POTENTIAL USE OF HYBRID VERMITEA-CHEMICAL SOLUTION FOR CULTIVATION OF HYDROPONIC VEGETABLES

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By

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POTENTIAL USE OF HYBRID VERMITEA-CHEMICAL SOLUTION FOR CULTIVATION OF HYDROPONIC VEGETABLES

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At present, hydroponic cultivation use chemical nutrient solution to provide nutrients for plant growth. Ironically, crop production with less chemical application would significantly improve the nutritional level of the crop over the full-chemicals counterpart. Therefore, the present study formulate a hybrid solution (hybrid vermitea-chemical hydroponic solution) as an alternative to increase the crop growth performances and nutritional quality while reducing the chemical application in hydroponic cultivation. Vermitea is an organic extract of vermicompost that contains high levels of beneficial microbes and soluble nutrients. While, the hybrid vermitea-chemical solution is a combination of vermitea with a certain level of Cooper commercial chemical hydroponic solution. In this study, Chinese kale were grown in hybrid vermitea-chemical hydroponic solutions that include; VT25 (25% vermitea + 75% Cooper hydroponic solution), VT50 (50% vermitea + 50% Cooper hydroponic solution), VT75 (75% vermitea + 25% Cooper hydroponic solution) and VT100 (100% vermitea) with CP ('Cooper'; commercial chemical hydroponic solution) as control. The nutrient contents of the hydroponic solutions were measured using Auto Analyzer for N and P and Atomic Absorption Spectrometry (AAS) for K, Mg, Ca, Fe, Zn, Mn and Cu. The vegetative growth performances (chlorophyll content, height, number of leaves, leaves area and fresh weight) and the vegetables quality (mineral contents, total phenolic content (TPC) and antioxidant activity) of the vegetables were also measured. The results showed that the reduce of chemical Cooper solution by 25% in VT25 solution recorded higher concentration of P, K, Mg, Fe, Zn, and Cu compared to the other hybrid treatments including the CP solution. The vegetative performances (chlorophyll content, height, number of leaves, leaves area and fresh weight) for Chinese kale in VT25 also recorded as good as its counterpart in CP solution. Meanwhile, the antioxidant activity of Chinese kale planted in hybrid vermitea-chemical solutions was significantly higher but, total phenolic contents recorded no significant different compared to vegetable

in CP solution. The study suggested that the hybrid vermitea-chemical solution could be potentially used for hydroponics, thus the usage of chemical fertilizers in producing vegetables crops could be reduced.

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

POTENSI PENGGUNAAN LARUTAN BAJA HIBRID VERMITEA-KIMIA UNTUK PENANAMAN SAYURAN HIDROPONIK

Oleh

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Pada masa ini, penanaman hidroponik menggunakan larutan baja kimia bagi membekalkan nutrien untuk pembesaran tumbuhan. Ironinya, pengeluaran tanaman dengan penggurangan penggunaan baja kimia meningkatkan kualiti nutrisi tanaman yang lebih baik berbanding tanaman yang dibaja sepenuhnya oleh baja kimia. Oleh itu, kajian ini merumuskan satu formulasi baja hibrid (larutan baja hidroponik hibrid vermitea-kimia) sebagai satu inisiatif untuk meningkatkan pertumbuhan dan kualiti nutrisi tanaman sekaligus mengurangkan penggunaan baja kimia dalam penanaman hidroponik. Vermitea adalah ekstrak organik daripada vermikompos yang mengandungi banyak mikrob yang bermanfaat dan nutrien larut. Sementara itu, larutan baja hibrid vermitea-kimia adalah gabungan vermitea dengan beberapa tahap tertentu larutan baja komersial 'Cooper' hidroponik kimia. Dalam kajian ini, sayur kailan ditanam dalam larutan baja hidroponik hibrid vermitea-kimia iaitu; VT25 (vermitea 25% + 75% larutan baja hidroponik Cooper), VT50 (50% vermitea + 50% larutan baja hidroponik Cooper), VT75 (75% vermitea + 25% larutan baja hidroponik Cooper) dan VT100 (100% vermitea) dengan CP ('Cooper'; larutan baja komersial hidroponik kimia) sebagai kawalan. Kandungan nutrien dalam larutan baja hidroponik diukur menggunakan *Auto Analyzer* untuk analisis N dan P dan *Atomic Absorption Spectrometry (AAS)* untuk K, Mg, Ca, Fe, Zn, Mn dan Cu. Pertumbuhan sayur kailan (kandungan klorofil, ketinggian, jumlah daun, luas daun dan berat basah) dan tahap kualiti dalam sayuran (kandungan mineral, jumlah kandungan fenolik dan aktiviti antioksidan) juga diukur. Keputusan menunjukkan bahawa pengurangan larutan baja kimia sebanyak 25% dalam larutan baja VT25 mencatatkan kandungan P, K, Mg, Fe, Zn, dan Cu yang lebih tinggi berbanding dengan larutan baja yang lain termasuk larutan baja CP. Pertumbuhan vegetatif (kandungan klorofil, ketinggian, jumlah daun, luas daun dan berat basah) untuk kailan yang ditanam dalam larutan VT25 juga mencatatkan keputusan yang setara dengan sayuran dalam larutan CP.

Sementara itu, aktiviti antioksida dalam kailan yang ditanam dalam larutan baja hibrid vermitea-kimia adalah jauh lebih tinggi tetapi jumlah kandungan fenolik mencatat tiada perbezaan yang signifikan berbanding dengan kailan dalam larutan baja CP. Kajian menunjukkan bahawa larutan baja hibrid vermitea-kimia berpotensi untuk digunakan dalam hidroponik, oleh itu pengurangan pengunaan baja kimia dalam menghasilkan sayur-sayuran hidroponik boleh dilakukan.

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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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LIST OF ABBREVIATIONS

ANOVA	One-way Analysis of Variance
SPSS	Statistical Package for Social Sciences
SEM	Standard Error Mean
UA	Urban Agriculture
UPM	Universiti Putra Malaysia
FAO	Food and Agriculture Organization of the United Nations
WHO	World Health Organization
USDA	United State Department of Agriculture
RBD	Randomized Block Design
NFT	Nutrient Film Technique
pH	Potential Hydrogen
EC	Electrical Conductivity
DOC	Dissolved Oxygen Content
NPK	Nitrogen, Phosphorus, Potassium
FYM	Farmyard Manure
OM	Organic Matter
GAs	Gibberellic Acids
CKs	Cytokinins
LDL	Low-Density Lipoprotein
DNA	Deoxyribonucleic Acid
ATP	Adenosine Triphosphate
GIT	Gastrointestinal Tract
NCDs	Noncommunicable Diseases
CVDs	Cardiovascular Diseases

ROS	Reactive Oxygen Species
DRIs	Dietary Reference Intakes
TPC	Total Phenolic Content
TFC	Total Flavonoid Content
DPPH	2,2,-Diphenyl-1-Picrylhydracyl
AA	Auto Analyzer
AAS	Atomic Absorption Spectrometry
CNS	Carbon/Nitrogen/Sulfur Analyzer
dS/m	deciSiemens Per Metre
rpm	Revolutions Per Minute
ppm	Parts Per Million
nm	Nanometer
GAE	Gallic Acid Equivalent
IC50	50% Inhibition

CHAPTER 1

INTRODUCTION

Urbanization has grown rapidly around the world. In 2014, about 25 per cent increment of the world population residing in urban areas compared to the past 60 years (United Nation, 2015). In Malaysia, urban population is expanding and rapidly transforming into an urban society (Masron, Yaakob, Mohd Ayob, & Mokhtar, 2012), with two-third of Malaysians live in urban areas (Yaakob, Masron, & Masami, 2010; Duflot, 2012).

The rapid growth of population led to a competing access for food supply, increasing the demand on food and nutrition which creating food security issues to the nation (Islam & Siwar, 2012). In Malaysia, the exponential growth of cities has shifted the agricultural sector from the rural to urban agriculture. Many of the arable land especially in the urban areas has been converted and utilized for housing, industrial development and building of infrastructures (Razak & Roff, 2007). Therefore, urban agriculture (UA) is getting more important and attracting a lot of attention recently. As the national agriculture-based university, Universiti Putra Malaysia (UPM) has taken a lead in introducing UA to encourage the public to practice modern farming activities in the limited spaces of their homes as an alternative for sustainable source of food by 2020 (Juraimi, 2014; Tiraieyari & Hamzah, 2015).

In UA, food crops such as vegetables are produced in a relatively small area, adopting methods and technologies that ensure good yields and quality of crops. Soil-less agriculture technique such as hydroponic is widely practiced in urban areas around the world especially in the developed countries. Hydroponic is a simple technique of planting vegetables without using soil. It is basically designed to grow plants in a solution that provide the needs for optimal plant growth (Kumar & Cho, 2014). This technique is simple, low-cost and also suitable to be practiced in limited spaces. The hydroponic container could be set-up at any places such as balcony or terrace that can provide enough sunlight for the plants (Razak & Roff, 2007).

In hydroponic, the nutrients and water are supplied directly to the plant roots. This system allows us to monitor the water and nutrient supply thus improving the plant productivity (Wahome, Oseni, Masarirambi, & Shongwe, 2011). A hydroponic solution that contains all the essential elements is required for a normal plant growth and development (Corrêa et al., 2008; Domingues, Takahashi, Camara, & Nixdorf, 2012; Libia & Fernando, 2012). For example, ‘Cooper solution’ formulated by Dr. Allan Cooper in 1979 has been commercially used as the hydroponic solution to supply the necessary nutrients to plants (Libia & Fernando, 2012).

Most of the agriculture practices at present, including hydroponics use chemicals due to their readily available of dissolving nutrients that will increase plant growth and yields (Chen, 2006; Omidire, Shange, Khan, Bean, & Bean, 2015). However, it is generally accepted that crops grown with organic fertilizers significantly showing a better nutritional value by having higher mineral contents, vitamins and antioxidant level compared to their counterparts in full chemical (Ibrahim, Jaafar, Karimi, & Ghasemzadeh, 2013; Vinha, Barreira, Costa, Alves, & Oliveira, 2014; de Oliveira et al., 2017). The crops with higher nutritional level would improve a better health for human (Dias, 2012; Slavin & Lloyd, 2012). Switching to total organic fertilizer is however not a realistic solution as some studies found that the use of fully organic could not support normal plant growth (Amanolahi-baharvand, Zahedi, & Rafiee, 2014; Ceglie, Amodio, & Colelli, 2016). Therefore, minimizing use of chemicals in hydroponic via hybrid fertilizer could be as an alternative that would increase the growth and nutritional value of the crops.

Hybrid fertilizer is produced from the combination of organic fertilizer with the minimal level of chemical fertilizer. Many studies found that the combine use of organic and chemical fertilizer is practical in improving nutrients availability hence improving crops production (Pant, Radovich, Hue, Talcott, & Krenek, 2009; Verma & Chauhan, 2013; Han, An, Hwang, Kim, & Park, 2016). Besides that, hybrid fertilizers also provide encouraging results in increasing crops yield and improving growth parameters (Meena et al., 2013). Therefore, hybrid fertilizers could be practiced in order to reduce the use of chemicals in crop production. Recently, vermicompost is getting a lot of attention due to its tremendous benefits as organic fertilizer. Some studies also showed that the conjunction use vermicompost and chemical fertilizer could improve the plant productivity (Chanda, Bhunia, & Chakraborty, 2011; Amanolahi-baharvand et al., 2014).

Vermicompost is a product of non-thermophilic biodegradation and stabilization of organic materials, by interactions between earthworms and microorganisms (Arancon et al., 2003; Edwards, Arancon, & Sherman, 2011). Whilst, vermitea, a waterbased vermicompost extract could be potentially used to supply nutrients in soil-less cultivation. Study by Quaik, Singh, & Ibrahim (2014) showed the potential use of vermitea from vermicompost as plant nutrient solution. It contains high levels of beneficial microbes, hormone-like molecules, humic substances and soluble nutrients which are good for plant development and also helps to improve biotic factors in the planting medium (Pant, Radovich, Hue, & Arancon, 2011; Salter & Edwards, 2011; Zaccardelli, Pane, Scotti, Maria, & Celano, 2012; Zhang et al., 2014).

However, no study has been reported involving the use of vermitea as hydroponic solution especially in Malaysia. Preliminary studies in Vermitechnology Lab, Biology Department, Faculty of Science, UPM (Fatin, 2015; Shahirah, 2016; unpublished) found that the vegetables planted in 100% vermitea solution showed malnutrition symptoms with low vegetative performances. Therefore, hybrid vermitea-chemical hydroponic solution is proposed in the present study in order to increase nutrients availability but at the

same time to minimize the reliance on chemical fertilizer in growing hydroponic vegetables. Thus, the objectives of this study are:

1. To determine the nutrient contents in different ratio of hybrid vermitea-chemical hydroponic solution.

2. To compare vegetative growth performances of vegetable planted in different ratio of hybrid vermitea-chemical hydroponic solution.

3. To compare biochemical quality (mineral contents, total phenolic content and antioxidant level) of vegetables planted in different ratio of hybrid vermitea-chemical hydroponic solution.

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