



Faculty of Resource Science and Technology

**Growth Performance of *Brassica sp.* Using Hydroponic Technique**

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Bachelor of Science with Honours  
(Plant Resource Science & Management)  
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# **Growth Performance of *Brassica sp.* Using Hydroponic Technique**

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A project proposal submitted in partial fulfilment of the  
Requirement for the degree of  
Bachelor of Science with Honors  
(Plant Science and Management)

Supervisor: Dr. Hollena Anak Nori

Faculty of Resource Science and Technology  
Universiti Malaysia Sarawak  
2022

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# Growth Performance of *Brassica sp.* Using Hydroponic Technique

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## ABSTRACT

Pak Choy (*Brassica rapa chinensis*) is a green leafy vegetable that most popular vegetables in Asia, including in Malaysia. However, since the local production is insufficient, it must be imported. This demand can be met by using hydroponic technique. This research was conducted to assess the growth performance of Pak Choy (*Brassica rapa C.*) plants under different nutrient concentrations in the hydroponic system. The Pak Choy species were subjected to three levels of nutrient concentrations which were (T1) 35ml fertilizer A + 35 ml fertilizer B, (T2) 25ml fertilizer A + 25ml fertilizer B, (T3) 15ml fertilizer A + 15ml fertilizer B) with 8 replications for each treatment. Each replicate consists of 3 plants making a total 24 plants for each treatment. The parameters observed were plant height, number of leaves, leaf chlorophyll content and plant above ground biomass. Data were analyzed by using a one-way ANOVA. Research results after 39 days from sowing showed that in hydroponic system, T2 proved significantly more productive than other treatment. Plants grown under T2 produced the highest plant height (11.6 cm), a greater number of leaves (7.3 leaves/plant), higher chlorophyll content (34.64 SPAD value) and lastly have the highest above ground biomass (0.075 g/plant). Although T1 have the highest concentration nutrients, however the yield production is similar with T2. This showed that the T2 concentration of 25 ml fertilizer A + 25 ml of fertilizer B can be use to obtain the optimum yield of Pak Choy and can save more budget to produce it. These findings will facilitate leafy vegetable growers in decision making on financial management, i.e. to determine the minimum cost of hydroponic nutrients while at the same time retaining optimum crop yield.

**Key words: Concentration, Hydroponic, Nutrient Solution, Pak Choy**

## ABSTRAK

Pak Choy (*Brassica rapa chinensis*) ialah sejenis sayuran berdaun hijau yang paling popular di Asia, termasuk di Malaysia. Walau bagaimanapun, memandangkan pengeluaran tempatan tidak mencukupi, ia mesti diimport. Permintaan ini boleh dipenuhi dengan menggunakan teknik hidroponik. Penyelidikan ini dijalankan untuk menilai prestasi pertumbuhan tumbuhan Pak Choy (*Brassica rapa C.*) di bawah kepekatan nutrien yang berbeza dalam sistem hidroponik. Spesies Pak Choy telah dikenakan tiga tahap kepekatan nutrien iaitu (T1) 35ml baja A + 35 ml baja B, (T2) 25ml baja A + 25ml baja B, (T3) 15ml baja A + 15ml baja B) dengan 8 replikasi untuk setiap rawatan. Setiap replika mengandungi 3 tumbuhan menjadikan jumlah keseluruhan 24 tumbuhan untuk setiap rawatan. Parameter yang diperhatikan ialah ketinggian tumbuhan, bilangan daun, kandungan klorofil daun dan biojisim tumbuhan di atas tanah. Data dianalisis dengan menggunakan ANOVA sehalu. Hasil penyelidikan selepas 39 hari dari menyemai menunjukkan bahawa dalam sistem hidroponik, T2 terbukti lebih produktif daripada rawatan lain. Tumbuhan yang ditanam di bawah T2 menghasilkan ketinggian tumbuhan tertinggi (11.6 cm), bilangan daun yang lebih banyak (7.3 daun/tumbuhan), kandungan klorofil yang lebih tinggi (nilai SPAD 34.64) dan terakhir mempunyai biojisim atas tanah tertinggi (0.075 g/tumbuhan). Walaupun T1 mempunyai nutrien kepekatan tertinggi, namun penghasilan hasil adalah sama dengan T2. Ini menunjukkan bahawa kepekatan T2 25 ml baja A + 25 ml baja B boleh digunakan untuk mendapatkan hasil optimum Pak Choy dan dapat menjimatkan bajet untuk menghasilkannya. Penemuan ini akan memudahkan penanam sayuran berdaun dalam membuat keputusan mengenai pengurusan kewangan, iaitu untuk menentukan kos minimum nutrien hidroponik dan pada masa yang sama mengekalkan hasil tanaman yang optimum.

**Kata kunci: Campuran Nutrien, Hidroponik, Kepekatan, Pak Choy**

## **Chapter 1**

### **1.0 Introduction**

Hydroponics is a plant cultivation technology that replaces soil as the primary growing medium with a nutrient-rich solution (Nugraha & Anas, 2015). A hydroponic system can be set up in a small space (Wahyuningsih et al., 2016). Due to its easy control of nutrient content, no soil-borne disease risk, increase plant development, shorter crop cycles, superior product quality, and commercial acceptance, hydroponics has become an important alternative plant production approach (Sapkota et al., 2019). There are various model of hydroponic system. From the pyramid, suspended growbag, stacked and column models to the plant factory idea (Liu et al., 2004; Hayden, 2006; Neocleous et al., 2010; Mahdavi et al., 2012; Touliatos et al., 2016; Liu et al., 2004; Hayden, 2006; Neocleous et al., 2010; Kozai, 2018). All of the systems discussed above have one thing in common where they all rely significantly on fertilizer solution to maintain healthy plant growth. It is critical to keep an eye on the fertilizer solution and make sure the plants are getting enough of it. The two most important parameters of fertilizer solution that need to be monitor and control are the pH and Electrical Conductivity (EC). The plant may not receive adequate nutrients if the pH of the fertilizer solution is too high or too low. Different nutrients are available at different pH levels. Electrical conductivity measurements can be used to monitor and adjust the nutrient solution content. Electrical conductivity is a measure of ionic strength in a solution that can be converted to concentration. Hydroponics is a very beneficial method of growing, but it is extremely dependent on monitoring the pH and EC of the fertilizer solution. Growers can get the most out of their hydroponic systems and grow large, healthy plants if pH and EC are properly measured and controlled (Dunn & Singh, 2016).

Pak Choy (*Brassica rapa chinensis*) is a green leafy vegetable belongs to the Brassicaceae family. It is one of the most popular vegetables in Asia, including in Malaysia (Cartea et al., 2010). However, because local production is insufficient to meet market demand, it must be imported. To meet the demand, RM87.0 million of *Brassica rapa*, also known as Pak Choy, was imported into Malaysia (FAMA, 2017). According to Fahey (2003) and Acikgoz (2016), Pak Choy is not only known for its economic importance but also to provide health benefits. Pak Choy contains beneficial phytochemicals, provitamin A, vitamin C, minerals and fibre. Pak-choy raw flesh comprises water, vitamin, energy, carbohydrate, protein, sugar, and different minerals in a 100-g serving (USDA, 2019). Anticarcinogenic and antioxidant chemicals are also produced by brassica vegetables (Park et al., 2014). These vegetables will aid in the digestion and absorption of glucosinolates into our bodies (Barba et al., 2016). Vegetable consumption, particularly Pak choy, is increasing as a result of the rapidly growing human population, rapid urbanization, and increased health concern. However, one of the major constraints to vegetable cultivation is a lack of land space (Sapkota et al., 2019). This demand can be met by using modern farming technology, which allows farmers to create conditions that allow crops to reach their genetic growth potential. In this regard, a hydroponic system could be an efficient crop management strategy for increasing crop yield (Maludin et al., 2020). Although hydroponic culture can produce optimal plant growth, its efficiency is dependent on a variety of factors including nutrient availability, crop genotype, growing method, and pest management (Spehia, et al., 2018). Despite insufficient production to meet the recommended minimum intake, demand for Pak Choy vegetables continues to rise (FAO, 2005). Agriculture production is

also impacted by the world's rapidly shrinking available land as a result of rapid urbanization and industrialization. In general, there is no uniform concentration of nutrient solution for vegetable growth in a hydroponic system. Depending on the type of vegetable crop, most hydroponic practices use different nutrient concentrations. Nonetheless, there is no standard nutrient concentration for a specific crop species that indicates the minimum or optimum requirement for crop productivity. This results in either under or overutilization of nutrient solution, which may result in crop underperformance or fertilizer waste. Thus, the purpose of this study was to investigate the effects of different nutrient solution concentrations on the growth of Pak Choy grown in a wick hydroponic system in relation to plant height, number of leaves and above biomass and chlorophyll content of *Brassica sp.* vegetable grown under different concentrations of AB fertilizer

## CHAPTER 2

### 2.0 Literature Review

#### 2.1 *Brassica rapa C*

Pak Choy, scientifically known as *Brassica rapa chinensis* is a leafy vegetable native to Southern and Northern China (Xie et al., 2020). Pak Choy also known as Chinese cabbage, is a popular leafy vegetable that is grown all over the world (Fatemi et al., 2020). Pak Choy is an edible biennial that is grown as an annual. Plants can reach 0.6 m in height and weigh more than 2 kg. Fresh leaves are preferred, but they can also be blanched and dried for use when fresh vegetables are scarce (Fahey, 2016). Pak Choy can only be harvested once, according to Hermanto et al., 2021. Pak Choy is harvested between 40 and 60 days after planting. When harvesting is delayed, the leaves become bitter and purplish lines appear on the stalks (Ministry of Food Production, Land and Marine Affairs, 2009). Pak Choy are hardy and this vegetable can be grown in a variety of soil types, and many crops are now grown in greenhouse as well as direct sowing (Fahey, 2016). Pak Choy is popular among the general public due to its numerous health benefits, including the presence of minerals and vitamins (Zatnika, 2010). Pak Choy has a high nutritional. Since the Brassicacea family contains a large number of phytochemicals, the majority of which are phenolic compounds, it provides many health benefits to humans, such as preventing cancer, inflammatory diseases and scavenging free radicals (Lee et al., 2018). Pak Choy also contains nutrients like calcium, folic acid and magnesium, which can help with bone health (Zanika, 2010). One thing that all brassica vegetables have in common is that they all contain glucosinolates, sulfur-containing compounds that are hydrolyzed to produce mustard oils, which give these vegetables their distinct flavours and aromas (Fahey, 2016).

## **2.2 Hydroponic System**

A hydroponic system is a low-cost and simple method of producing vegetables. It is a method of growing plants in water using mineral nutrients rather than soil (Jones, 1982). Hydroponic systems use less water than land-based agriculture because water can be recycled and refilled with nutrients multiple times. It requires little to no pesticides and fewer nutrients than traditional land-based agriculture (Aquino, 2020). Hydroponics has become an important alternative plant production technique due to its easy control of nutrient composition, lack of soil contamination, faster plant growth, shorter crop cycles, high product quality, and consumer acceptance (Ohse et al., 2001). Plants grown in hydroponics contain more minerals and chlorophyll than plants grown in traditional soil-based systems (Massantini et al., 1988). A hydroponic solution's macro- and micronutrient composition determines plant growth, leaf number, leaf area, marketable yield, and crop quality, including mineral and chlorophyll content (Fallovo et al., 2009). Although hydroponic culture can produce optimal plant growth, its efficiency is dependent on a variety of factors including nutrient availability, crop genotype, growing method, and pest management (Spehia, 2018).

The main component that becomes an important factor in the cultivation of hydroponic systems is nutrient solution. Nutritional solutions for hydroponics must be done precisely in order to achieve the desired final concentration. Nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, copper, zinc, manganese, molybdenum, boron, chlorine, nickel, carbon, hydrogen, and oxygen are currently considered essential for most plants (Salisbury & Ross, 1994). The essential elements are obtained from the growth medium, with the exception of carbon (C) and oxygen (O), which are supplied from the atmosphere. Other elements considered beneficial include selenium, silicon, vanadium, cobalt, aluminium, iodine, and sodium, among

others, because some of them can stimulate growth, replace essential nutrients in a less specific role, or compensate for the toxic effects of other elements (Trejo-Téllez et al., 2012). The composition and concentration of solution are two important factors in making nutrient solutions in a hydroponic system. Plants will suffer from nutrient deficiencies if the dose is too low, whereas plants will be poisoned if the dose is too high (Setiawati et al., 2019).

### **2.3 Benefits and Limitations of Hydroponic Cultivation System**

Hydroponic techniques are popular because they are a clean and simple method that eliminates the possibility of soil-borne disease, insect, or pest infection, reducing or eliminating the need for pesticides and their associated toxicity. Plants also require less growing time than field crops, and plant growth is faster because the roots are not mechanically hampered and all nutrients are readily available to the plants (Sharma et al., 2019). Hydroponic technique is extremely beneficial in areas where environmental stressors such as cold, heat, and desert are a major issue (Polycarpou et al., 2005). Hydroponic crops can be grown all year and are considered off season crops (Manzocco et al., 2011). Furthermore, commercial hydroponic systems are automated, which is expected to reduce labor, and several traditional agricultural practices, such as weeding, spraying, watering, and tilling, can be eliminated (Jovicich et al., 2003). Since irrigation and other types of sprays are not required, hydroponics saves a significant amount of water, and water logging is never an issue. According to Resh in 2013, in hydroponic techniques, weeds are virtually non-existent, whereas pests and diseases are easily controlled. Because the number of plants per unit is greater than in conventional agriculture, increased yields are possible. While soilless cultivation is a beneficial technique, it does have some significant disadvantages. Commercial scale cultivation necessitates technical expertise as well as a larger initial investment (Resh, 2013).

Water-borne diseases can easily spread from one plant to another in a hydroponics system because each plant shares the same nutrient (Ikeda et al., 2002). Hot weather and a lack of oxygenation may limit production and cause crop loss. It is critical to keep the nutrient solution's pH, EC, and concentration stable. Finally, to operate the system within the protected structure, a source of light and energy is required.

## **2.4 Electrical Conductivity (EC) and pH Management**

In hydroponics, plant nutrients are typically inorganic and ionic forms that are dissolved in water. All 17 elements required for plant growth are provided by various chemical combinations. Hoagland's solution is the most commonly used nutrient solution for hydroponic systems. Cooper's 1988 and Imai's 1987 nutrient solutions were also used to grow leafy vegetables, tomatoes, and cucumber. The pH and EC of the fertilizer solution are critical for plant performance and should be properly maintained. The ideal EC range for hydroponics for most crops including Pak Choy is 1.5 to 2.5 dS m<sup>-1</sup>. Higher EC prevents nutrient absorption due to osmotic pressure, while lower EC has a negative impact on plant health and yield (Samarakoon et al., 2006). As a result, effective EC management in hydroponics can be a powerful tool for increasing vegetable productivity and quality (Gruda, 2009). Tomato production, for example, increased as the EC of the nutrient solution increased from 0 to 3 dS m<sup>-1</sup>, but decreased as the EC increased from 3 to 5 dS m<sup>-1</sup> due to increased water stress (Zhang et al., 2016). At the vegetative, middle vegetative, and generative phases, EC levels of 1.5, 2 and 3 dS m<sup>-1</sup> increased crop height, fruit number, and pepper fresh weight, respectively.

The pH of a nutrition solution determines the availability of critical plant components. The optimal pH range of nutritional solution for plant development for most species including Pak Choy is 5.5 to 6.5 (Trejo-Tellez & Gomez, 2012), but some species may fall outside of this range. When the plant matures, it will change the

composition of the nutrient solution by depleting specific nutrients faster than others, withdrawing water from the solution, and changing the pH by excreting acidity or alkalinity. Wang et al.,(2017) discovered that a combination of three acids ( $\text{HNO}_3$ ,  $\text{H}_3\text{PO}_4$ , and  $\text{H}_2\text{SO}_4$ ) outperformed a single acid in maintaining a pH range of 5.5 to 6.5 in a solution. A pH change can cause a nutritional imbalance, causing the plant to show signs of deficiency or toxicity. As a result, it is critical to monitor the pH, EC, and nutrient levels in a hydroponic solution. In a soilless hydroponic system, vegetables, spices, flowers and ornamentals, medicinal plants, fodders and to a lesser extent, grains can all be grown.

## **2.5 Vegetable Growth and Yield Production of Pak Choy**

A plant species' height is critical to its ecological strategy. Plant height has a strong correlation with traits such as leaf mass fraction, leaf area ratio, leaf nitrogen per area, leaf mass per area, and canopy area (Falster & Westoby 2003). Plant height is also an important part of a coordinated set of life-history traits that includes seed mass, time to reproduction, longevity, and a plant's annual seed production capacity (Moles & Leishman 2008). The development of leaves is a complicated process, but one factor that may influence its progress is light (Malinowski, 2013). Sunlight energy is primarily taken up by chlorophyll in plants, where it is converted to chemical energy and then used again in chlorophyll production (Wettstein et al., 1995). This is a circular biosynthetic process in which plants produce additional chemical energies for leaf formation and development in order to meet the plants' ever-increasing chemical energy and chlorophyll requirements as they grow. Plants that receive early sunlight are expected to produce more chemical energy for leaf formation and development. Morning photosynthetic activity is higher in rate and quality than afternoon photosynthetic activity (Mohotti & Lawlor, 2002; Ibrahim & Jaafar, 2011; Koyama &

Takemoto, 2014). Although the optimal photoperiod for Pak Choy (*Brassica rapa* C.) has not been determined, the vegetation period of *Brassica rapa* is stated to be 28–30 days at 8.0–8.4 sunshine hours and 43–47 days at 6.0–6.4 sunshine hours (Kalisz, 2011), implying that a photoperiod of more than 6 hours will accelerate the growth of this Brassica. Some brassicas can have a neutral day (Rabbani et al., 1997), but *Brassica rapa* is not one of them (Falik et al., 2014). A short day (short photoperiod) maintains vegetative development in *Brassica rapa*, whereas a long day (long photoperiod) promotes blooming (Falik et al., 2014). Finally, plants in shaded areas have larger leaf-area/leaf as a means of capturing more sunlight energy (Setiawati et al., 2018; Johnson et al., 2005). This explains why leaf expansion is greater in the hydroponic raft system because the leaf-area/plant is greater.

## CHAPTER 3

### 3.0 Materials & Methods

#### 3.1 Study Site and Plant Species Selection

This experiment was conducted at the corridor outside the Plant Growth Laboratory, Faculty of Resource Science and Technology, UNIMAS Kota Samarahan, Sarawak, Malaysia. This experiment was conducted for a duration of 39 days from 17<sup>th</sup> March to 25<sup>th</sup> April 2022. In this study, Pak Choy (*Brassica rapa chinensis*) was selected because of its high market demand and suitability for hydroponic culture.

#### 3.2 Hydroponic Set-up and Management

A wick hydroponic system was constructed from plastic containers, styrofoam plates, soft fabric string and net pots (Figure 1).



Figure 1: Hydroponic Set

About 11.0 L of tap water were added into the plastic container. Then for Treatment 1, 35ml of fertilizer A + 35ml fertilizer B added into the plastic container. For Treatment 2, 25ml of fertilizer A + 25ml fertilizer B added into the box and lastly for Treatment 3, 15ml of fertilizer A + 15ml of fertilizer B added. In this study, three treatments with eight replicates were designed according to the different volumes of AB fertilizer (Table 1). Then, the electrical conductivity (EC) and pH of each treatments were determined by using EC meter and pH meter. In each replicate, three seeds of Pak

Choy vegetable were sown in a hydroponic net pot on 17<sup>th</sup> March 2022. Immediately after sowing, the hydroponic sets were placed outside the laboratory at the shaded corridor where plants received indirect sunlight. The plants were left to grow for a duration of 39 days.

Table 1                      The volumes of AB fertilizer, electrical conductivity and pH for cultivation of Pak Choy vegetables in a hydroponic system at Universiti Malaysia Sarawak.

Treatment	Volume of AB fertilizer	Electrical conductivity	
label	(ml)	(dS/m)	pH
T1	35ml fertilizer A + 35ml fertilizer B	1.7	6.02
T2	25ml fertilizer A + 25ml fertilizer B	1.46	6.16
T3	15ml fertilizer A + 15ml fertilizer B	0.9	6.42

### 3.3 Data collection for growth performance of Pak Choy

Pak Choy plants were harvested at 39 days after cultivation. For each plant, the height, number of leaves, leaf chlorophyll content, and above ground biomass were measured once when harvesting. Plant height of all plant was measured using a ruler from the ground surface to the tip of the plant while the number of leaves of all plant was counted manually. The estimation of leaf chlorophyll content was determined by the average of 5 leaves for each replicates by using a chlorophyll meter (SPAD 502 Plus, Konica Minolta). Following harvest, the plants were dried in a force draught oven at 60 °C for 48 hours for dry weight of all plant in each treatment determination. The plant dry weight is also known as the above ground biomass where the root will be not included.

### **3.4 Statistical Analysis**

The data were analyzed using Minitab version 17.0 statistical software. A one-way Analysis of Variance (ANOVA) was used to compare the treatment means for each measured parameter. Post-hoc test used Fisher's Least Significance Difference when ANOVA results showed significant difference at  $p \leq 0.05$ .

## CHAPTER 4

### 4.0 Results

After 39 days from sowing, the growth performance of plants grown at three different treatments were observed. Visual observation found noticeable variations in the size of plants in all treatments as shown in Figure 2.



Figure 2: Growth Performance of Pak Choy (*Brassica rapa* C.) in three treatments of AB fertilizers within a hydroponic system.

#### 4.1 Plant Height

The height of plants showed variations ( $p < 0.05$ ) among treatments of nutrient solutions (Table 2). Plants grown in T2 solutions were taller (11.6 cm) compared with those in T1 solutions (9.5 cm). Plants in T1 solutions produced the shortest height among all treatments despite having the highest electrical conductivity of 1.7 dS/m. Visual plant height in all treatments are shown in Figure 3:



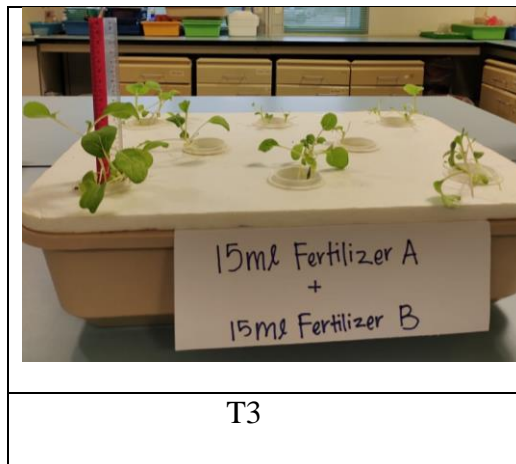


Figure 3 Plant height of Pak Choy under T1, T2 and T3 nutrient solutions in a hydroponic system.

Table 2: Plant Height of Pak Choy (*Brassica rapa C.*) grown at different treatments of hydroponic solution

Treatments	Plant height (cm)
T1 (35ml fertilizer A + 35ml fertilizer B)	9.5 <sup>b</sup>
T2 (25ml fertilizer A + 25ml fertilizer B)	11.6 <sup>a</sup>
T3 (15ml fertilizer A + 15ml fertilizer B)	10.8 <sup>ab</sup>
Significant level (P-value)	0.044
Standard Error of Mean	0.39

Means with the same superscripts are not significantly different ( $P>0.05$ ) according to Fisher's Least Significance Difference test.

## 4.2 Number of leaves

ANOVA analysis revealed that there was no significant difference in the number of leaves among treatments ( $P>0.05$ ) (Table 3). Irrespective of treatment solutions, each plant produced an average of 7 leaves within the growth duration of 39 days. This demonstrates that the number of leaves was independent of plant height.

Table 3: Number of leaves of Pak Choy (*Brassica rapa C.*) grown at different treatments of hydroponic solution

Treatments	No of leaves/plant
T1 (35ml fertilizer A + 35ml fertilizer B)	7.1 <sup>a</sup>
T2 (25ml fertilizer A + 25ml fertilizer B)	7.3 <sup>a</sup>
T3 (15ml fertilizer A + 15ml fertilizer B)	6.8 <sup>a</sup>
Significant level (P-value)	0.159
Standard Error of Mean	0.112