock melon is fast growing popular fruit among locals and has very high demand. High value crop such as rockmelon could open new markets for greenhouse growers in Malaysia (Cantliffe *et al*., 2001; Shaw *et al*., 2000) and give consumers in Malaysia the choice of new and high quality produces.

Mendlinger and Pasternak (1992) made a field experiment suggested that they did not find any significant differences in terms of vegetative growth, yield components, or fruit quality when saline waters were applied throughout the experiment or only during very early growth stages. When salinity was applied later, at the beginning of fruit set or during fruit ripening, it did not affect the number of fruits but reduced mean fruit weight on melon plants grown on substrate in a greenhouse (Del Amor *et al*., 1999). Although, melon is known for its tolerance to salinity, several reports suggested that salt tolerance in melons is dependent on the cultivars sensitivity (Shannon and Francois, 1978; Meiri *et al.*, 1982).

The moderately salt tolerant variety can be suggested if transplanting establishment was favour (Cuartero and Fernandez, 1999). Previously, priming of melon seeds, with

1% (EC: 18 dS m^{-1}) for 3 days able to lessen effect of NaCl and promote stress tolerance during germination but also increases salt tolerance of melons during seedling stage (Sivritepe et al., 2003).

Many studies have been conducted to evaluate the effect of salinity on plant growth, physiology and yield of different kinds of cucurbit plants like watermelon, cucumber and muskmelon. Despite melon is known for its tolerance to salinity, salt tolerance in melons is influenced on the cultivars with sensitive and tolerant cultivars existing (Shannon and Francois, 1978; Meiri *et al*., 1982). Salinity is a factor affecting the whole metabolism of the plant, as well as, its morphology and anatomy (Levitt, 1980). Other researches indicate that, salt tolerance of melon plants differs among cultivars, varying from salt sensitive to moderately tolerant (Shannon and Francois, 1978; Shannon *et al*.,1984; Mangal *et al*., 1988; Mendlinger and Pasternak,1992).

In arid and semi-arid regions and in agricultural areas in particular, the soil is cleaned from the vegetative cover such are trees with deep roots and perennial crops and plant a shallow rooting crop instead. This causes the rise of underground water, moving the salt to the top surface of the soil. Salinity problem and shortage of good quality water for irrigation mean that farmers are left without choice but to use poor quality water, which will impart negatively on crop production, with dire implication for food security. In such situation, farmers need to have knowledge of the possible response of specific crops to a given level of salinity, as well as its source. Farmers usually lack such knowledge.

This study therefore proposes to evaluate the effect of salinity water inclusion at rate of 1.5 mS/cm as a source on the growth, physiology and fruit quality of *Cucumis melo*. Since, quality produce of crops were targeted to middle to high incomes people. With ever growing higher purchasing power parity (PPP), the demand of such produce was exist. The inclusions of salinity as a way to improve would provide a significant insight to farmers to better produce their fruits.

1.1 Objective of study

- **Overall objective**

To examine and understand the effects of using salinity in order to evaluate the response of *Cucumis melo* (MG 9) in terms of plant growth, physiology and fruit quality.

- **Specific objectives**

1. To determine the effect of salinity on growth, physiological process and fruit quality parameters of rockmelon (*Cucumis melo* L)
2. To compare the different level of salinity will significantly have an effect on vegetative growth, physiological process and flowering of rockmelon (*Cucumis melo* L)
3. To evaluate and compare the effects of salinity on growth, relative water content and leaf water potential of rockmelon (*Cucumis melo* L)

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PUBLICATION

Yaqoob-Ali, N.A.A.1, Yahya. A.1, Putri Edayowati, M.W. (2018) Effect of Salinity on Growth, Physiology, Quality and Water Content of *Cucumis Melo L*. MG 9 Variety cultivated using Soilless System. *Bioscience Research*, 2018 15(2): 1145-1152.

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