



**UNIVERSITI PUTRA MALAYSIA**

***IMPACT OF LED LIGHTINGS ON MISAI KUCING HERBS GROWTH  
BASED ON DIFFERENT HEIGHT EXPOSURE***

**NURFARHANA BINTI SHAARI**

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BASED ON DIFFERENT HEIGHT EXPOSURE**

**NURFARHANA BINTI SHAARI**

**A project report submitted in partial fulfilment of the  
requirement for the award of the degree of  
Bachelor (Hons.) of Food and Process Engineering**

**FACULTY OF ENGINEERING  
UNIVERSITI PUTRA MALAYSIA**

**2018**

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**This thesis is specially dedicated to :**

**To my dearest father,**

**SHAARI BIN AHMAD**

**To my supportive mother,**

**HASNAH BINTI WAHAB**

**To my siblings,**

**HASRIZAL, MUHD. FIRDAUS, NORHIDAYAH, MOHD. FAIRUZ, SITI**

**SOLEHAH, NURUL ATHIRAH**

**To my project supervisor,**

**IR. DR EFFENDY BIN YAACOB**

**To my project assistant,**

**NADIRAH BINTI ROSLAN, HAFIZ, RAHMAN**

**To all my friends,**

**Especially RADEN NURUL AFAF KARTINI BINTI ZAILAN**

**Thanks for all your support.**

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## **IMPACT OF LED LIGHTINGS ON MISAI KUCING HERBS GROWTH BASED ON DIFFERENT HEIGHT EXPOSURE**

### **ABSTRACT**

*Orthosiphon stamineus* Benth. from family Lamiaceae, is locally known as Misai Kucing is a very popular herb among Malaysian because of its health benefits such as treatment for gallstones, hepatitis, rheumatism, hypertension and etc. To meet the increasing demand for raw materials of this herb, controlled environment agriculture is an alternative and a supplement for herb production. There are various constraints in the commercial cultivation of this herb especially low light. Light is one of the most prominent factors influencing herbs quality, growth and development. Thus, LEDs (light-emitting diodes) technologies have opened up new perspectives for new sustainable solutions and highly efficient light source for greenhouse lighting. However, the most challenging for growers when growing plants under LED artificial light source were designing an array of lights adequate for the lighting needs for each plot and proper placing of the lights above the plants. Four different level of height (15H, 20H, 25H and 30H) of LED light were exposed to Misai Kucing in a Randomized Complete Block Design (RCBD) trial with the objective to obtain the quantitative information about the effect of different level of height of LED light exposure on growth and relative chlorophyll content of *Orthosiphon stamineus*. From the experiment also proved that *O.stamineus* exhibited a great ability in adaptation to light intensity as  $16.13\mu\text{molm}^{-2}\text{s}^{-1}$  which reflected by the high relatively chlorophyll content (SPAD value) is at 20H to 30H treatment.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

World Health Organization (WHO) estimated that more than 80% of the world populations rely on herbal medicine for some part of their healthcare (Akerele,1993). Recently, herbal medicine industry had become a developed industry in Malaysia since that the market value of herbal industry in Malaysia is projected to reach Gross National Income (GNI) of RM2,213.9 million with 1,822 projected jobs by 2020 (annual growth rate of 8%). *Orthosiphon stamineus*, Benth or commonly known as Misai Kucing is herb plant, perennials which belongs to the family Lamiaceae that widely grown in Southeast Asia included Malaysia. It has two types based on the floral color, one having white flowers and other with light purplish flowers (LH *et al.*, 2014). The *Orthosiphon stamineus*, Benth extract has many advantages for medicinal purposes such as kidney stone elimination effect, diuretic effect, cardiovascular effect and herb-drug interaction (Han *et al.*, 2008). A variety of studies are being conducted to overcome the issue and challenges faced by the herbal

industry in Malaysia and also to improve the quality of *Orthosiphon stamineus* in an endeavor to increase the growth rate of herbal industry in Malaysia.

Environmental factors such as light, water, temperature and soil nutrients are vital elements to produce high quality of *Orthosiphon stamineus* (Ibrahim *et al.*, 2013). Among those factors, light factor needs to be emphasized due to the low sunlight conditions caused by abnormal climate which responsible for the depression of photosynthesis. This will negatively affect to the crop production. To overcome the crops yield from having reduction effect by the shortage of sunlight, the introduction of Light Emission Diode (LED) technology during the cultivation of *Orthosiphon stamineus* has been proposed. It is a newly developed light technology for the cultivation of crops. This technology is developed to increase the rate of growth and photosynthesis. To promote crop growth and photosynthesis, the red and blue wavelengths of LED lights are usually chosen (Choi *et al.*, 2015).

However, a number of challenges of growers when growing plants under artificial light source like LED include, greenhouse or growth chamber climate control, designing an array of lights adequate for the lighting needs for each plot, and proper placing of the lights above the plants.

From the previous experiment with artificial light by Poorter *et al.* (Poorter *et al.*, 2012) proved that light intensity strongly decreases with increasing distance between the lamp and plant leaves. According to Niinemets and Keenan (Niinemets, 2012), light gradients also result from a distance-dependent reduction of light. As a result low-light conditions interfere with normal growth and photosynthetic activity in the plants by affecting the synthesis of photosynthetic pigment likes chlorophyll pigment

(Zhao *et al*, 2012). For instance, Zhang, Zhong *et al*. (Zhang *et al*, 2016) were found that the content of photosynthetic pigments (chlorophyll) of both *Physocarpus amurensis* and *Physocarpus opulifolius* increased significantly in the leaves under shade condition (low light intensity). The higher chlorophyll content and the smaller specific leaf area in the leaves of *P. opulifolius* provided this cultivar with a better photosynthetic capacity as compared to *P. amurensis*. Therefore, *P. opulifolius* exhibits an advantage in shade tolerance plant.

At present, the common artificial supplementary lighting systems are fluorescent lamp, high-pressure sodium lamp, metal halide lamp, etc. But these artificial light sources applied in the supplementary lighting system have obvious drawbacks. For example, their spectra are mainly linear spectral line which causing a mismatch with plant photosynthetic absorption spectrum. Only part of wavelengths from the lamp can be absorbed by the plants and other wavelengths of light are wasted. Second, the power consumption of the incandescent light bulbs, fluorescent tubes, high-pressure sodium lamps and metal halide lamps is very big, at the same time they produce a lot of heat. So they cannot expose the plants on a relatively close distance to plant. Third, these artificial light sources are not energy-saving lamps compared with the newly developed LED light sources. On the above comprehensive analysis, the incentive efficiency of these traditional lights on the plant growth is not high, and they greatly increase the cost of artificial lighting [J.Jwo *et al*, 2015].

Most engineering designs can be classified as inventions-devices or systems that are created by human effort and did not exist before or are improvements over existing devices or systems. Inventions, or designs, do not suddenly appear from nowhere.

They are the result of bringing together technologies to meet human needs or to solve problems. Sometimes a design is the result of someone trying to do a task more quickly or efficiently. Design activity occurs over a period of time and requires a step-by-step methodology.

The fundamental engineering is applied in this project is the engineering design process. In this engineering design process, there are five basic steps used for solving design problems. The steps are:

1. Define the problem
2. Gather pertinent information
3. Generate multiple solutions
4. Analyse and select a solution
5. Test and implement the solution

The first step in the design process is the problem definition. This definition usually contains a listing of the research requirements and specially information about the research and other things. In this research, the problem that wants to discover is the suitable height for the *Orthosiphon stamineus* to be exposed to the LED light source. A survey regarding to the availability of the LED chamber are performed at this stage. Considering cost, safety, and other criteria for selection, the more promising alternatives are selected for further analysis. Following this step, a prototype of the design is constructed and functional tests are performed to verify and possibly modify the design.

The second step is collecting all the information available that relates to the problem. The beginning of searching information is must be prepared to go to many different sources. The primary source of information is still library and followed by the

electronic information transfer and retrieval. But in this research, there are not so much information can be found related to the research since it is not done by many researchers.

The third step is generating multiple solutions. This step begins with creativity in generating new ideas that may solve the problem. In this stage, the process called synthesis occurred where the combining new ideas, tools and methods to produce a totally unique solution. For this project, we came out with four different heights in order to find the most suitable height for LED exposure. The heights are 15cm, 20cm, 25cm and 30cm from the LED light source.

The fourth step is analyzing and selecting a solution. In this step, these solution are analyzed and decide which solution is the best suited for implementation. Analysis is the evaluation of the proposed designs. During the analysis, there are several parameters that measured to assist in making a decision which is the best height for LED exposure. The parameters measured are taken to the number of branches, number of leaves, plant height and SPAD (relative chlorophyll content) meter reading. These reading are taken before and after experiment in order to do analysis. The data was analyzed using the analysis of variance procedure in Statistical Analysis System (SAS) Version 9.4 (SAS Institute, Cary, NC). Mean separation test between treatments was performed using Duncan Multiple Range Test (DMRT) with the least significant level of 5%.

The last step is testing and implementing the solution. This step refers to testing, construction, and manufacturing of the solution to the design problem. There are several methods of implementation, such as prototyping and concurrent engineering, as well as distinct activities that occur during implementation, such as documenting the design solution and applying for patents. But, for this project, we do not proceed

to this step due to the time consuming. This step can be proceeding for further research about the LED system.

## **1.2 Aims and Objectives**

The aim of this study is to obtain the quantitative information about the effect of different level of height of LED light exposure on growth and relative chlorophyll content of *Orthosiphon stamineus*. This study can provide useful information for supporting the plant grower, thus contributing to make the artificial light greenhouse capable of producing income.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

This chapter consists of research related to the problem solving, where may be applied to research further over the light emitting diode (LED) system needed to conclude such project requirements. Details of the rough system theory and equipment may be justified on this chapter in order to gain appropriate understanding of effect of LED on plant growth. Research gap is also to be expected in this chapter by addressing a gap—that is, attempt to fill in some piece of information missing in the scientific literature. The literature reviews next are bringing forward as a source to perform methodology that will be discussed in Chapter 3: Methodology.

#### **2.2 Overview**

LED technology is a current technology applied to plant growth in controlled environment conditions. Light emitting diodes (LEDs) are the ultimate light source in the lighting technology. The LED technology has flourished for the past few

decades. High efficiency, reliability, rugged construction, low power consumption, and durability are among the key factors for the rapid development of the solid-state lighting based on high-brightness visible LEDs. Conventional light sources, such as filament light bulbs and fluorescent lamps depend on either incandescence or discharge in gases. These two processes are accompanied by large energy losses, which are attributed to the high temperatures and large Stokes shift characteristics. On the other hand, semiconductors allow an efficient way of light generation. LEDs made of semiconductor materials have the potential of converting electricity to light with near unity efficiency.(Yam & Hassan, 2005)

LED is an artificial light source that can be used to make the vegetables grow more quickly in a closed-type plant production systems, especially in the environment of the light intensity is insufficient (Xu, Chang, Chen, & Lin, 2016). The closed-type plant production system is applied with LED lighting as well as combinations of LED wavelengths (Margit Olle, 2013).

### **2.3 Photosynthetically Active Radiation (PAR)**

The most vital source of energy for plants is known as Photosynthetically Active Radiation (PAR) which range is between 400 to 700 nm (Kalaji *et al.*, 2014). PAR also defined as the amount of light available for photosynthesis. Photosynthetically Active Radiation is needed for photosynthesis and plant growth. Higher PAR promotes plant growth, and monitoring PAR is important to ensure plants are receiving adequate light for this process. Photosynthetically Active Radiation (PAR) is reported as millimoles of light energy per square meter. It is measured by a silicon photovoltaic detector. This detector measures light in the 400 nanometer to 700 nanometer range (Staff, 2010).

### **2.4 LED Configuration**

The LEDs are fabricated from semiconductor materials. The basic LED consists of a p–n junction. Under forward bias condition, electrons are injected into the p-type region, and holes are injected into the n-type region. Recombination of these minority carriers with the majority carriers at the p–n junction leads to light generation. The wavelength and color of the light is determined by the difference in the energy levels of the electrons and holes. This simplest type of LED design is no longer used in current LED technology since there are some drawbacks which could lower the efficiency in the lighting and illumination applications. First, electron injection into the p-type region is desired for achieving high internal quantum efficiency, therefore, a low injection level of holes into the n-region is required.

Second, self-absorption of the generated light is high due to the entire structure possesses same composition; this reduces the light extraction efficiency. Third, the radiative recombination in such LEDs is monomolecular, so that only increasing the doping can increase the emission rate [Zukauskas *et al*, 2002].

Maximization of light generation is the primary goal in LED fabrication; this can be done by the application of various epitaxial structures in the LED. Currently, the fabrication of high intensity LEDs are based on hetero-structures. Structures consist of dissimilar semiconductor materials which have different bandgaps because of different chemical composition are called heterostructures.

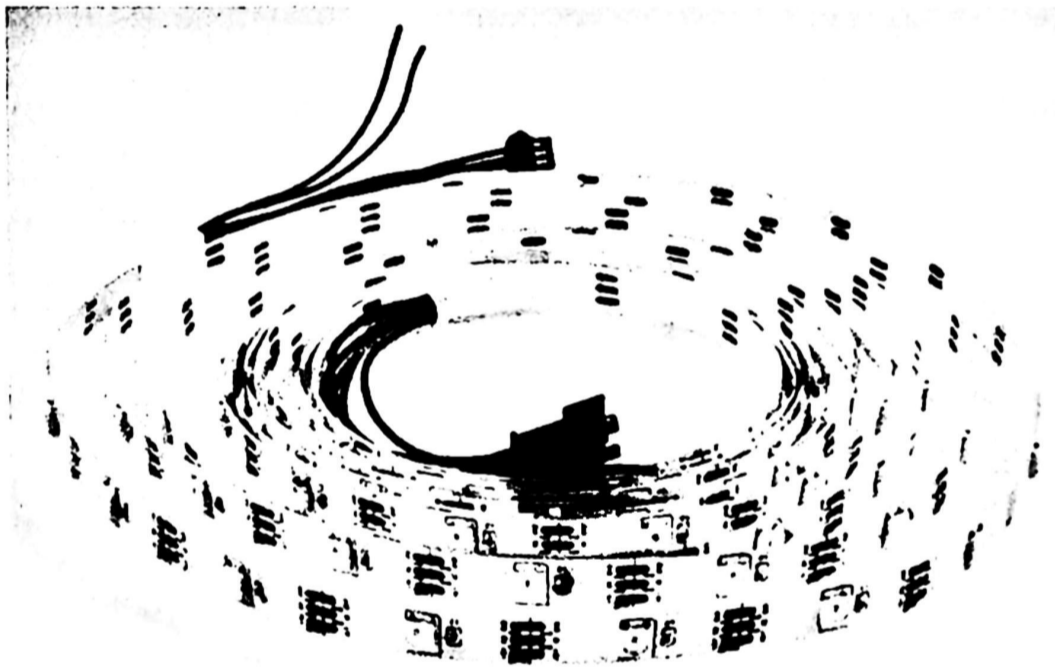


Figure 2.1: LED strips

The wavelength of the light emitted, and hence the color, depends on the band gap energy of the materials forming the p-n junction. The emitted photon energy is approximately equal to the band gap energy of the semiconductor. The following equation relates the wavelength and the energy band gap:

$$h\nu = E_g$$

$$hc/\lambda = E_g$$

$$\lambda = hc/ E_g$$

Where;

**h** is Plank's constant,

**c** is the speed of the light and

**E<sub>g</sub>** is the energy band gap

## **2.5     *Orthosiphon stamineus***

*Orthosiphon stamineus* Benth. from family Lamiaceae, is locally known as Misai Kucing is a medicinal herb easily found in Southeast Asia (Han, 2006). It is very popular herb among Malaysian because of its health benefits such as treatment for gallstones, hepatitis, rheumatism, hypertension and etc. To meet the increasing demand for raw materials of this herb, controlled environment agriculture is an alternative and a supplement for herb production. There are various constraints in the commercial cultivation of this herb especially low light. Light is one of the most prominent factors influencing herbs quality, growth and development.



Figure 2. 2:*Orthosiphon stamineus*

With a multitude of medicinal potentials, new cultivars of *O. stamineus* with economically valuable secondary metabolites are being propagated in the pharmaceutical industry (Anna *et al.*, 2008). Precise and reliable identification of plant cultivar is therefore crucial for breeding and plant proprietary rights protection.

## 2.6 SPAD Meter

Leaf chlorophyll concentration is an important parameter that is frequently measured as an indicator of chloroplast development, photosynthetic capacity, leaf nitrogen content or general plant health. In the laboratory, it is commonly determined photometrically following extraction of the pigments using an organic solvent, such as acetone or dimethyl formamide (Arnon 1949; Porra *et al.* 1989). Whilst this method is well established and accurate, it is time-consuming, destructive (the leaf material must be excised from the plant, and is lost), and necessitates the use of toxic or flammable chemicals. The SPAD-502 meter (Konica-Minolta, Japan) provides an alternative method for the measurement of relative leaf chlorophyll levels that overcomes these disadvantages.

The SPAD-502 meter is a hand-held device that is widely used for the rapid, accurate and non-destructive measurement of leaf chlorophyll concentrations. It has been employed extensively in both research and agricultural applications, with a range of different plant species (Ling, Huang, & Jarvis, 2011). It is designed to help users improve crop quality and increase crop yield by providing an indication of the amount of chlorophyll present in plant leaves. The chlorophyll content of plant leaves is related to the growth condition of the plant, and thus can help us to determine whether additional fertilizer is necessary (Minolta, 2017).

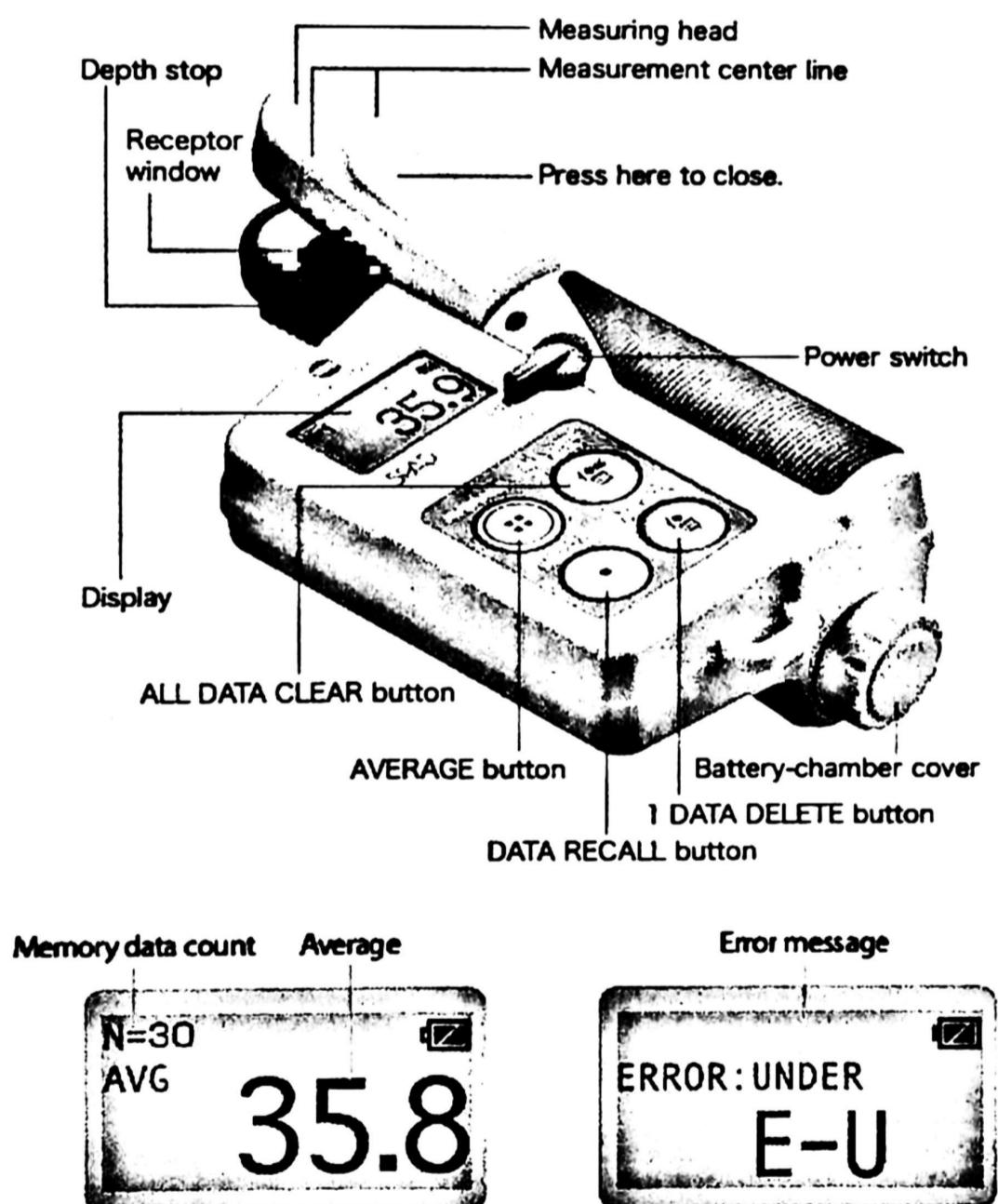


Figure 2. 3: Features of SPAD-502Plus Meter

## **CHAPTER 3**

### **METHODOLOGY**

#### **3.1 Introduction**

This chapter is the design procedure used throughout the project, where started from research, planning, sampling and testing. Each of the phase may need multiple steps where may contains many step or systematic techniques. All the phase performed and monitored in a good ways in order to interpret the data that can be used into practical world issues and descriptive into documentation.

#### **3.2 Statistical Analysis**

The experiment conducted based on a Randomized Complete Block Design (RCBD) with four replications. The data was analysed using the analysis of variance procedure in Statistical Analysis System (SAS) Version 9.4 (SAS Institute, Cary, NC). Mean separation test between treatments was performed using Duncan Multiple Range Test (DMRT) with the least significant level of 5%

### **3.3 Research Stages**

The research stages include all the project stage used to gather the data and information, preparation of the sampling and running the experiments. The research stages are vital to execute this project which primarily giving step needed in order to achieve project successfulness and effectiveness. There are three stages are highlighted in this project; first stage (Plant materials), second stage (Preparation of samplings) and third stage (Field test).

#### **3.3.1 First stage: Plant materials**

The experiment was conducted in a LED compartment (as shown in Figure 3.1(a)(b) ) at the PV Pilot UPM Malaysia which is located near to Banquet Hall, Universiti Putra Malaysia. The construction of the LED compartment is taking place about one month. And this construction is done by the master students of Ir. Dr. Effendy bin Yaacob. The LED compartment constructed is equipped with the air humidifier, controller, fertigation system and sunlight-free. The function for air humidifier is to maintain the humidity of LED compartment. The compartment is prepared in the sunlight-free condition to ensure that the plants are received 100% LED light. The chamber also equipped with the LED strips. The configuration of the LED compartment is shown in the Figure 3.1(c)(d). The arrangement of the plants in the LED compartment is shown in the Figure 3.5.

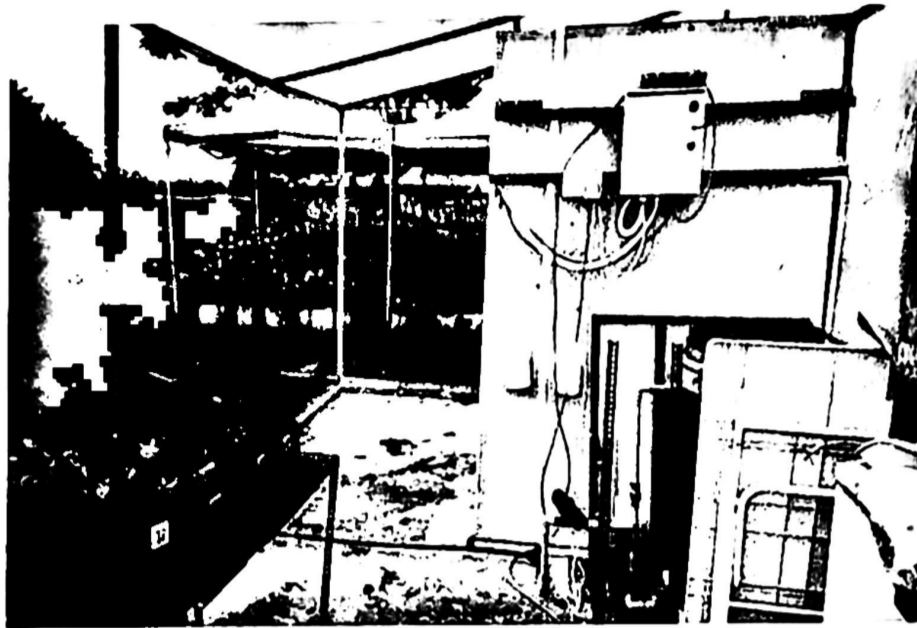


Figure 3.1(a)

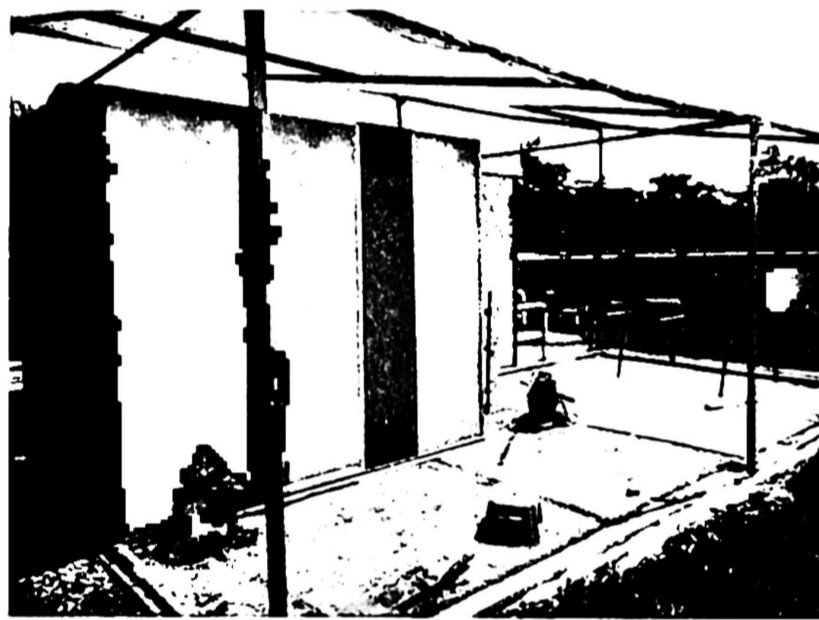


Figure 3.1(b)

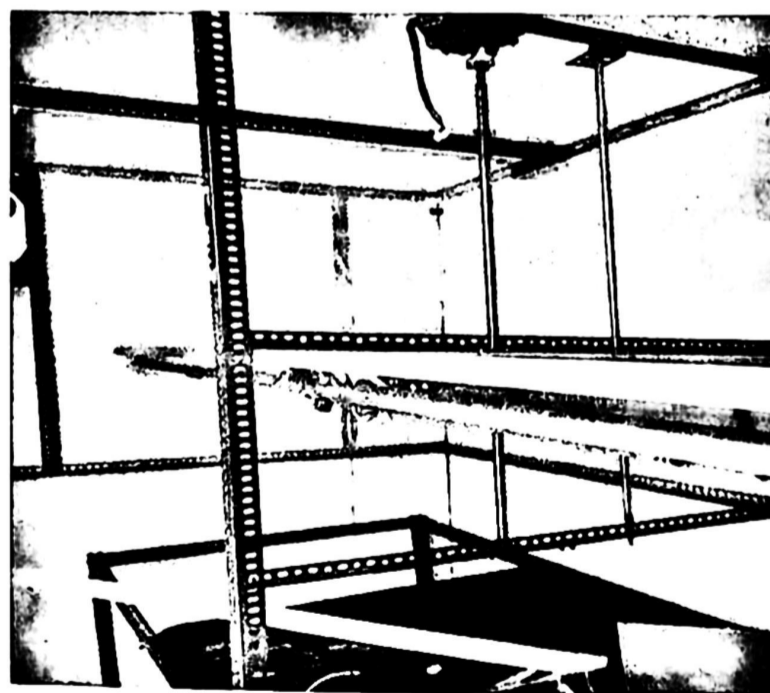


Figure 3.1(c)



Figure 3.1(d)

Figure 3. 1 (a)(b)(c)(d) The LED compartment equipped with the air humidifier, controller, fertigation system

During this stage, the preparation of soilless media for this project was take place. The soilless media are included the mix of burn rice husks, coco peat and chicken manure in ratio 5:5:1 respectively as shown in Figure 3.2. The benefits to used soilless media are soilless media had been proven to be sterile and free from pathogens cause by the soil-borne. The plants will also have faster growth rate because they do not need to waste energy searching for diluted nutrients in the soil (Beatrice,2017). Then, 50 stem cuttings of *Orthosiphon stamineus* was selected from the matured mother plant of *Orthosiphon stamineus* as shown in Figure 3.3 and 3.4. The 50 stem cuttings were propagated in the labelled black polyethylene bags filled with a soilless media. Irrigation was optimized at the field capacity level and foliar fertilization was applied once every two weeks.



Figure 3.2: The soilless media of burn rice husks, coco peat and chicken manure in ratio 5:5:1 respectively



Figure 3.3: Matured mother plant of *Orthosiphon stamineus*.

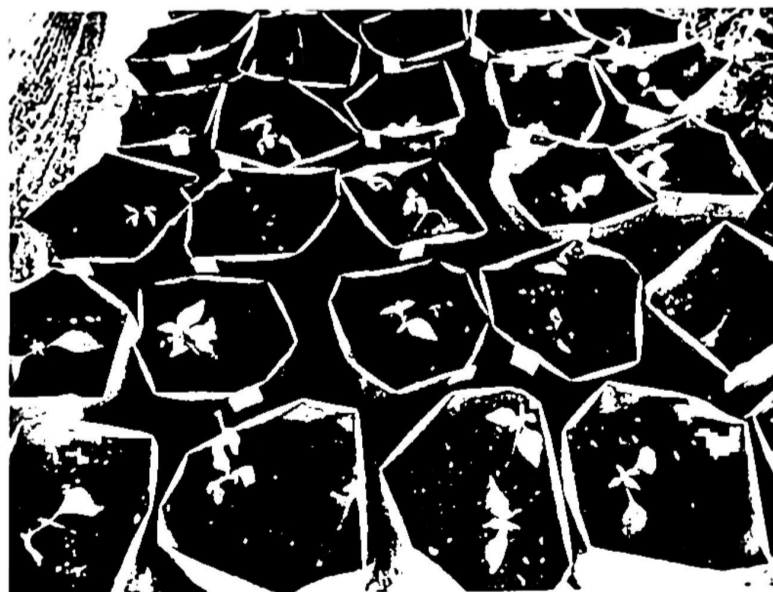


Figure 3.4: 50 stem cuttings were propagated in the labelled black polyethylene bags filled with a soilless media

### 3.3.2 Second stage: Prepare samplings

During the preparation of sampling, there are several things need to concentrate on such as the amount of water given that will keep plants from wilting up, the pest that will affect the growth of *O. stamineus* and so on. While in the LED chamber, there are four sections divided based on the different LED height exposed to the *O. stamineus*. The sections are divided using the trays as shown in Figure 3.5. Within 2 months after planting, sixteen *O. stamineus* were selected based on the distance between the highest shoot and the LED source which divided into 4 levels as there are 15cm, 20cm, 25cm and 30cm respectively.

The Figure 3.5 shows the arrangements of plants in the LED chamber. In this project, there are four treatments are done. The treatments done are based on the height level of the exposed plant to the LED source. Treatment 1 consists of the plant labelled with 24, 44, 50 and 45. For treatment 2, the plant labelled with 27, 15, 43 and 40 were chosen. Treatment 3 included plants with labelled 35, 23, 41 and 20. For treatment 4, consists of plant labelled 36, 32, 33, and 30. Table 3.1 shows the treatment with the number of plant labelled.

Table 3.1: The treatment of plants

Treatment (T)	Plant	Replication
T1	45	1
	50	2
	44	3
	24	4
T2	40	1
	43	2
	15	3
	27	4
T3	20	1
	41	2
	23	3
	35	4
T4	30	1
	33	2
	32	3
	36	4

Controlled LED

Fixed LED

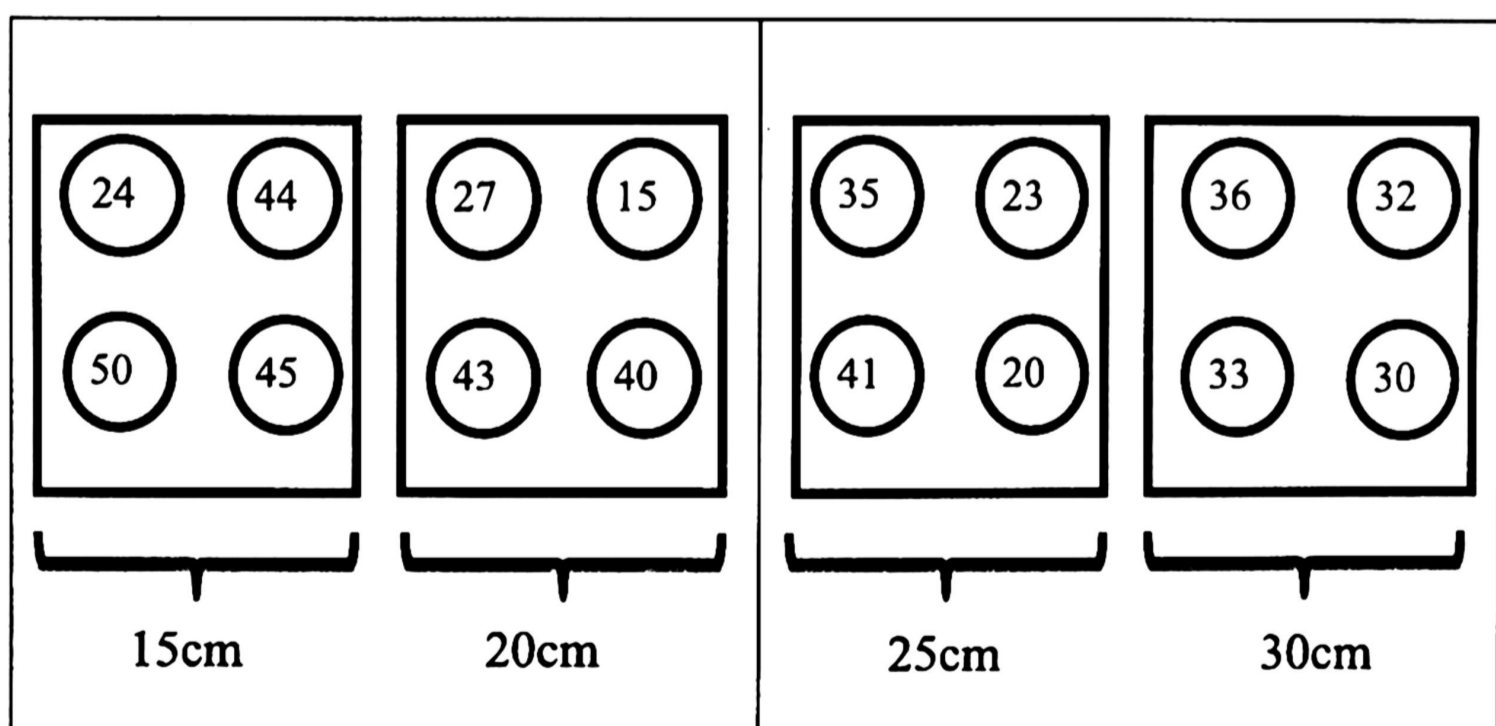


Figure 3.5: The configuration of plants in the LED chamber.

### 3.3.3 Third stage: Field Test

In this stage, all the 16 *O. stamineus* that selected based on the distance between the highest shoot and the LED source were transferred to LED growth chamber. The experiment consisted of 4 replication of plant for each level of LED height exposure for 7 days as shown in Figure 3.6. The light intensity expressed as Photosynthetic Photon Flux Density (PPFD) for 15cm, 20cm, 25cm and 30cm level of LED height exposure were valued  $20.62\mu\text{molm}^{-2}\text{s}^{-1}$ ,  $19.41\mu\text{molm}^{-2}\text{s}^{-1}$ ,  $16.13\mu\text{molm}^{-2}\text{s}^{-1}$ , and  $13.15\mu\text{molm}^{-2}\text{s}^{-1}$  respectively. The light intensity was measured by using light meter (LI-189, LI-COR, USA). All the plants were irradiated 12 hours photoperiod to the combination of red and blue LED light with ratio 4:1 respectively. Fertigation system (fertilization and irrigation run simultaneously to the roots of the plants through water dripper) was used four times per day and the electrical conductivity (EC) and pH were adjusted to  $2.0\text{Sm}^{-1}$  and 5.5-6.5 respectively. Environmental conditions in the experiment were maintained at 27-30°C (light period), 18-21°C (night period) and 50-60% relative humidity (RH).

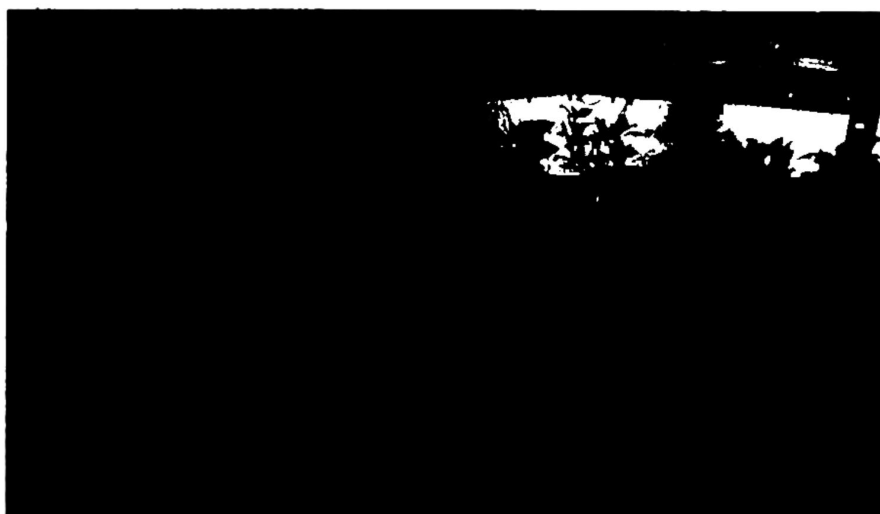


Figure 3. 6: Four different levels of LED height exposed to *O. stamineus* based on the distance between the highest shoot and the LED source.

Growth responses were determined by measured number of branches per plant, stem diameter, plant height and SPAD meter value. Number of branches were manually calculated while the stem (just above the soil) diameter was measured by using digital caliper (Mitutoyo, Japan). And the plant height was measured using measuring tape. Relative chlorophyll content of leaves was measured by using SPAD meter 502, Minolta Inc, USA. The measurement of relative chlorophyll content was taken from two levels from fully expanded young leaves.

## **CHAPTER 4**

### **RESULTS AND DISCUSSIONS**

#### **4.1 Introduction**

The study aimed for this study is to obtain the quantitative information about the effect of different level of height of LED light exposure on growth and relative chlorophyll content of *O. stamineus*. This chapter presents the results of the study according to the data collected through the instruments of the study. In addition, this chapter introduce the analysis of the results as the following. This chapter will also include the discussion of the results that needed to be used in the next chapter. There are generally four major data studied through this experiment which are the reading of number of branches, stem diameter, plant height and SPAD meter value.

## 4.2 Sampling observation based on number of branches

Table 4.1: The mean value of number of branches before and after experiment.

	H15	H20	H25	H30
<b>Before experiment</b>	37	19	13	12
<b>After experiment</b>	38	21	14	15
<b>Increment</b>	1	2	1	3

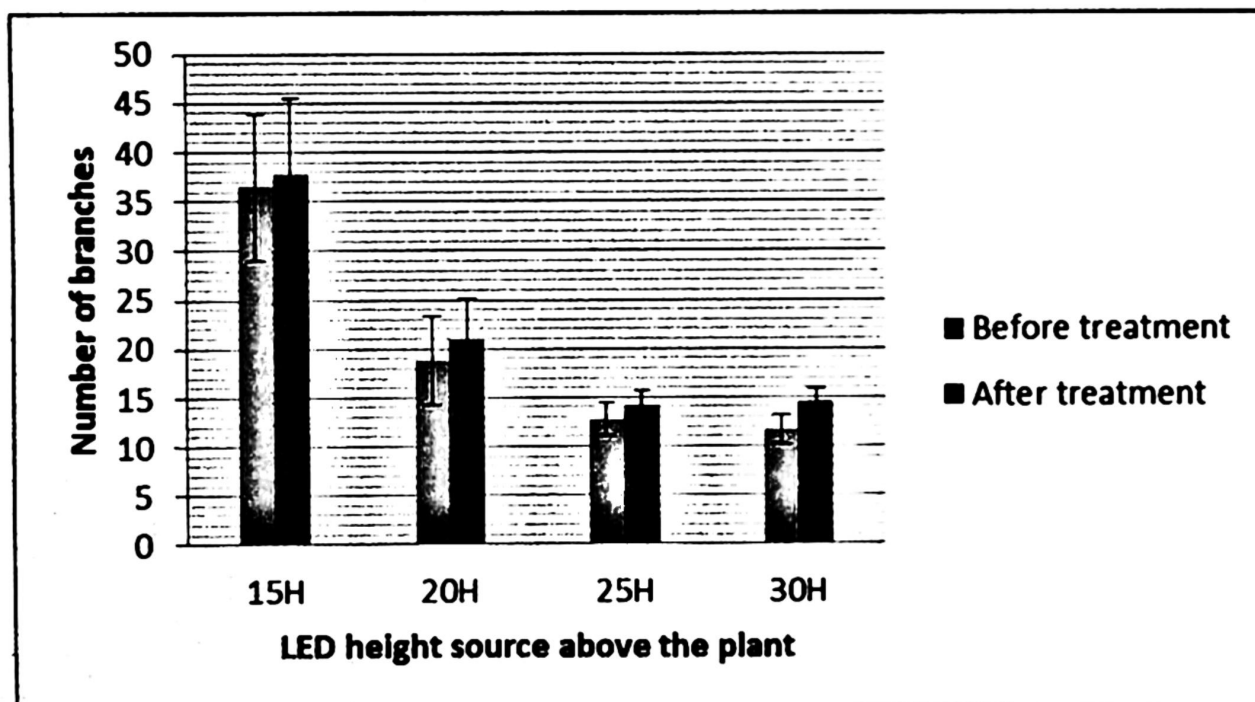


Figure 4.1: The effects of different level of LED source height before and after experiment on number of branches in *O.stamineus*.

Table 4.1 shows the different of value of mean number of branches before and after experiment. From the data, the plant with height of 30cm from the LED source shows the highest increment number of branches. The second highest

increments number of branches is the plant with height of 20cm from the LED source. The plants with the height of 15cm and 25cm from the LED source show the same increment number of branches. Figure 4.1 represent the data in the bar chart diagram to compare the result for before and after experiment in order to have more clear view of comparison.

### 4.3 Sampling observation based on the stem diameter

Table 4.2: The mean value of stem diameter before and after experiment.

	H15	H20	H25	H30
<b>Before experiment</b>	4.45	3.52	3.81	3.74
<b>After experiment</b>	5.14	4.30	3.83	3.81
<b>Increment</b>	0.69	0.78	0.02	0.07

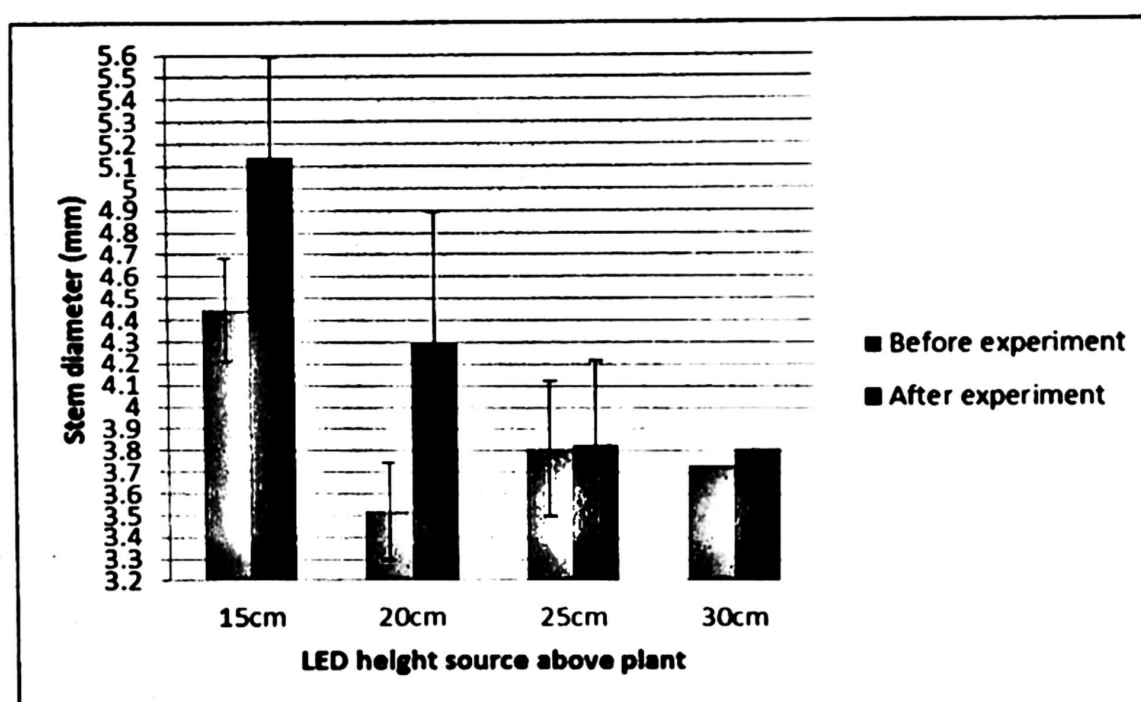


Figure 4.2: The effects of different level of LED source height before and after experiment on stem diameter in *O.stamineus*.

Table 4.2 shows the different of value of mean stem diameter before and after experiment. From the data, the plant with height of 20cm from the LED source shows the highest increment stem diameter which is 0.78cm. The second highest increments stem diameter is the plant with height of 15cm followed by the 30cm and 25cm from the LED source. Figure 4.2 represent the data in the bar chart diagram for the difference stem diameter the before and after experiment.

#### 4.4 Sampling observation based on the plant height

Table 4.3: The mean value of plant height before and after experiment.

	H15	H20	H25	H30
<b>Before treatment</b>	36.28 cm	21.95 cm	20.00 cm	19.75 cm
<b>After treatment</b>	38.25 cm	27.63 cm	22.00 cm	21.95 cm
<b>Increment</b>	1.97	5.68	2.00	2.20

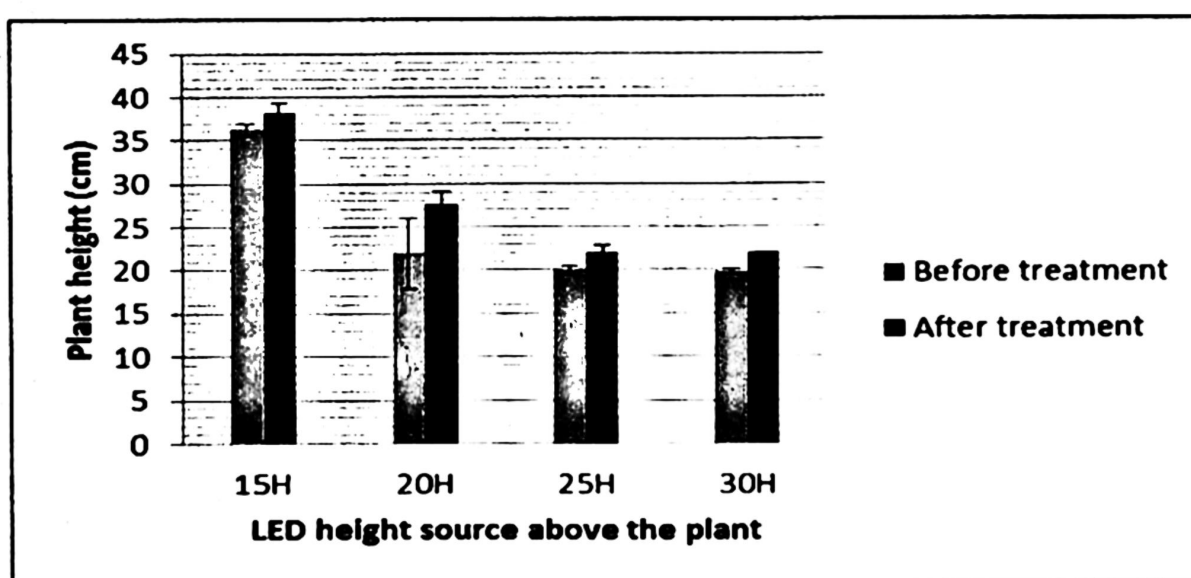


Figure 4.3: The effects of different level of LED source height before and after experiment on plant height of *O.stamineus*.

Table 4.3 shows the different of value of mean on plant height before and after experiment. From the data, the plant that exposed to LED source with height of 20cm shows the highest increment of plant height. The plants with the height of 25cm and 30cm show almost the same value of increment for plant height before and after experiment. The 15cm height shows the less value increment of plant height. Figure 4.3 represent the data in the bar chart diagram for the difference plant height before and after experiment.

#### 4.5 Sampling observation based on SPAD Meter reading

Table 4.4: The mean value of SPAD value (relative chlorophyll content) before and after experiment.

	H15	H20	H25	H30
<b>Before experiment</b>	32.91	29.67	29.93	30.36
<b>After experiment</b>	28.78	27.95	33.74	33.02
<b>Increment</b>	-4.13	-1.72	3.81	2.66

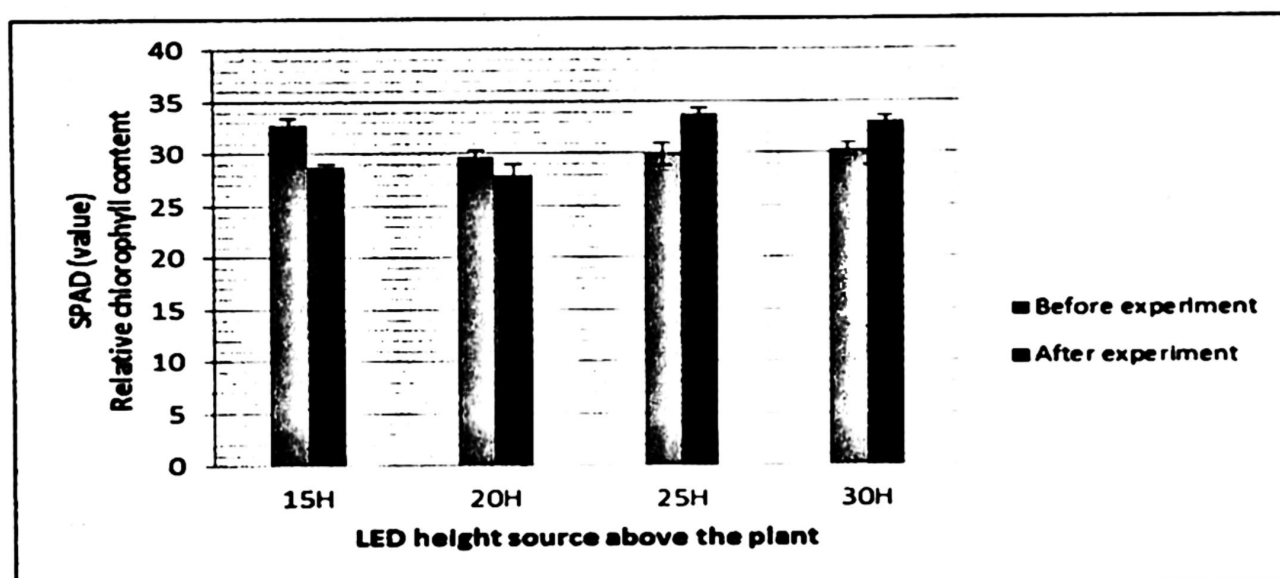


Figure 4.4: The effects of different level of LED source height before and after experiment on SPAD value (relative chlorophyll content) in *O.stamineus*.

Table 4.4 shows the different of value of mean of SPAD value (relative chlorophyll content) before and after experiment. From the data, the plant that exposed to LED source with height 25cm shows the highest increment. The second highest increments SPAD value (relative chlorophyll content) is the plant with height of 30cm. The height of 15cm and 20cm shows the negative value. Figure 4.4 represent the data in the bar chart diagram for the SPAD value (relative chlorophyll content) in *O.stamineus* before and after experiment.

Plant growth could be defined as the increasing of plant volume and/or mass with or without formation of new structures such as organs, tissues, cells or cell organelles. Growth is usually associated with development (cell and tissue specialization) and reproduction (production of new individuals) (Brukhin etc al. 2011). As knowledge on the fundamentals of plant embryogenesis, growth and development is constantly improving. In this project, the data on number of branches, number of leaves, stem diameter and SPAD meter value are gather here to investigate the plant development with the basic background knowledge.

The number of branches and stem diameter found for the plants exposed to the LED source was not so affected since the value increment number of branches was not so high. It is because short of time exposure which is only 7 days cause the growth of branches cannot be seen so clearly.

Next, for the height plant after experiment also shows the high increment. The height of plants is also important parameter to measure the growth of plants. If the plant received the enough light, the height of plants will increase faster.

Meanwhile, the SPAD value (relative chlorophyll content) was found affected after exposed plant to different level of LED height source as shown in Figure 4.4. The results implied that the SPAD value of 15H, 20H, 25H and 30H treatment as followed 28.78, 27.95, 33.74 and 33.02 respectively. The greater SPAD value for treatment 25H and 30H may have been attributable to the response of plant to low light intensity as consequently the leaf turns green when chlorophyll is abundant. Zhang et al also reported that chlorophyll content in *Physocarpus opulifolius* "Diabolo" was significantly increased under low light intensity which provided this cultivar to optimize the photosynthetic capacity. This results was suggest that *P. opulifolius* exhibits a greater ability in adaptation to low light intensity and shade tolerance. In contrast, the results of SPAD value decreased significantly for treatment 15H and 20H after experiment. From the observation, the leaves for treatment 15H and 20H became slightly green and yellowish. This symptom may have been attributable to the heat damage when LED source and plant too closed.

Some interesting findings can be concluded that as the distance between LED source and plant increases the light intensity became decreased as consequently negatively effects on plant growth. In fact, the light gradient depends on the distance between LED light source and vegetation. The proper distance between LED source and plant is vital in order to get healthy plant. From the experiment also proved that *O.stamineus* exhibited a great ability in adaptation to light intensity as  $16.13\mu\text{molm}^{-2}\text{s}^{-1}$  which reflected by the high relatively chlorophyll content (SPAD value) is at 20H to 30H treatment. However, this study is pre-assessment test. In order to get most significant data for plant height, stem diameter and number of branches the

duration of experiment must be extended to 4-8 weeks. Thus the optimum level of LED height source above the plant will be identified. The consideration also should be given to light intensity factor to neglect biasness of the results.

## **CHAPTER 5**

### **CONCLUSION AND RECOMMENDATIONS**

#### **5.1 Introduction**

This chapter displays the details that needed to be reviewed per conclusion of the project. In this part also details everything that require to be improved so that the project can be more powerful and better for the future, and thus able to help community to ease problems. This chapter also issues details during project construction.

#### **5.2 Conclusion**

When researches are being performed to an extent, the project is given ideas and recommendation over the project improvement. The idea could help other university student to provide helping hands in the university and to the Malaysian itself. The project can be upgraded to very large scale as the system is designed to the

practical system. The Research and Development (RnD) could be benefit by using the existed LED chamber.

To giving a conclusion, the project able to give the most suitable height exposed to the LED source which is around 20H to 30H. The growth rate of plant which was carried out the supplemental lightening was obviously fast then that without supplementary lighting. From the experimental results, we can know that the *O.stamineus* as a herb is very suitable as the research object in this system. Nowadays, the application of LED in lighting has become more and more widely and plays an important role in people's lives. The LED supplementary lighting lamp makes the LED to combine with the agricultural development more closely. China is a big agricultural country and its land area is vast. The light radiation of the sun varies according to the geographical latitude, season and weather conditions. In winter, the daytime becomes short in high latitude areas or in some areas there are specific climatic conditions like cloudy, rain, snow, fog for days. So the lack of light intensity and illumination time happens and then the LED supplementary lighting systems will be required. Therefore, artificial lighting has become an important means of efficient production in the production system of modern plants (such as greenhouse etc.). In the future, LED supplementary lighting systems will be widely applied to agricultural production. It will become a trend to use the supplementary lighting systems in the modern agriculture all over the world.

### **5.3 Recommendations**

By finishing the project, normally recommendation is provided to give ideas that is useful to upgrade the system, while not able to be produced in the time allocation given by the University. The idea is applied here so that the system could be given some improvements for the system to continue. Hopefully, for the future project, LED chamber can be design successfully and produce the more accurate and expected result. Besides, for the next improvement, other herbs that also give more benefit that can be used as a sample for the LED light exposed. Another recommendation is the control plant for measurement should be existed to as a control to this project.

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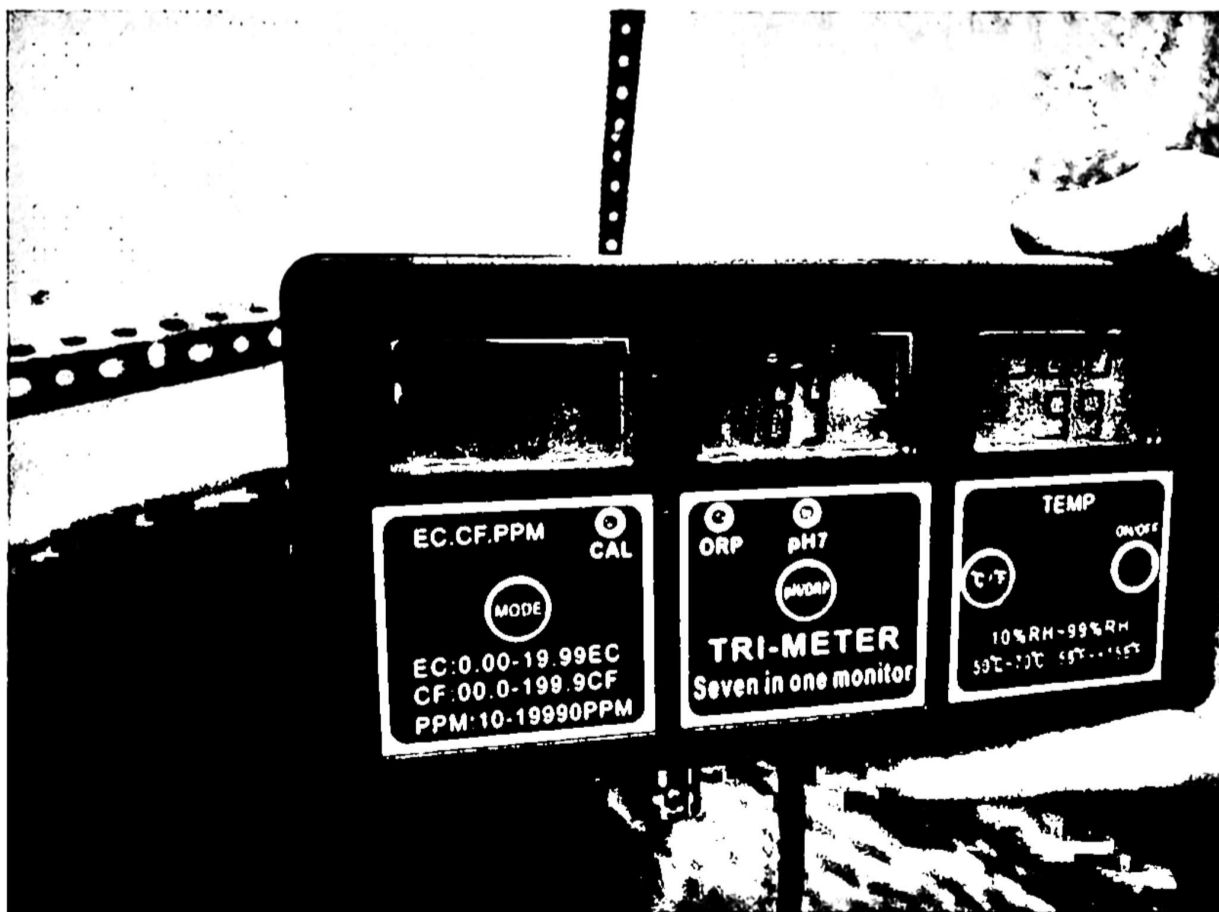
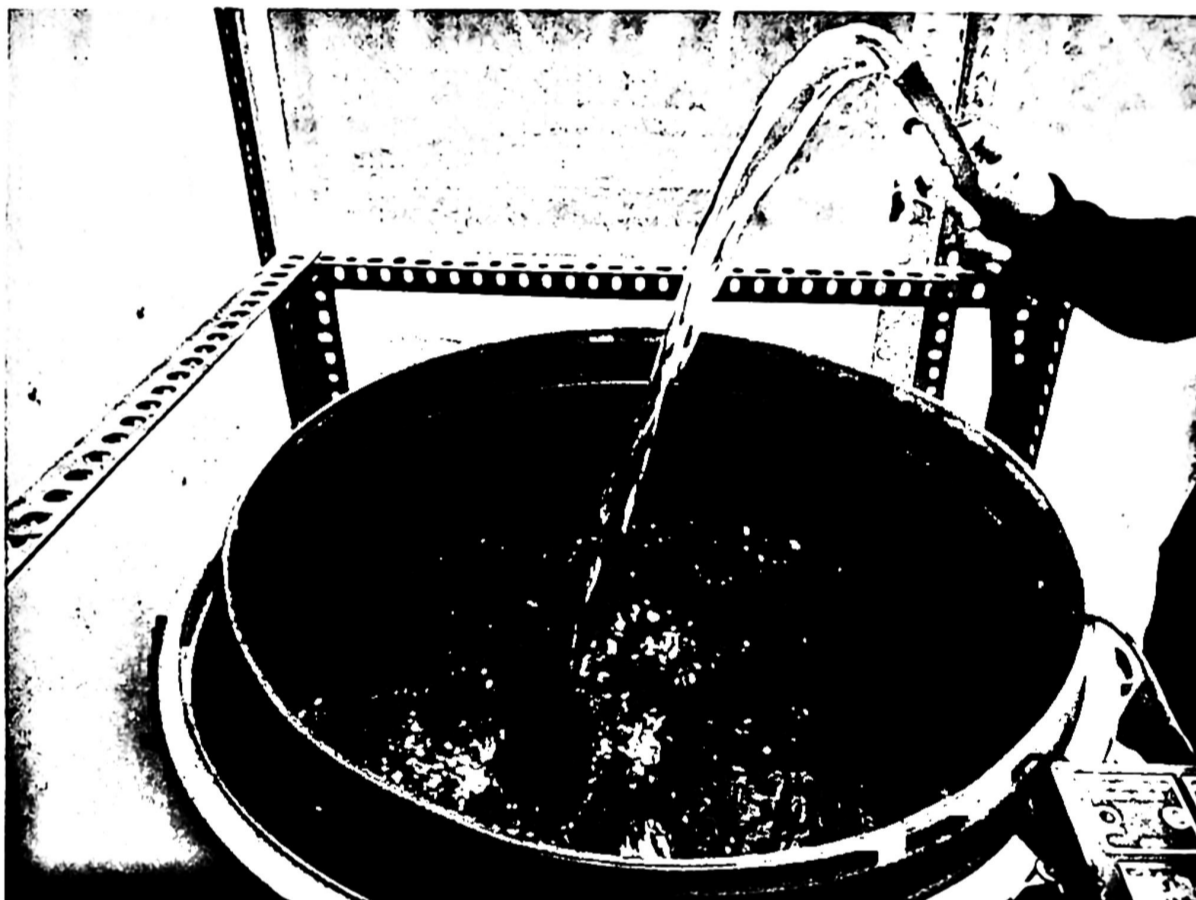
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## APPENDICES

### APPENDIX A: Preparation of water solution for fertigation system



**APPENDIX B: Measuring the parameters (number of branches,leaves, plant height and SPAD meter reading) for the plants**

