



***THE EFFECT OF ORGANIC, CHEMICAL AND HYBRID FERTILIZERS ON  
PLANT DEVELOPMENT AND ANTIOXIDANT LEVEL IN HYDROPONIC PAK  
CHOY (*Brassica rapa L. var. chinensis*)***

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**By**

**NOR HASNI BINTI LIZAR**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra  
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Science**

**October 2019**

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

**THE EFFECT OF ORGANIC, CHEMICAL AND HYBRID FERTILIZERS ON PLANT DEVELOPMENT AND ANTIOXIDANT LEVEL IN HYDROPONIC PAK CHOY (*Brassica rapa* L. var. *chinensis*)**

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Climate change, food security and over dependency of cheap food import are one of the major concerns facing this country. It is clear that Malaysia needs to focus more on food crops toward self-sufficiency by providing more agricultural commodities, protections and incentives towards local farmers. Therefore, to overcome these problems a study was initiated to study the impact of organic, chemical and hybrid fertilizers on NPK content, plant growth, chlorophyll and Brix content, and the antioxidant level of pak choy (*Brassica rapa* var. *chinensis*) in a hydroponic farming. Treatments of different types of fertilizer composed of: 100% chemical, 100% organic and hybrid (50% chemical + 50% organic) were used for this study. The planting experiment was conducted in completely randomized design with eighteen replications under rain sheltered area near the Department of Biology. The plant growth, chlorophyll and Brix content, and the antioxidant level were measured following established methods. There were significant different of NPK content of all types of fertilizer. Organic fertilizer has the highest N content, but the plant height & leaf area data showed poor plant development. Hybrid fertilizer showed no significant different in plant growth with chemical fertilizer. Plant treated with hybrid fertilizer had the highest Brix content with an average of  $6.17 \pm 0.76$ . Chemical, organic and hybrid fertilizer showed no significant different to the amount of chlorophyll *a*, *b* & carotenoid. The phenolics content of the pak choy treated with organic fertilizer was significantly different between pak choy treated with hybrid fertilizer only ( $p < 0.05$ ). Pak choy planted in hybrid fertilizer recorded highest antioxidant activity ( $9.69 \pm 0.35 \text{ mg/ml}$ ) compared to organic and chemical fertilizer by denoting low concentration of IC50 ( $p < 0.05$ ). In terms of scoring method, pak choy treated in hybrid fertilizer has the highest value suggesting that these plants have balance amount (in term of quantity and quality) of all beneficial aspect studied in this research. In conclusion, the results indicated that application of hybrid fertilizer produced better plant growth

performance, productivity and as good as chemical fertilizer therefore minimizing the use of chemical fertilizer.



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

**KESAN PENGGUNAAN BAJA ORGANIK, KIMIA DAN HYBRID  
TERHADAP PERTUMBUHAN TUMBUHAN DAN TAHAP  
ANTIOKSIDAN TUMBUHAN HIDROPONIK PAK CHOY (*Brassica rapa* L.  
*var chinensis*)**

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Perubahan iklim, keselamatan makanan dan kebergantungan terhadap makanan import yang murah merupakan salah satu kebimbangan utama yang dihadapi negara ini. Jelas sekali Malaysia perlu memberi tumpuan lebih kepada tanaman makanan ke arah kecukupan dengan menyediakan lebih banyak komoditi pertanian, perlindungan dan insentif kepada petani tempatan. Oleh itu, untuk mengatasi masalah-masalah ini satu kajian telah dijalankan untuk mengkaji kesan penggunaan baja organik, kimia dan hibrid pada kandungan NPK, pertumbuhan tumbuhan, kandungan klorofil dan Brix, dan tahap antioksidan tumbuhan pak choy (*Brassica rapa var. chinensis*) menggunakan kaedah penanaman hidroponik. Rawatan pelbagai jenis baja terdiri daripada: 100% baja kimia, 100% baja organik dan hibrid (50% baja kimia + 50% baja organik) telah digunakan untuk kajian ini. Kajian penanaman telah disesuaikan dengan reka bentuk rawak sepenuhnya dengan lapan belas replikasi di bawah kawasan perlindungan hujan di Jabatan Biologi. Pertumbuhan tumbuhan, kandungan klorofil dan Brix, dan tahap antioksidan diukur mengikut kaedah yang ditetapkan. Terdapat kandungan NPK yang ketara bagi semua jenis baja. Baja organik mempunyai kandungan N yang tertinggi, tetapi data ketinggian tumbuhan dan luas permukaan daun menunjukkan kadar pertumbuhan yang rendah. Penggunaan baja hibrid menunjukkan tiada perbezaan yang signifikan untuk pertumbuhan tumbuhan dengan baja kimia. Tumbuhan yang dirawat dengan baja hibrid mempunyai kandungan Brix yang tertinggi dengan purata  $6.17 \pm 0.76$ . Penggunaan baja kimia, organik dan hibrid tidak menunjukkan perbezaan yang signifikan terhadap kandungan klorofil a, b & karotenoid. Kandungan fenolik di dalam tumbuhan pak choy yang dirawat dengan baja organik menunjukkan perbezaan yang signifikan dengan tumbuhan yang dirawat dengan baja hibrid sahaja ( $p < 0.05$ ). Tumbuhan pak choy yang ditanam menggunakan baja hibrid mencatatkan aktiviti antioksidan

yang tertinggi ( $9.69 \pm 0.35 \text{ mg / ml}$ ) berbanding baja organik dan kimia dengan menunjukkan kepekatan IC50 yang rendah ( $p < 0.05$ ). Dari kaedah pemarkahan, Pak Choy yang dirawat menggunakan baja hibrid menunjukkan nilai yang tertinggi yang menandakan bahawa tumbuhan ini mempunyai kandungan yang sekata (dari segi kuantiti dan kualiti) bagi semua aspek yang bermanfaat di dalam kajian ini. Kesimpulannya, keputusan kajian menunjukkan bahawa penggunaan baja hibrid menghasilkan perkembangan dan produktiviti tumbuhan yang lebih baik setanding dengan penggunaan baja kimia dan oleh itu dapat meminimumkan penggunaan baja kimia.



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I certify that a Thesis Examination Committee has met on 21<sup>th</sup> October 2019 to conduct the final examination of Nor Hasni Binti Lizar on her thesis entitled "The effect of organic, chemical and hybrid fertilizers on plant development and antioxidant level in hydroponic pak choy (*Brassica rapa* var. *chinensis*)" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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## LIST OF ABBREVIATIONS

%	Percentage
°C	Degree
\$	Dollar
µg/g	Microgram per gram
µL	Microlitre
AAPFCO	Association of American Plant Food Control Official
AAS	Atomic absorption spectroscopy
ANOVA	Analysis of variance
chl <i>a</i>	Chlorophyll <i>a</i>
chl <i>b</i>	Chlorophyll <i>b</i>
cm	Centimetre
CRD	Completely Randomized Design
DOA	Department of Agriculture
DPPH	2,2-Diphenyl-1-picrylhydrazyl
EC	Electrical conductivity
FAO	Food and Agriculture Organization
g	Gram
GDP	Gross Domestic Product
H <sub>2</sub> SO <sub>4</sub>	Sulphuric acid
IC <sub>50</sub>	The half maximal inhibitory concentration
K	Potassium
mg GAE 100g <sup>-1</sup>	Miligram of gallic acid equivalent per 100 gram
mg mL <sup>-1</sup>	Milligram per millilitre
mg/L	Milligram per litre
ml	Millilitre
mm	Milimetre
mS/cm	Millisiemens per centimeter
N	Nitrogen
NAFP	National Agro-Food Policy
nm	Nanometre
P	Phosphorus
pcs	Pieces
ppm	Part per million
ROS	Reactive oxygen species
Rpm	Round per minute
SEM	Standard error of the mean
SPSS	Statistical Package for Science Social
TPC	Total phenolics content
UPA	Urban and Peri-urban Agriculture
UPM	Universiti Putra Malaysia
v/v	volume/volume

## CHAPTER 1

### GENERAL INTRODUCTION

Malaysia's food security are challenged by many threatening issues including global financial crisis, trade war between super power, climate change affecting agriculture productivity, cheap importation of agriculture produce as well as disease and environmental degradation. For the record, Malaysia has spent US\$10.7 billion in 2016 for food import including fruit and vegetables (FAO, 2018). According to the FAO statistics, the food import has caused an increase bill from US\$4.456 billion to US\$6.244 billion in 2005. Most of the imported foods were originated from countries such as India, China, Thailand, Australia and even Singapore.

Based on this, it is clear that this country is highly dependent on many imported agricultural products including dairy items from other countries. According to Ahmed & Siwar (2013), this dependency is due to the increasing demand as well as relatively low local productions. In accordance with the statement in the FOA report (2015), to minimize the food security issues in this country, the government should plan out strategies to reduce the dependency of products especially food items that are imported from other countries. Over dependent on food imports can cause the prices of some food items to rise partly due to the drastic drop in Ringgit value.

It is clear that Malaysia needs to focus more on food crops toward self-sufficiency by providing more agricultural commodities, protections and incentives towards local farmers. There is also an urgent need from the relevant authority to plan for more constructive policies and strategies towards reducing the food security issues by increasing local food produce. The National Agro-Food Policy (NAP) has intended to secure enough food supply for the whole nation in Malaysia (Abu Dardak, 2018). In order to achieve this, Rezai, Shamsudin & Mohamed (2016) have stated that urban agriculture has been considered as a way to maintain and stabilize the sustenance and wellbeing of urban households. According to FAO (2001), urban agriculture is considered as any agricultural practice in certain agricultural land within the cities that can provide agricultural products to a population. Urban farming has many advantages because it has the potential to improve both food security and food safety of a country. For instance according to Mougeot (2006), application of urban agriculture able to increases urban food security and it also creates sources of income to a city in Kampala, Uganda. Furthermore, by applying the hydroponic cultivation method, increase of product yield can be achieved. As been stated by Nicola, Hoeberechts & Fontana (2005), increase production yields through hydroponic have allowed a better control and standardization of the cultivation process, that ultimately reduces the overall production costs.

Currency crisis and over relying on cheap food import has forced Malaysia to consider an alternative for producing fruits and vegetables through intensive agricultural programs for a more self-sufficiency. One of the incentives is providing fertilizer subsidies to farmers to increase their production and improve their income (FAO, 2004). However, there is no strict enforcement and control on these intensive farming. The over usage of agro-chemical has caused the health of the environment to deteriorate slowly (Barrow, Weng & Masron, 2009).

Over-fertilization, especially from nitrogen fertilizer in highly productive agricultural areas has caused major environmental problems. Thompson, Martinez-Gaitan, Gallardo, Gimenez, Fernandez (2007) and Ray, (2001) have stated that environmental pollution have led to groundwater pollution and eutrophication of rivers and lakes. Not only that an excessive N fertilization can deteriorate some quality in different types of crops, but a low application of N fertilizers can enhance positive vegetative performances of crop and better its quality (Stefanelli, Goodwin & Jones, 2010). Hence, growers are encouraged to reduce the application of N fertilizers to their agricultural lands. This in-turn can lower the negative effects to the environment and at the same time increasing the sustainability of their agro-systems. In contrast, this fertilizer may produce products that contain high vitamins and minerals that will somehow improve the health of consumers (Albornoz, 2016).

The rapid growth and development of global organic agriculture were mainly due to the increasing awareness on environmental issues and food safety amongst the population. Not only that, consumers that are health conscious have begun to change their food preferences which includes more organics products. According to Azadi *et al.* (2011), in order to provide enough healthy food for a population, organic agricultural approaches have to develop and be applied. Applying a sustainable agricultural method can reduce environmental damage by minimizing chemical fertilizers and pesticides usage which in-turn can produce more non-toxic crops.

According to Ibrahim, Jaafar, Karimi & Ghasemzadeh, (2003), a sufficient amount of nutrients must be available to plants in order to produce a healthy crop. Hence, chemical fertilizers or organic fertilizers are needed to meet the growth requirements of the growing plants. It has been reported that fertilization has a positive response on the phytochemical compounds in crops. An example of phyto-nutrients in plants are antioxidants which are the substances that delay or inhibit oxidative damage (Scalbert & Williamson, 2000). Besides that, according to Wong, Li, Cheng & Chen, (2006), antioxidant also plays an important and crucial role in plant disease prevention which ultimately promotes growth of the plant.

However, it is known that chemically-based fertilizer may reduce the antioxidant levels in plants, while the organically-based fertilizer has been proven to increase antioxidant content in plants (Dumas, Dadomo, Di Lucca &

Grolier, 2003). Hence, according to Riahi *et al.* (2009), source of fertilizer used is important to determine the quality of plant and its nutrient compositions. There are a lot studies to compare the level of antioxidant compounds between the crops grown organically and chemically. As reported by Asami, Hong, Barrett & Mitchell (2003), marrion berries that were organically grown contains significantly higher total phenolic compounds compared to chemically-grown ones. Besides that, Benbrook (2005) have also validated this by stating that organic farming has elevated antioxidant levels of spinach up to 50% as compared to the food grown chemically. Not only that the antioxidant level of organically grown vegetables may increase, but also its mineral content and vitamins were also expected to increase. Based on Perez-Lopez, Del Amor, Serrano-Martinez, Fortea & NunezDelicado (2007), organic farming had a significantly positive effect on nutritional content by increasing the vitamin C, total phenolic compounds and carotenoid contents in peppers.

In the last decade, intensive farming and excessive use of chemical fertilizer produce side effects such as dead soil, loss of farm productivity, contamination of underground water and others. Excessive use of organic fertilizer also has it down side. Because of those effects, scientist and farmer began experimenting using combination of chemical and organic fertilizer. For sustainable crop production, application of hybrid fertilizer has proved to be highly beneficial (Chen, 2008; Xu, Li, Li, Qin & Kazuyuki, 2008).

Based on these current issues, this research was conducted to study the effect of organic, chemical and hybrid fertilizers on the nutrients content, plant development and antioxidant level of vegetables crop. *Brassica rapa* subsp. *chinensis* plant which is commonly known as pak choy have been chosen as the experimental plant this study.

Therefore, the following objectives were established to fulfill the requirement:

- To analyze the N, P & K content of organic, chemical and hybrid fertilizers
- To compare the effect of organic, chemical and hybrid fertilizers on the vegetative growth, chlorophyll content and brix content of *Brassica rapa*
- To compare the effect of organic, chemical and hybrid fertilizers on the total phenolics content and antioxidant activity of *Brassica rapa*

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