Micro Fertigation System Using Arduino Mega in Outdoor Vertical Garden.

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A report submitted in fulfillment of the requirements for the degree of Bachelor Applied Sciences (Agrotechnology) with Honours

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DECLARATION

I hereby declare that the work embodied in this report is the result of the original research and has not been submitted for a higher degree to any universities or institutions.

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MICRO FERTIGATION SYSTEM USING ARDUINO MEGA IN OUTDOOR VERTICAL GARDEN

ABSTRACT

Micro fertigation using Arduino mega based on soil moisture sensor in outdoor vertical garden is an automatic plant fertigation system in a vertically stacked structure. The system can automatically sense dry soil condition and answered correctly by fertigating the soil with the sufficient fertilizer mixed water solution . This study aimed was to compare the growth of three types of vegetables which are pak choy(*Brassica rapa l. var. chinensis*) ,kale(*Brassica oleracea cv. group chinese kale*) and kangkong (*Ipomea reptans l. pior*) in micro fertigation system using Arduino Mega in outdoor vertical garden. The experiment was conducted with three treatments and one control. Kangkong irrigated using automatic fertigation as first treatment, Kale irrigated using automatic fertigation as second treatment, Pak Choy irrigated using automatic fertigation as third treatment and one of each of the vegetables irrigated manually act as control. There are three replication for each treatment. From the result obtained, there are significance differences between all the treatments on the height of the plants, number of leaves and light intensity received by the plants ($P < 0.05$). But, there are no significant difference between all the treatments on the chlorophyll content of the vegetables($P > 0.05$). Optimum height of plants is from Kangkong plant with value of 29.17cm. Next, the highest number of leaves produced is by Kangkong (7.15 units). Plus, the highest chlorophyll content recorded from Kangkong (36.86 µmol per m^2 of leaf). Lastly, highest light intensity received is by Kale Sensor 3(532 lx).

Keywords: micro fertigation, Arduino mega, vertical garden, vegetables

FERTIGASI MIKRO MENGGUNAKAN ARDUINO MEGA DALAM SISTEM TANAMAN POKOK MENEGAK DILUAR BANGUNAN

ABSTRAK

Fertigasi mikro menggunakan Arduino mega berdasarkan sensor kelembapan tanah dalam sistem tanaman pokok menegak diluar bangunan adalah sebuah sistem fertigasi automatic dalam struktur menegak. Sistem ini secara automatik dapat mengesan keadaan tanah kering dan membekalkan air campuran baja yang cukup kepada tanah. Kajian ini bertujuan untuk membandingkan pertumbuhan tiga jenis sayur-sayuran iaitu pak choi *Brassica rapa l. var. chinensis*) ,khailan (*Brassica oleracea cv. group chinese kale*) dan kangkong (*Ipomea reptans l. pior*) dalam sistem fertigasi mikro menggunakan Arduino mega dalam sistem tanaman pokok menegak diluar bangunan. Eksperimen ini dijalankan dengan tiga rawatan dan satu kawalan. Kangkong disiram secara fertigasi automatik sebagai rawatan pertama, Khailan disiram secara fertigasi automatik sebagai rawatan kedua, Pak Choi disiram secara fertigasi automatik sebagai rawatan ketiga dan setiap satu dari sayur-sayuran disiram secara manual bertindak sebagai kawalan. Terdapat tiga replikasi untuk setiap rawatan. Dari hasil yang diperoleh, ada perbezaan yang signifikan antara semua rawatan pada ketinggian tanaman, jumlah daun dan intensitas cahaya yang diterima oleh tanaman($P < 0.05$). Namun, tidak ada perbezaan yang signifikan antara semua rawatan pada kandungan klorofil sayuran($P > 0.05$). Ketinggian optimum tumbuhan adalah dari tumbuhan Kangkong dengan nilai 29.17cm. Seterusnya, bilangan daun yang paling banyak dihasilkan ialah oleh Kangkong (7.15 unit). Tambahan, kandungan klorofil tertinggi dicatatkan dari Kangkong (36.86 μmol per m^2 daun). Akhir sekali, intensiti cahaya tertinggi yang diterima tumbuhan oleh Kale Sensor 3 (532 lx).

Kata kunci: fertigasi mikro, arduino mega,tanaman menegak, sayur-sayuran

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CHAPTER 1

INTRODUCTION

Urban farming is described as any agro activities which produces, rears, processes and delivers farm products of land area and total human resources in the cities and towns (FAO, 2000). Urban farming donates to the enhancement of sustainability in metropolises by developing environmental value. By adding green atmosphere to the neighborhood, it can also diminish adverse impacts of urbanization on the environment (Tsuchiya *et al*., 2015).

According to Malaysia International Trade and Industry Report (2015), urban population percentage in Peninsular Malaysia is estimated to reach 75% in 2020 from 65.4% in 2004. Peninsular Malaysia suffers lack of food production. Each year, importing of food increased RM10.68 million from 2003 to 2007. Malaysia might face great struggle if global food crisis happen due to high dependency on imported food from other country. Urban cultivation is an significant medium to guarantee constant food supply, decrease cost living in cities, improve food safety and security and protect urban environment with better value. Increasing living costs faced by town citizens mainly due to rising of food manufacturing cost, processing and markets. Zezza & Tasciotti (2010) stated that food security, dietary diversity and nutritionally adequate diet closely related to urban agrarian activities. An irrigation network is also necessary while fertigation, monitoring, and lighting systems are optional (Luis *et. al,* 2016). FAO's support of water in urban and peri urban agriculture includes water saving technologies, including pressurized irrigation systems such as drip irrigation or sprinklers.

Drip irrigation is water application via point or line emitters positioned above or in the soil surface at low operating pressure (Dasberg and Or, 1999). A study by Schwankl (1997), showed that drip irrigation technology also improves irrigation efficiency by reducing rate of evaporation from soil surface, reducing eliminating runoff and deep percolation, and eliminating the need to drastically over irrigate some parts of the field to compensate for uneven water application. Drip irrigation can be the best energy saving and water saving among all types of irrigation systems. Water utilization reduced up to 50% correlated to regular sprinkler type irrigation (Lamont *et. al*, 2002). Preferably, water is supply in the required volume to the root of the plant, reducing water leakage from the root region and lessening rate of water evaporation as the water is not applied as mist into the air (Shock, 2006; Lamont *et. al*, 2002).

Generally, the farming sector use about 70% of the Earth's freshwater. Wasteful usage of water in crop growing sector is a problem that needs to be focus. The main causes of agriculture water waste and inefficient water use are damage irrigation systems, incorrect farm application techniques and farming of high water use crops that not appropriate to the surroundings. The problem is made worse by misapplied inputs, low community and governmental consciousness of the disaster, and frail ecological law (Edward *et. al.*, 2017). To make the agricultural works easily, the automated crops irrigation system is invented. With the use of Arduino to set up a fertigation system, the problems may be solve or reduce.

Automatic crops irrigation system is believed as one of the most frequently applied and currently the most helpful automated systems that ease people in their daily routines by decreasing or totally substituting their work. This system utilizes sensor technology together with microcontroller and other electronic devices to function as intelligent system which measure soil moisture level and waters the crop if needed. Arduino is a single-board microcontroller created using electronics that make multidisciplinary tasks more manageable. The tiny yet smart hardware comprises of a simple open source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. The software consists of a standard encoding language compiler and a boot loader that performs on the microcontroller (Next & Vme, 2010). This can be supported by Lambert(2018), arduino also known as a set in system of computer system with a particular, committed purpose that is unplanned so that it should ever require to be re encoded. The most common type of set in system is a microcontroller, which is a tiny computer system on a solo combined circuit. Microcontrollers are specialized at carrying out jobs such as interpreted sensors and applying controller rule, but it is significant to remind that the microcontroller are not analog, which means they are discretized in how they interpret data, in contrast to the real world in which we live which is in real time, and so that everything occur is rapidly in nature. In order to resolve this, a microcontroller will use together non analog -to-analog alteration (DAC) to change from dualistic values to real production voltages and non-digital-to-digital alteration (ADC) to change from an input hint to numerical information that the microcontroller can utilize. The microcontroller type used in this study is Arduino Mega.

1.1 Problem Statement

Irrigation system using manual watering is easy to handle, simple and use no technical equipment. However, it is more labor demanding, cause water spills, overwatering problems that can cause crops damage and cause wastes water issues. To reduce this problem this study focused on using Arduino Mega micro controller to produce a low cost micro fertigation system in vertical garden that could be a better solution for fertigation especially in urban farming. Sufficient information on the benefits of using this system for growing vegetables is not available in Malaysia.

1.2 Objective

To compare the growth of three types of vegetables which are pak choy(*Brassica rapa l. var. chinensis*) ,kale(*Brassica oleracea cv. group chinese kale*) and kangkong (*Ipomea reptans l. pior*) in respect of growth parameter using manual watering and micro fertigation system using Arduino mega in outdoor vertical garden.

1.3 Hypothesis

- H null: the growth of three types of vegetables which are pak choy(*Brassica rapa l. var. chinensis*) ,kale(*Brassica oleracea cv. group chinese kale*) and kangkong (*Ipomea reptans l. pior*) using manual watering and in micro fertigation system using Arduino Mega in outdoor vertical garden cannot be compared.
- H alternate: the growth of three types of vegetables which are pak choy(*Brassica rapa l. var. chinensis*) ,kale(*Brassica oleracea cv. group chinese kale*) and kangkong (*Ipomea reptans l. pior*) using manual watering and in micro fertigation system using Arduino Mega in outdoor vertical garden can be compared.

1.4 Scope Of Study

The scope of study in this project is on set up a micro fertigation system which is inline drip system using Arduino Mega in an outdoor vertical garden with three treatments and one control. Kangkong irrigated using automatic fertigation as first treatment, Kale irrigated using automatic fertigation as second treatment, Pak Choy irrigated using automatic fertigation as third treatment and one of each of the vegetables irrigated manually act as control. There are three replication for each treatment.

1.5 Significant of study

The significant of this study is to growing vegetables using automation technology in a small scale farming which is in vertical stacked structure in an automatic fertigation system by using smart microcontroller Arduino Mega based on soil moisture sensors in which the fertigation will carried out only when the sensor senses dry soil condition. Water and fertilizer inputs utilization can be reduced and applied in efficient amount for desired yields. This project is suits to be implant at kitchen garden that suits for family consumption.

CHAPTER 2

LITERATURE REVIEW

2.1 Urban farming.

The world's population continues to grow rapidly, but the productive cropped land area is decreasing very rapidly due to industrialization and urbanization (Oliver and Gregory, 2015).According to Poulsen *et. al*,(2015), urban farming can reduce daily expenses and inspire citizens to grow their own vegetables crops around their houses. Urban farming may offer alternative food source or earnings for families and aid to lessen the food poisoning issues. Urban farming is cultivating and rearing livestock in urban settings for local food supplies (Mindy,2011). Rafiqah and Aziz (2015) defined urban agriculture as foods and goods production by farming, cultivation, animal husbandry and forestry. Furthermore, urban agriculture described as the agricultural practice in and around towns and cities such as cultivating plants, fungi, fish and other animals defined by Tim and Ilina (2016). According to Raba (2018) ,farmers in the town is one of the main gears to define urban agriculture development.

Therefore, urban farming meaning is the techniques of producing crops and animals livestock in metropolitan settings or in the suburbs designed to meet urban farmers and communities nearby demands.

There are advantages of urban farming in economically, socially, environmentally and health is among the knowledge needed by urban farmers in Malaysia (Raba,2018). Even though urban farming does not help significantly to create job opportunities, however in terms of food safety it plays vital role to reduce urban poverty issues (Nugent, 2002). City residents can harvest their own vegetables daily and securely through urban farming activities (Ratnawati and Abdullah, 2012). Tsuchiya *et al*., (2015), stated that urban farming have a significant part in some environmental features such as contributes an option to the waste disposal problem by making it to be useful resources through composting. Zaidi *et al*., (2013), exposed that urban farming can also recover the natural habitat and biodiversity in urban settings by creating green spaces comprising of plants variation to ensure the stability and survival of certain floras and faunas. In addition, the green concept of urban farming recommend that it decreases the risky effects of erosion accidents, improve sunlight shading and regulate surrounding area temperature to be more conducive and enhance aesthetic value of the town. Many gardeners said that the plants related activities helps them to reduce mental pressure, improved health and also caused individuals to be more active in their free time which has been found to avoid disease and other sicknesses (Teig *et al.,* 2009).

2.2 Vertical farming

Vertical farming is the key for city, lack of land metropolises, and republics such as Singapore. The model of vertical garden is already famous previously. Growers in East Asia have been cultivating paddy in vertical hill slopes in order to save space and water. An American geologist Gilbert Ellis Bailey was the creator of “Vertical Farming” in 1915. In 1950s, a trial to assimilate farming into the urbanized location was done in Denmark when an agrarian cultivated cress in a workshop on a bulk quantity. Later, vertical agricultural has grown into rising crops in whole-organized, interior municipal surroundings. “In vertical farming, plants are cultivated in multi-stacks or vertically-inclined surfaces of buildings, warehouses, or greenhouses located in cities or urban areas. The plants could be cultivated in three ways such in a soil-based system in which plants are potted in trays of soil and sprayed periodically with a, mist of nutrients, or an aeroponic system in which the roots of plants are sprayed periodically with a mist that provided the necessary nutrients, hydration, and oxygen for growth, or hydroponic system in which the roots of plants dipped in water containing nutrients and grown soilless. Nevertheless growing vegetables method, vertical farming based on inputs-conservation principles is said to be workable in the long period of time”(Despommier, 2010). In instance, rising crops in stackable drawer lessens area use for crops growing. Glass houses where natural light from sun can be enhance using light-emitting diode that decrease electrical energy utilization. Cultivation area in municipalities also can reduces transports requirements and petroleum usage (Rt *et al.*, 2015).

Some of benefits of vertical farming for ecology, they can imitate natural flora and faunas surroundings (Madre *et al.*, 2015), they offer habitats (Brenneisen, 2006) for birdies and bugs that is significant for many roles and ecological services, such as act as pollinating agents or as biological controller (Madre *et al.*, 2015). Vertical garden also functions to grow species that can offer specific purposes that are absent in the metropolitan setting, commonly focused on crops' ability to eliminate air impurities (Francis and Lorimer, 2011). In terms of environmental implications, in interior vertical gardens case, a house's inside atmosphere may benefit from vegetation on air quality (Todd, 2005), which linked to the plants' ability to filter dirty dust from air and also to their efficacy. Hunter *et al.*,(2014), stated that outdoor vertical garden may control internal temperature via solar heat capture by plants; warm air insulation by the plants, give cooling effects and wind pattern adjustment in the construction envelope. Wong *et al.,(*2010), added that the application of vertical farming system may also contribute a great impact on urban landscape makeover.

2.3 Irrigation

According to Devika *et al.*, (2014), irrigation is the helps in applying water to the land or soil. Irrigation function to help in the cultivating of food crops, sustenance of landscapes, and replanting crops on eroded areas and during low rainfall season. In agriculture, irrigation benefits in avoiding crops against blight diseases, destroying weed growing in grain farms and inhibiting soil consolidation. Irrigation systems are also utilized for dirt elimination, removal of manure, and in excavating. The traditional technique utilized for watering was with watering cans, waterways that have to be unclosed and closed by hand or using knapsack sprayers. In irrigation practices, lots of water is loss. Irrigation systems duty is to irrigate crops at rates, in quantities, and at times required to meet irrigation desires and plans. Water will be divert from it source, convey it to cultivation areas, and send it over the area need to be irrigated. A dependable and proper irrigation water supply can result in huge enhancements in farm yields and promise the profitable vitality of the region. However, inadequate irrigation practice can cause water waste and nutrient loss from plant root in result may cause groundwater pollution. Thus, ideal irrigation programing is significant to enhance water and nutrient uptake of crops (Alva *et al*., 2005).

A study by Gutierrez *et al.*, (2001), stated that there is requirement for enhancement on the present or traditional irrigation system. An automatic plant watering system must be established to improve water usage for crops production. Based on a study carried out by Qiuming *et al.*, (2007), informed that a smart automated plant watering system has to have all the elements that separately observe and regulate the water supply level for crops devoid of some breakdown or man involvement .

2.3.1 Fertigation

Sureshkumar *et al*., (2017), explained that fertigation is where the nutrients water mix in necessary amount at correct time are applied in the plant root zone in order to ensure the plant can get maximum nutrients water mix absorption and assured to produce more yields per drop of water. 'Fertigation' is a fusion of two words: 'fertilizer' and 'irrigation.' Fertigation is the process of applying mineral fertilizers to crops along with the irrigation water (Kafkafi *et al*.,2005). Based on a study by Joseph, Thirunavuakkarasu, Bhaskar and Penujuru(2017), the technique of supplying vital nutrients to crops by providing fertilizer mixture in irrigation water is termed as fertigation. It is a new farming system that is being adapted widely in current agriculture and horticulture industries. Based on a study Kafkafi *et al*., (2005), explained that in the last 40 years, fertigation system has widely spread all over the world as a tool to supply the plant with its daily demand of water and fertilizers as needed by its specific growth phase all through its growth to attain full productivity of the fertilizer applied. One of the characteristics of good agricultural practices is to have the most optimum applied inputs effectiveness specifically water and fertilizers. Therefore at appropriate concentrations the fertilizers are dissolved in water and applied through irrigation water by micro irrigation systems.

According to Chen *et al*., (2010), some of advantages of fertigation are the crops roots zone will absorb more nutrients and water supplied, reduce nutrient leaching possibilities and also minimized crop damages during fertilizer application. "Effective foraging space" (EFS) of a crop is term as the soil space which accounts for 80 per cent or more of root activity hence, it is possible to supply the nutrients in the EFS to assure almost complete absorption according to the crop demand throughout the growing season" (Wahid, 2000). The are also possibilities of high production for crops as water and fertilizer are supplied evenly to all the crops. Singh(2002) stated that fertigation guarantees greater quality and high crop yield plus with time flexibility and energy savings which makes fertigation economically cost-effective. Fertigation make the best use of the two most worth resources particularly water and nutrients and also exploits the synergism of their simultaneous availability to plants The expensive investment of fertilizer injection system, and safety devices are the limiting factors for fertigation.

2.3.2 Drip Fertigation

Based on a study by Liang *et al.*, (2014), stated that drip fertigation is a system utilized to control water and fertilizer deliveries based on crops water and fertilizer requirement. It can be supplied to green crops to balance stable contents of water and fertilizer in the crops root zone. It supplies repeated constant and little quantities of soluble nutrients mixed in water .This system has been practiced for ages in developed states but still infrequently applied in agriculture in developing countries. Drip fertigation has become an ideal technique for supplying fertilizer water straightly to the crops root due to its ability of accurately provide water nutrients applications. The aim of drip fertigation is synchronizing the application of water and nutrient with crop requirements and maintaining the proper concentration and distribution of nutrient and water (Assouline,2002). Narda and Lubana (2002), also describe drip fertigation as a method of irrigation in which water and fertilizer is supplied to plant root zone at controlled amount and in addition fertilizer application can also be done along with irrigation which is called drip fertigation.

By minimizing fertilizer and water losses it gives economic benefit to the crop grower. The main disadvantage of drip irrigation system is its high initial cost. To reduce the burden on farmers, government (state and central) provides financial subsidy. Lack of knowledge and delays in getting subsidies are the other important factors for the non-adoption of the drip irrigation(Kaushal and Singh,2011).Adoption of drip irrigation requires appropriate economic incentives to farmers, changes in the structure of production costs and increased value of production to achieve desired economic benefits.

2.4 Nutrient Requirement

The practice of fertigation usually does not alter the fertilizer supplies for type of crop. Sufficient amount of fertilizer needed differ with crops' location, type of soil and type of crop grown (Hartz and Hochmuth,1996). All type of soils, excluding for organic soils are lacking in Nitrogen (N), which need to be supplied for almost all types of annual vegetables. Generally, mineral type of soils also deficient in Phosphorus (P) and Potassium (K), that needs to be supplied to the crops grown. Soil tests calibration should be carried out to recognized the requirements for micronutrients because it differ commonly depends on the types of crop ,the soil fertility range and nutrients requirements. Farmers should apply fertilizer using recommended fertilizer ratio established by local experts based on the soil fertility basis and rate of nutrients crops required (Hochmuth and Hanlon,1995).

2.5 Microcontroller

It has been proposed that microcontrollers contributed a very important part in the advancement and application of robotics field. Robotics is the procedure of directing system and data to reduce the requirement of people involvement (Lakra and Gupta, 2015).

A microcontroller is a whole computer incorporates on a chip that integrates all the functions that are establish in central processing unit of a computer. As a resolution of these system, they have great concerns on-chip abilities such as built in Timers, ROM, Clock circuit RAM, I/O ports, Counters, Serial Port, Interrupts controllers, Analog-to-Digital Converters, and Parallel I/O ports. As a great digital processor, the regulatory degree and ability to be code or fit in program, they offer meaningfully improves the efficiency of the system (Ajao *et al.,* 2015). Microcontroller is known as Arduino and it comes in different types of boards.

Table 2.1 : Different types of Arduino boards.

Features	Arduino Uno	Arduino Due	Arduino Mega	Arduino Leonardo
Processor	16Mhz ATmega328	84MHz AT91SAM3X8E	16MHz ATmega2560	16MHz ATmega32u4
Memory	2KB SRAM, 32KB flash	96KB SRAM, 512KB flash	8KB SRAM, 256KB flash	2.5KB SRAM, 32KB flash
Digital I/O	14	54	54	20
Analogue I/O	6 input, 0 output	12 input, 2 output	16 input, 0 output	12 input, 0 output

Sources: Zibon. K., and Hsan. F.,(2016).

2.5.1 Arduino Mega

The Arduino Mega is a microcontroller panel built on the ATmega2560. It has 54 numerical input/output pins 16 analog inputs, a 16 MHz crystal resonator, a USB joining, a power card, an ICSP heading, and a retune knob. It comprises all things needed to support the microcontroller; only link it to a PC with a Universal Serial Bus cable or rule it with a AC-to-DC electric plug or power cell to begin. The microcontroller contrasts from all other panels because it does not use the Future Technology Devices International. Universal Serial Bus -to-sequential driver chip. As an alternative, it use the Atmega8U2 set as a Universal Serial Bus -to-sequential proponent. The Arduino Mega can be function via the Universal Serial Bus connection or with an outside electrical source. The electrical supply is chose spontaneously. Outside electrical source can originate both from an AC-to-DC connector or lithium cell. The connector can be connected by plug in a 2.1mm center-positive plug into the panel's power port.(Devika *et al.*, 2014).

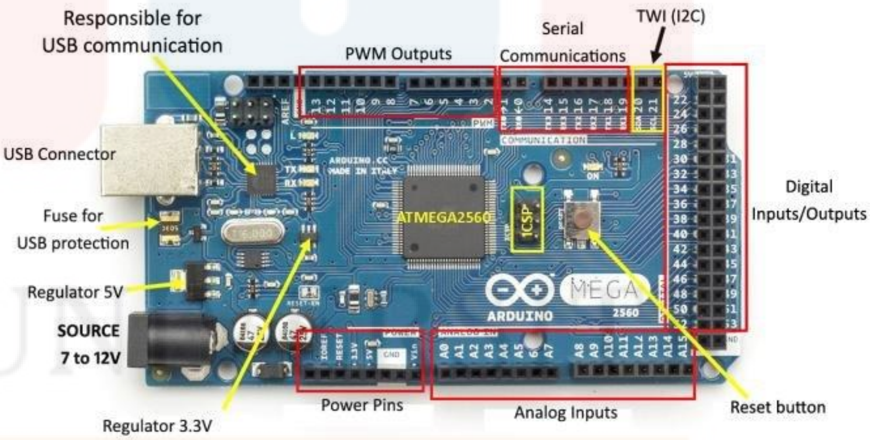

Figure 2. 1 : Arduino Mega

(Sources: Devika *et al.*, 2015)

2.6 Soil Moisture Sensor

The soil moisture sensor will be used is known as hygrometer. The hygrometer utilize capacitor rate to calculate dielectric permittivity of the soil medium. The dielectric permittivity calculated by the hygrometer will be proportional to the current produced, hence the soil moisture content will be determined. The hygrometer divides the soil moisture content over the whole extent of the hygrometer(Singh & Saikia, 2017).

Electrical conductivity in soil is basically evaluated using two metal electrodes separated apart in the soil. Dissolved salts in the soil are exclude because it can seriously change the conductivity of water and can confuse the soil moisture measurements. Therefore, utilization of soil moisture sensors cause the outstanding issue will be dependable and it is high quality cheap sensors and great sensing device for evaluation and reading the data.

Table 2.2 : Soil moisture sensor readings for the soil conditions.

SOIL MOISTURE SENSOR READINGS	
CONDITION	**READING RANGE**
Wet	Below than 550
Soggy	550-660
Dry	More than 700

(Sources: Edmond *et al*.,2015)

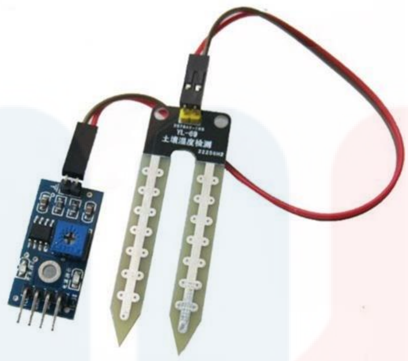

Figure 2. 2: Hygrometer used for Arduino.

(Sources: Edmond *et al.*,2015)

Table 2.2 shows the soil moisture sensor readings correlate to the soil conditions. The hygrometer is function to indicate the soil moisture condition whether it is in wet condition, soggy condition or dry condition to identify its irrigation necessity set in the Arduino system. Figure 2.2 showed a hygrometer used for Arduino.

2.7 *Brassica rapa l. var. chinensis*

Ong king Pak Choy or its scientific name *Brassica rapa L. var. chinensis* is a leafy vegetables that can be grown in fertile, well-drained soil with a pH level of 6.0-6.8 such as light (sandy), medium (loamy) and heavy (clay) soils. This vegetable bears soil with 4.3 to 7.5 pH . The plant is shallow rooted and intolerant of drought, it needs to be grown in a moist fertile soil for the best quality leaves. It can survive in medium shade or full sunlight location. The plant is self-fertile. The seeds need to be sow ¼" deep, ½" apart, in rows set 2 feet apart. It can be straightly sown into the crops area or it can be cultivated in the garden center and moved to the farms.

After about 40 to 60 days from the day of the seeds being sown, the vegetables can be harvested when the leaves size reached 7’’ long. Compared with many other vegetable crops, this short duration crop have a low production costs, high production of seed and pak choy adaptation to tropical weather and condition provides benefits to farmers in tropical regions(AVRDC, 2000).Thru the period of the vegetables growth, the soil must be keep moist, weeding must be carried out frequently regularly and well-drainage is a must. Ong king Pak Choy is high in dietary fiber and one of the best folic acid source that is important for our health. This type of vegetables also classified as annual crops that can grows rapidly under well maintained environment. All part of this Ong King Pak Choy except the root zone is eatable. For each 100 g part of Ong King Pak Choy rich in 1.7 grams of protein 1.7 g, 0.2 grams of fat, 3.1 grams of carbo, vitamins and minerals (Tay & Toxopeus, 1994). It accounts for 30%–40% of the vegetable production area in China and is widely consumed because of its nutritional bioactive components such as folate, vitamin C, carotenoids, polyphenols, and GSs (Podsedek, 2007; Hanson *et al*., 2009; Verkerk *et al.*, 2009).

2.8 *Brassica oleracea cv. group chinese kale*

Chinese kale or many called it as Chinese broccoli, Kailan, or Gai-lan is a China originated green vegetable. Chinese kale fits in the similar class as common kale, normal broccoli, cauliflower, and cabbage, *Brassica Oleracea*, but fits in *Alboglabra* cultivar. Chinese kale grows best in temperatures of 64-82°F (18-28°C) (Department of Agriculture and Fisheries, Queensland Government, 2010) Plants grow to about 1-

2 feet tall. Chinese kale is a long life plant, but is often grown commercially as an annual crop (one season) (Kopta and Pokluda, 2009). Chinese kale is a famous vegetable in Asia and currently is being widely sold fresh in the market. It is sold in bulk with all parts of the whole vegetables include its stem, flower and leaves.

According to Tuquero(2016), roughly 50- 70 days after germination, young leaves can be harvested. Generally after 80-95 days after germination, initial bolts (shoots with young leaves and flower buds) are ready to be harvest. When flower buds are unopened or slightly opened it is the most suitable timing for bolts(5-10 inches) to be harvested. There are also some Chinese kale varieties that can be harvested more earlier. After initial bolds first harvest, new bolts will grow and about one week after first harvest, harvesting activities can carry on. These bolts average 5-10 inches in height, and are usually lighter in weight than initial harvested bolts. At least for 60 days, the plants can yield a high harvest . Chinese kale taste a little bit bitter but usually sweet than normal broccoli(Tuquero, 2016). Chinese kale is said to be rich in vitamin a, vitamin c, vitamin k, folic acid, calcium, and fiber.

2.9 *Ipomea reptans l. pior*

Kangkong (*Ipomoea reptans L. Pior)* is a significant traditional green vegetable crop grown in Indonesia. Generally all parts of the young Kangkong are edible. Young soft stems are more preferable because old kangkong stems are more fibrous. Kangkong can be cultivated in low or high land and they fit to the *Convovulaceae* family. It has short cultivation time, fast and easy development, broadly flexible, and high resistance to disease that make it ideal for farming. Kangkong commonly cultivates in small scale farm, but in present Kangkong becoming an important profitable leafy vegetables and commercialized widely(Susila, Prasetyo and Palada, 2008).

In kangkong, the main axis and both laterals each produce about one leaf every 2-3 days. Growth of plant is rapid and the first harvest may take place one month after seed sowing and then can be done at weekly intervals. The higher part of the kangkong main shoot is cut, causing horizontal growing of the plant which create the usual straight young branch. During the first harvest, for transplantation of cut stems can be done in another place. Consequently the second harvest may be double that of the first, gradually increasing to four times before beginning to decline. It contains various vitamins such as A, B1, B2, B6, B12, C, E, K (Igwenyi *et al.*, 2011) and vitamin “U” (S-methylmethionine) to treat the ailments like gastric and intestinal disorders. The plant is also used in the treatment of liver diseases, constipations, diabetes, abscesses, mental illness and intestinal problems, nose bleeds and high blood pressure (Malala, Wick and Jansz,2000).

2.10 Plant chlorophyll content

According to Subandi(2008), chlorophyll is a photosynthetic green pigment owned by plants, Algae and Cynobacteria. The name "chlorophyll" comes from the ancient Greek: choloros means green, and phyllon means leaves. The chlorophyll function in the plant is absorbing energy from sunlight to be used in photosynthetic process in a biochemical process wherein the plant synthesizes carbohydrates (a process of converting sugar into starch), from carbon dioxide and water vapor with the help of sunlight. Chlorophyll is a green colorant, which is basically same like porphyrin pigments such as heme and it is synthesized through the similar metabolic pathway. Chlorophyll aids the body in a unique and typical ways. It benefits to remove bad toxins from the body and it is also used to combat infection. A suggested and regular intake of chlorophyll can maintain the circulatory and digestive systems much better. (Gaherwar, S., & Kulkarni, P. 2017).

It has been suggested that leaf chlorophyll content is a significant factor for testing plant status. For example, chlorophyll in plant can be utilized as an parameter of the photosynthetic potential along with plant yield (Carter, 1998; Filella et al., 1995). Plus, chlorophyll provides nutrient status estimation due to the most of leaf nitrogen is obtained in chlorophyll (Filella *et al.*, 1995). Chlorophylls also said to be the most lavish pigments in green plants and earning greater significance in the human nutrition, not only as food dyes, but also as healthy food elements. (Xue and Yang, 2009).

2.11 Plant light intensity

Light act as the basic source of energy and significant component for plants development (Naoya *et al.*, 2008). Appropriate light are required for best plant development, biological and physical processes in plants (Li and Kubota, 2009). Different light intensity is stated to have effect on progress of the plants in terms of leaves structure and plants composition (Hogewoning *et al.*, 2010; Macedo *et al.*, 2011). According to Long *et al.*,(1994), photo inhibition in plants occurred to plants that only get low light. Generally, the net photosynthesis rate (Pn) increases links with increasing light intensity . despite that, high light intensity caused low net photosynthesis rate (Bowes *et al.*, 1971; Khatib and Paulsen, 1989). Plants have developed many mechanisms, including morphological and physiological variations at the levels of the leaf in order to regulate the different light environments, (Zhang *et al.*, 2003). Low light intensity may cause increased in specific leaf area (SLA) and plant height. These evolutions help plants to capture maximum available light and also meeting the demand for photosynthesis (Steinger *et al.*, 2003).

CHAPTER 3

METHODOLOGY

3.1 Materials

Material and equipment used in this project are seed tray, coco peat, top soil, 13x10x11 cm polybag, shoe rack ,DC plug, Arduino Mega 2560, 10 x15 single side fiber glass green board prototype PCB Universal Board, L293D Dual H-Bridge Motor Driver Chip, 40 pin male header, IC socket 16 Pin, Single core wire, 2L Mini Diaphragm Water pump for arduino, LM393 Soil Moisture Sensor for Arduino(Hygrometer) with wire , 3 Way Terminal Block, 2 Way Terminal Block, 40cm Female to Female 40P Solderless Jumper Breadboard Wires, cable ties, 215mm x 150mm x 80mm ABS Waterproof , Micro drip emitter with wire, Pak Choy Seeds , Chinese Kale Seeds and Kangkong seeds.

3.2 Methods

3.2.1 Research design

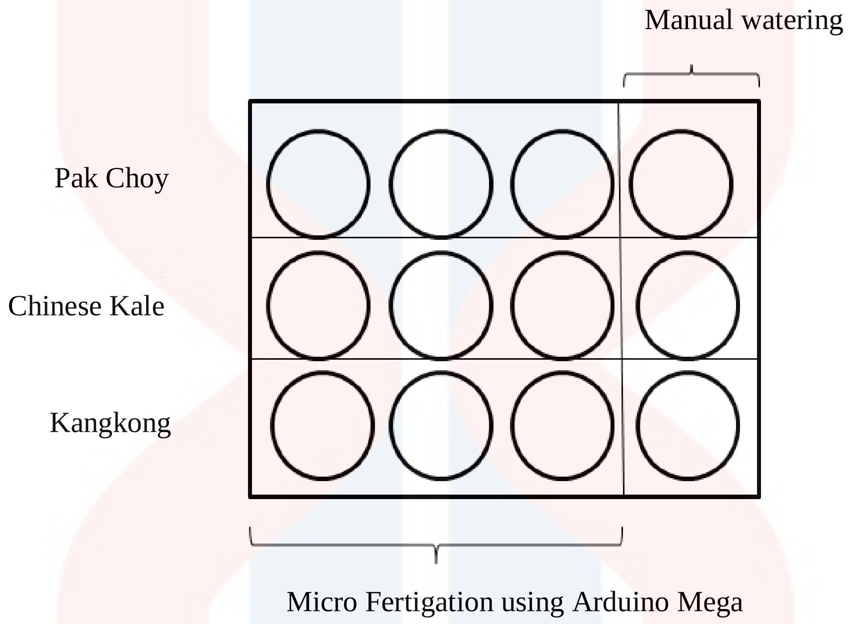

Figure 3.1 Research design for outdoor vertical farming system.

The project composed of vertical garden system , DC plug, Arduino Mega 2560, 10 x 15 single side fiber glass green board prototype PCB Universal Board, L293D Dual H-Bridge Motor Driver Chip, 40 pin male header, IC socket 16 Pin, Single core wire, 2L Mini Diaphragm Water pump for Arduino, LM393 Soil Moisture Sensor for Arduino(Hygrometer) with wire , 3 Way Terminal Block, 2 Way Terminal Block, 40cm Female to Female 40P Solderless Jumper Breadboard Wires, cable ties, 215mm x 150mm x 80mm ABS Waterproof and micro drip emitter with wire.

In this project, a protocol was followed during the treatment. The fertilizer used was A B fertilizer with recommended of 10ml of each A and B fertilizer that was mixed in the 1L water for the fertigation system on three types of vegetables which are

Pak Choy(*Brassica rapa l. var. chinensis*), Kale(*Brassica oleracea l. cv. group chinese kale*) and Kangkong(*Ipomoea reptans l. poir).* The vertical farming system consists of 12 polybags. The A B fertilizer and water was applied for irrigation of the vegetables. The experiment was conducted with three treatments and one control. Kangkong irrigated using automatic fertigation as first treatment, Kale irrigated using automatic fertigation as second treatment, Pak Choy irrigated using automatic fertigation as third treatment and one of each of the vegetables irrigated manually act as control. There are three replication for each treatments. The experiment was only done one time and took 34 days. The polybag size used are 13x10x11 cm (1 liter) and filled using mixture of top soil and coco peat. Each type of the vegetables were grown in 4 polybags, 3 out of 4 were fertigated using the Arduino Mega for micro fertigation purposes and one out 4 was watered manually. The effectiveness of using Arduino Mega in micro fertigation system compared to manual watering was observed based on the growth of the vegetables(cm), number of leaves, leaf chlorophyll content (μmol per m^2 of leaf) using SPAD-502 meter and light intensity received by the vegetables(lx) using lux meter.

Each polybag had single drip emitter that fertigated the plants once the hygrometer sensed low soil moisture and activated the water pump. In the Arduino code, the moisture range were set as wet (below than 550), soggy (550-660) and dry (above 700) respectively. The hygrometer was positioned at the centre of each polybag. The system used L293D Dual H-Bridge Motor driver that controlled the water pump On and Off that linked to water storage tank and drip emitter. The power supply unit was using electrical source plugged using DC plug. The PSU served as source of the entire system, including the exterior components like water pump and also the Arduino Board.

3.2.2 Block diagram.

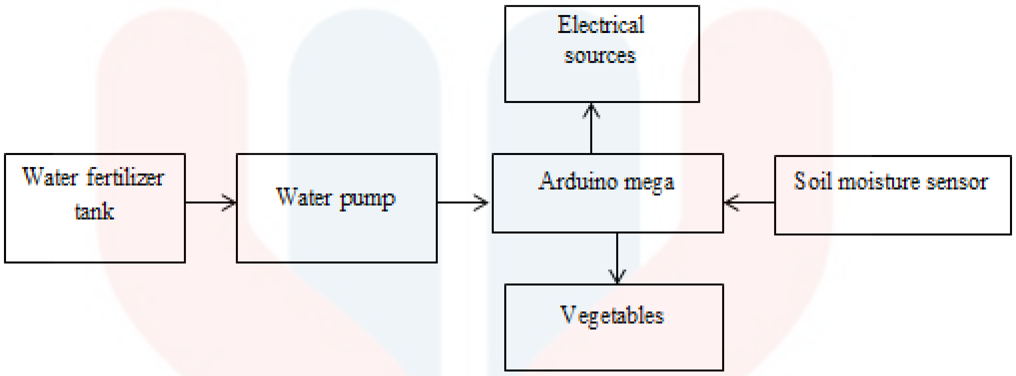

Figure 3.2:Block diagram of micro fertigation system using Arduino Mega.

(Sources: Edmond *et al*.,2015)

Figure 3.2 is the block diagram of the micro fertigation System using Arduino Mega in outdoor vertical farming. The DC Plug was connected to power sources. The value of the conditions for soil moisture if it is wet(<550), soggy (550-660)and dry (>700), was encoded in the Arduino Mega. Once the soil moisture sensor senses the dry conditions of the soil, the microcontroller will on the water pump and the right amount of fertilizer water will be supplied to the vegetables.

3.2.3 Micro fertigation system flowchart

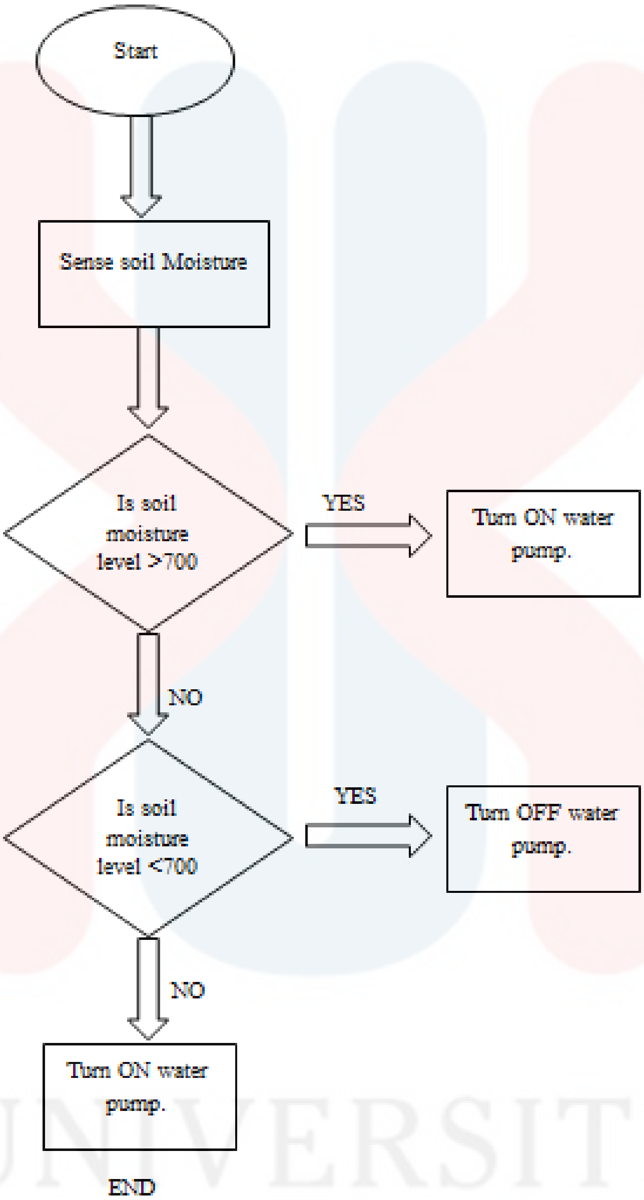

Figure 3.3: Flowchart of micro fertigation system using Arduino Mega.

(Sources: Edmond *et al*.,2015)

Figure 3.3 demonstrated the flowchart of the micro fertigation system. When Arduino sensed the soil condition of planned assortments, Arduino Mega caused the motor drivers to switch ON or OFF the water pump and supplied water fertilizer mixed to the plants. The micro fertigation system planned was constantly detect the soil moisture level. The system answered correctly by fertigating the soil with the sufficient water fertilizer mixed solution and then off the power of the water sources when the best soil moisture content is achieved.

3.3 Planting process

Sowing the plant seed is a vital in planting process. The seeds were directly sow in seedbed with well-drained but moisture retentive soil rich in organic matter. The seeds were regularly watered until it grow up to 10 days seedlings before it is ready to be transplant. The seedling then were transplanted into the vertical garden system with moisture-retentive soil and ensure to firming in well. The newly transplanted plants were kept well-watered to prevent bolting.

3.4 Variables observed

a. Plant height (cm)

The plant height of the vegetables was measured in cm from the surface of the planting media or the base of the plant to the highest growing point, this measurement recorded once every two days begins 10th day after sowing until 34th day after sowing. This variable was observed, measured and recorded as the graphs represented on Figure 4.1 until Figure 4.4.

b. Number of leaves(unit)

The number of leaves were counted according the leaves outgrowth from the stem of the plant starting from the bottoms part of the plants until the shoot part of the plants. The data of the number of leaves was counted and recorded once every two days from the 10^{th} day after sowing until 34^{th} day after sowing. Figure 4.5 until Figure 4.8 shown the growth pattern of the average number of leaves per plant taken from the 10^{th} day after sowing until 34^{th} day after sowing.

c. Leaf chlorophyll content (μmol per m^2 of leaf)

Leaf chlorophyll content in mol per m^2 of leaf was measured using SPAD-502 meter. The data of the leaf chlorophyll content was recorded once every two days from the 10th day after sowing until 34th day after sowing at every 5pm-6pm . Figure 4.9 until Figure 4.11 shown the leaf chlorophyll content mean taken from the 10th day after sowing until 34th day after sowing.

d. Light intensity received by the vegetables(lx)

Light intensity received by vegetables in lx was measured using lux meter. The data of the light intensity received by vegetables was recorded once every two days from the 10^{th} day after sowing until 34^{th} day after sowing at every 5pm-6pm . Figure 4.12 until Figure 4.15 shown the light intensity received by vegetables mean taken from the 10^{th} day after sowing until 34^{th} day after sowing.

3.5 Statistical analysis

The data collected from this project were analyzed by using SPSS software (IBM SPSS Statistics Version 22) tested on one-way analysis of variance Anova.

CHAPTER 4

RESULT

Table 4.1 Result for height of plant (cm), number of leaves (unit), leaf chlorophyll content (µmol per m^2 of leaf) and light intensity received by vegetables (lx).

Treatments	Height of plants (cm) (Mean ± SD)	Number of leaves (unit) (Mean ± SD)	Leaf chlorophyll content (µmol per m^2 of leaf) (Mean ± SD)	Light intensity received by the vegetables(lx) (Mean ± SD)
Kangkong control	27.14	6.05	36.86	177.59
Kangkong sensor	27.63 ± 1.45^{b}	7.07 ± 0.07^{c}	35.06 ± 1.26^{b}	172.99 ± 27.57^{a}
Kale control	12.27	4.30	31.78	381.69
Kale sensor	11.38 ± 0.94^{a}	4.38 ± 0.08^{a}	30.64 ± 1.29^{a}	487.91 ± 62.17^{b}
Pak choy control	10.16	4.76	34.31	146.42
Pak Choy sensor	10.02 ± 0.59^{a}	4.73 ± 0.04^{b}	33.25 ± 0.86^{b}	196.98 ± 29.39^{a}

The one-way analysis of variance (ANOVA) of height of plants, number of leaves, leaf chlorophyll content and light intensity received by plant of the growth of three type vegetables which are pak choy(*Brassica rapa l. var. chinensis*) ,kale(*Brassica oleracea cv. group chinese kale*) and kangkong (*Ipomea reptans l. pior*)in micro fertigation system using Arduino mega based on soil moisture sensor in an outdoor vertical garden were presented in appendices . One way ANOVA followed by Tukey post-hoc multiple comparison test was conducted to further determine the significant difference among the means of the results at ($P < 0.05$). The analyzed result of height of plants, number of leaves, leaf chlorophyll content and light intensity received by plant were summarized in Table 4.1 and illustrated in Figure 4.1 until 4.16.

Based on the data, the highest height plants using micro fertigation system was Kangkong Sensor with height 27.63 cm compare to Kangkong control(27.14 cm), Kale control (12.27 cm), Kale Sensor(11.38 cm) and followed by Pak Choy control (10.16 cm) and the lowest height of plant is from Pak Choy Sensor (10.02 cm). The plant heights showed significantly difference between all the treatments ($P < 0.05$).

Moreover, the highest number of leaves is by Kangkong Sensor which produced about 7.07 unit leaves compared to Kangkong control(6.05 units), Pak Choy control(4.76 units), Pak Choy Sensor (4.73 units) and followed by Kale Sensor(4.38 units) and the lowest number of leaves produced is from Kale control (4.30 units). The number of leaves showed significantly difference between all the treatments ($P < 0.05$).

Next, in terms of chlorophyll content, Kangkong control was recorded to have the highest chlorophyll content with 36.86 µmol per m^2 of leaf compared to Kangkong Sensor (35.06 µmol per m^2 of leaf), Pak Choy control (34.31 µmol per m^2 of leaf), Pak Choy Sensor (33.25 µmol per m^2 of leaf) and followed by Kale control (31.78 µmol per m^2 of leaf) and the least chlorophyll content is recorded from Kale Sensor with value of 30.64 µmol per m^2 of leaf. The plant chlorophyll content showed no significant difference between all the treatments (P > 0.05).

For the last parameter, the highest light intensity received was by Kale Sensor (487.91 lx) compared to Kale Control (381.69lx), Pak Choy Sensor (196.98 lx), Kangkong control (177.59lx) and followed by Kangkong Sensor (172.99 lx) and the lowest light intensity received is Pak Choy control (146.42 lx). The light intensity received by vegetables showed significantly difference between all the treatments (P < 0.05).

4.1 Height of Plants

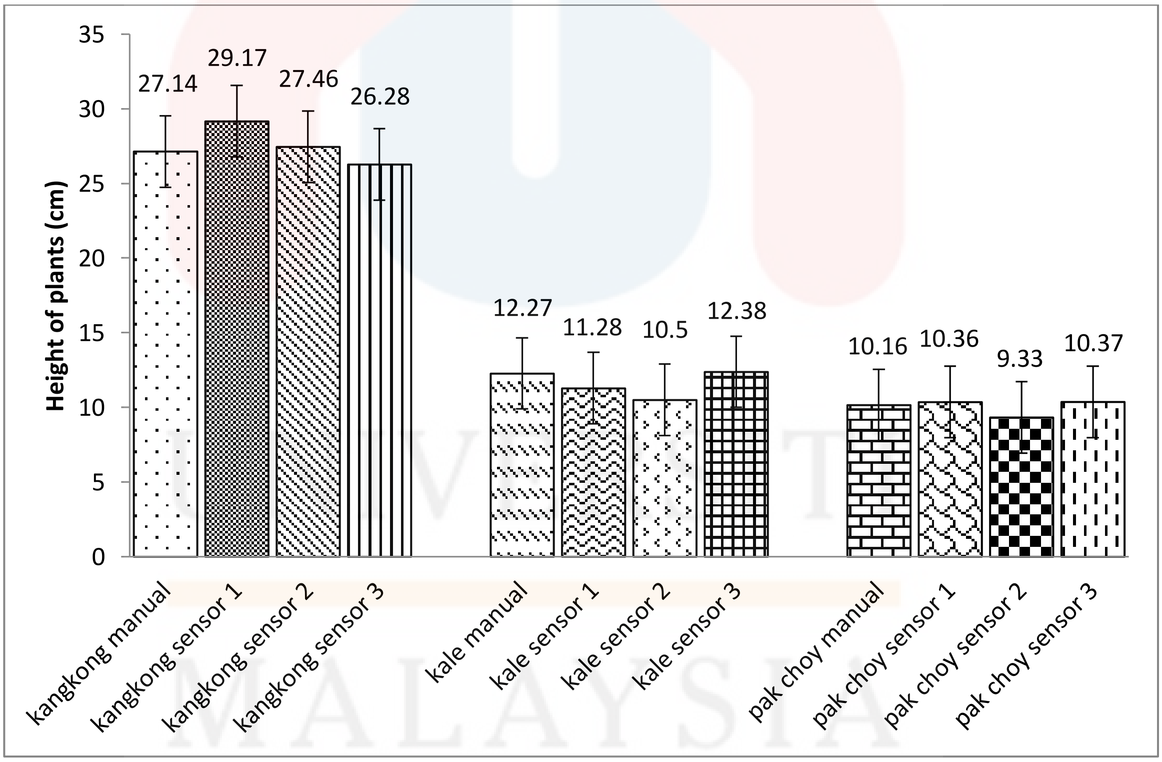

Figure 4.1 : Graph mean of vegetables against the height of the plants.

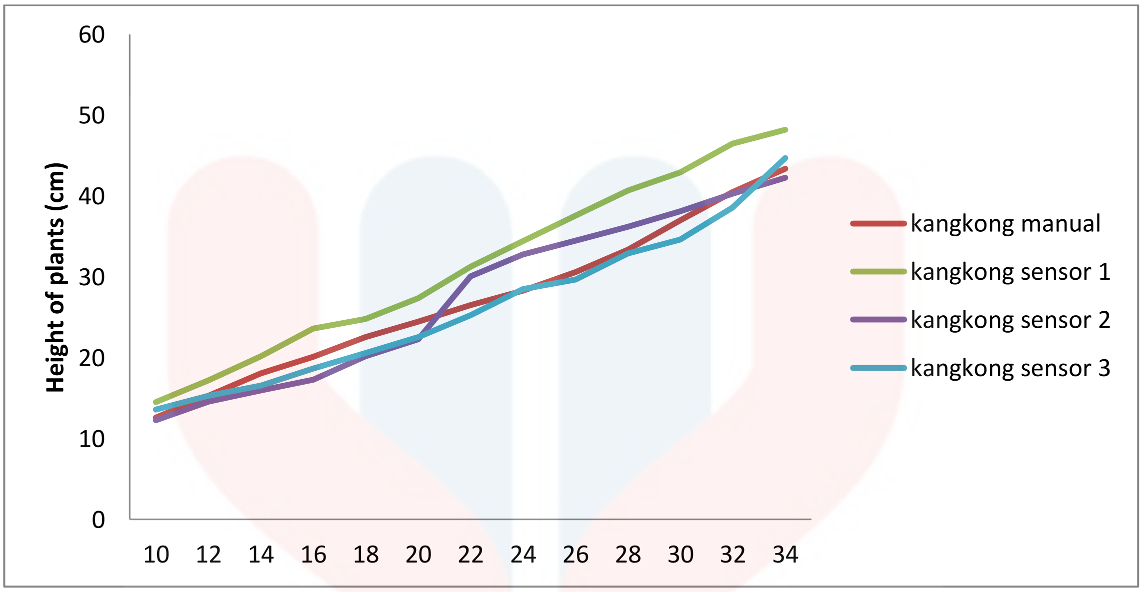

Figure 4.2 : Line graph of day after sowing against height of kangkong plant (cm).

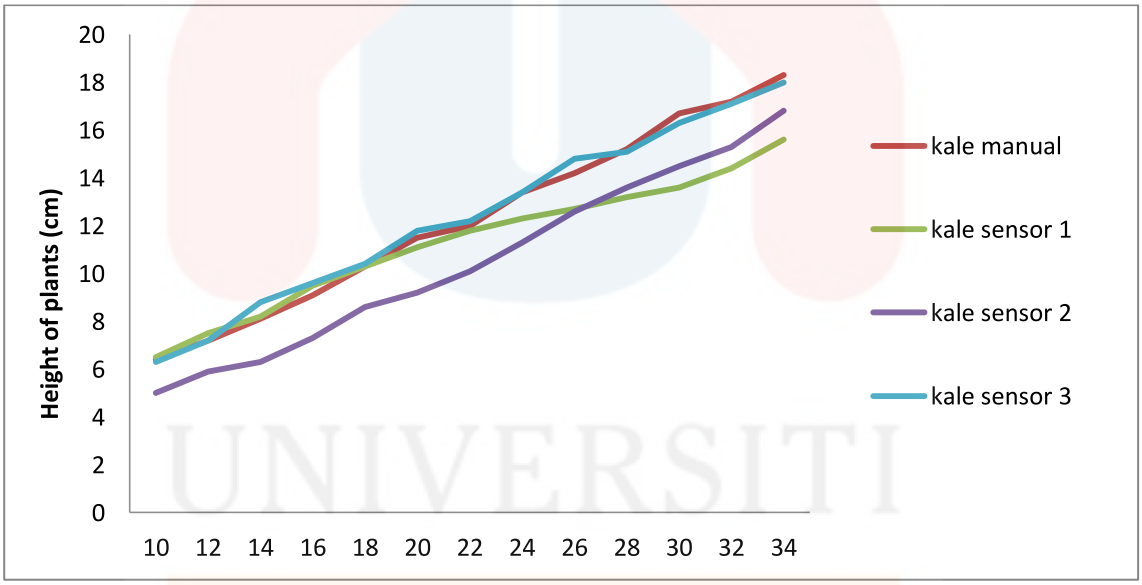

Figure 4.3 : Line graph of day after sowing against height kale plant (cm).

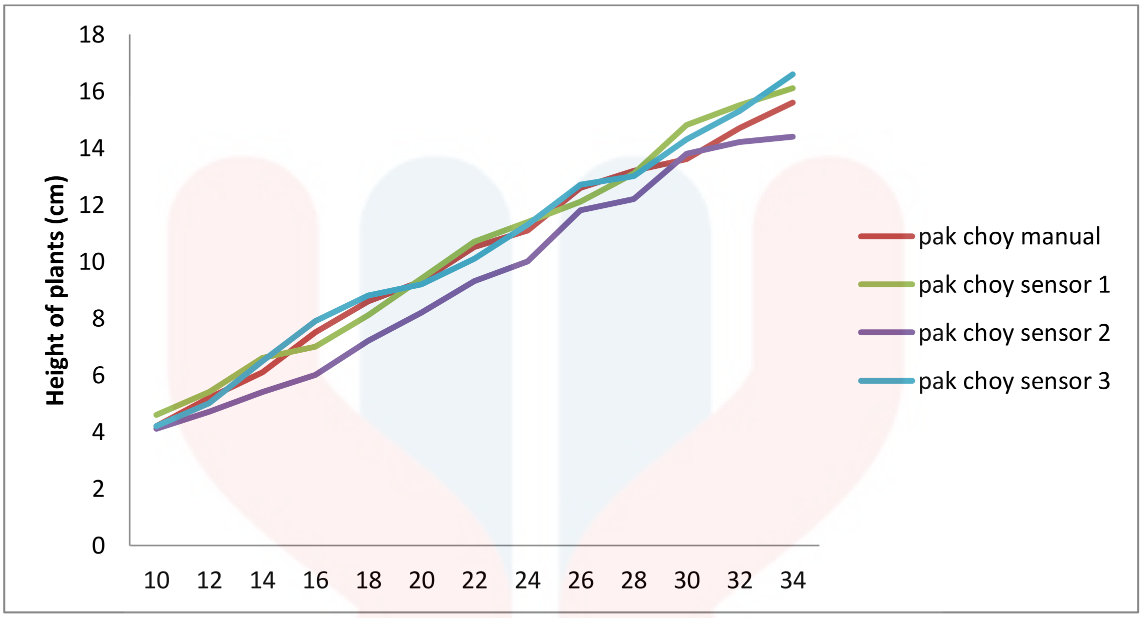

Figure 4.4 : Line graph of day after sowing against height of pak choy plant (cm).

The plant height of the vegetables was measured in cm from the surface of the planting media or the base of the plant to the highest growing point, this measurement recorded once every two days from 10th day after sowing until 34th day after sowing. This variable was observed, measured and recorded as the graphs represented on Figure 4.1 until Figure 4.4.

From the collected data, the bar graph mean of plants height against vegetables were created. For overall, kangkong plants is the highest compared to kale and pak choy. For kangkong plants, result shows that the highest height is kangkong sensor 1 (29.17cm) and the lowest kangkong height is kangkong sensor 3(26.28 cm). For kale, the highest kale is kale sensor 3(12.38 cm) and the lowest kale is kale sensor 2(10.5 cm). For pak choy, the highest pak choy is pak choy sensor 3(10.37 cm) and the lowest pak choy is pak choy sensor 2(9.33 cm). For manual watering plants, kangkong control(27.14 cm) is the highest and pak choy control(10.16 cm) is the lowest . For fertigation applied plants, kangkong sensor 1(29.17 cm) is the highest and pak choy sensor 2 (9.33 cm) is the lowest.

4.2 Number of leaves

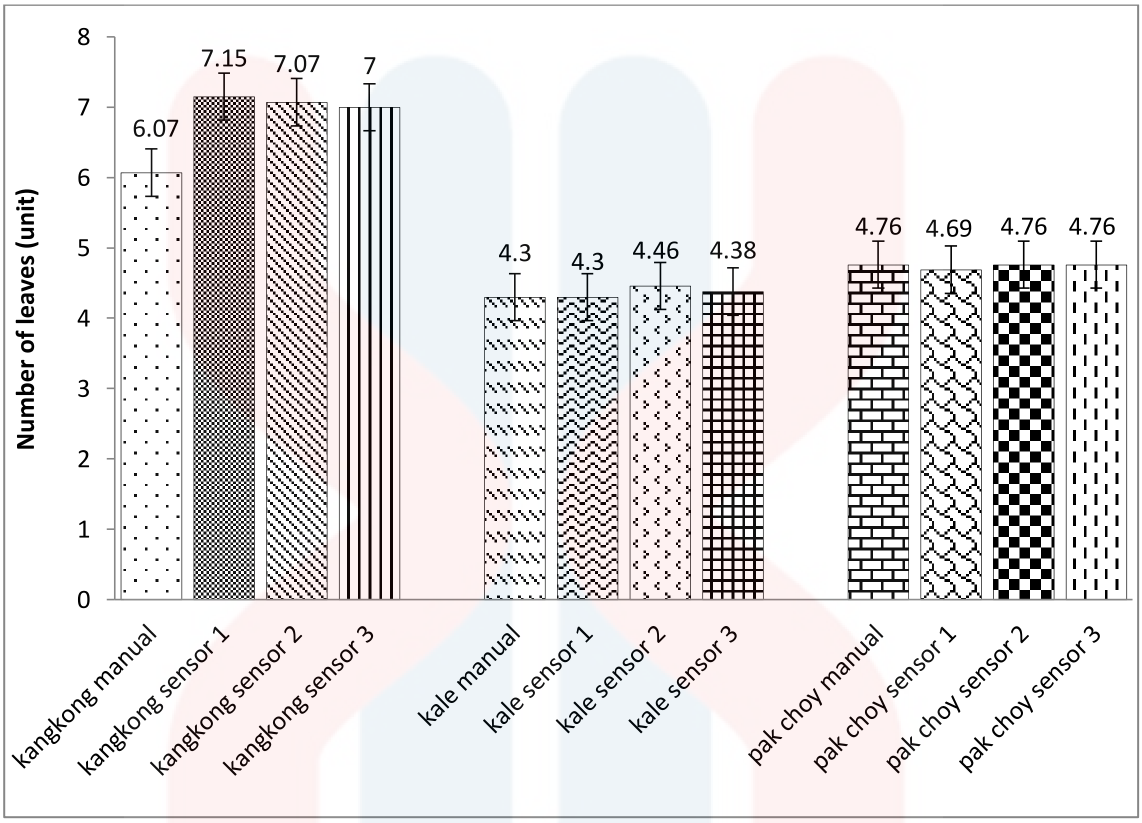

Figure 4.5: Graph means of vegetables against number of leaves produced.

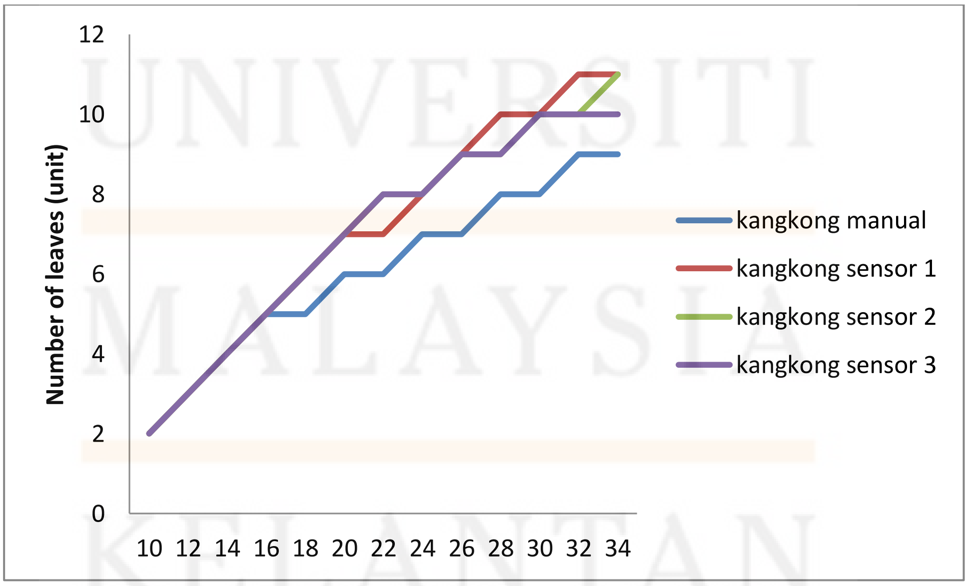

Figure 4.6 : Line graph of day after sowing against number of leaves produced in kangkong plant (cm).

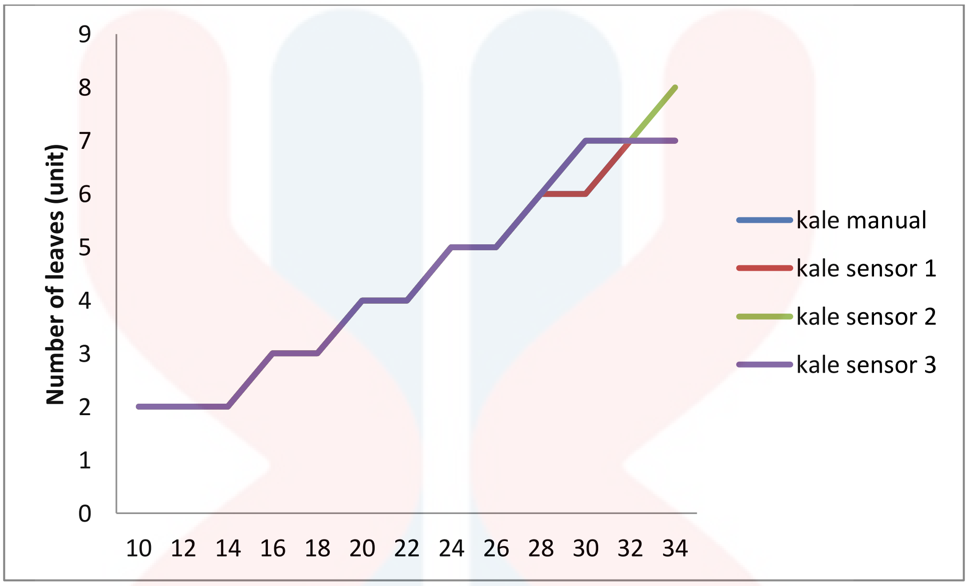

Figure 4.7: Line graph of day after sowing against number of leaves produced in kale plant (cm).

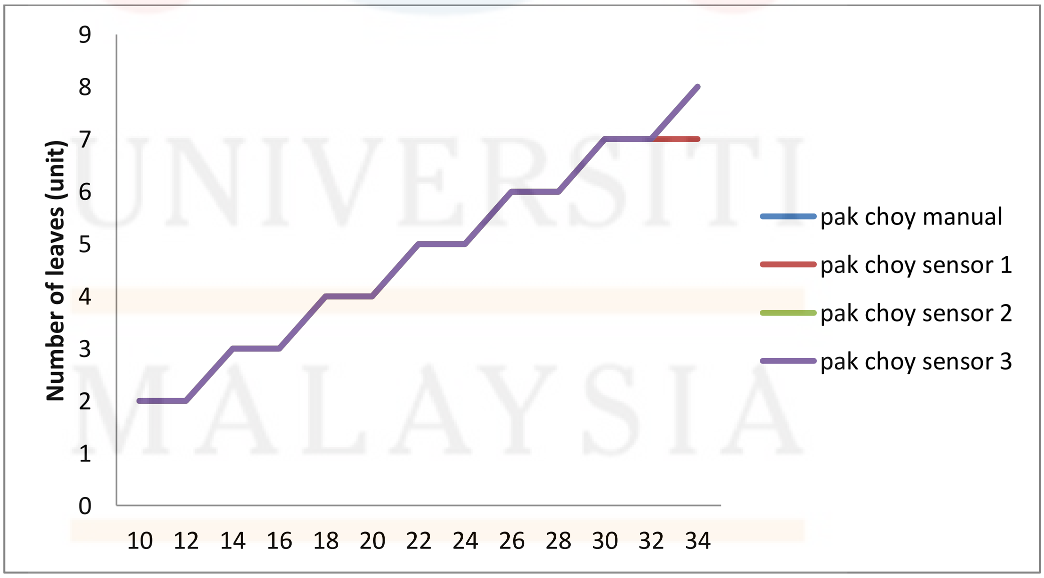

Figure 4.8: Line graph of day after sowing against number of leaves produced in pak choy plant (cm).

The number of leaves were counted according the leaves outgrowth from the stem of the plant starting from the bottoms part of the plants until the shoot part of the plants. The data of the number of leaves was counted and recorded once every two days from 10th day after sowing until 34th day after sowing. Figure 4.5 until Figure 4.8 shown the growth pattern of the average number of leaves per plant taken from the 10th day after sowing until 34th day after sowing.

From the collected data, the graph mean of number of leaves against vegetables were created. For kangkong plants, the highest number of leaves is Kangkong Sensor 1(7.15 units) and the lowest number of leaves is Kangkong control (6.07 units) . Next, for kale, the highest number of leaves is Kale Sensor 2 (4.46 units) and the lowest number of leaves is kale control and Kale Sensor 1,both of Kale control and Kale Sensor 1 have the same mean value for number of leaves produced which is 4.30 units. For Pak Choy vegetables, the highest number of leaves is Pak Choy control, Pak Choy Sensor 2 and Pak Choy Sensor 3. Those three pak choy vegetables have the same mean value for number of leaves which is 4.76 units. The least number of leaves for Pak Choy is Pak Choy Sensor 1(4.69 units).

4.3 Leaf chlorophyll content (µmol per m^2 of leaf)

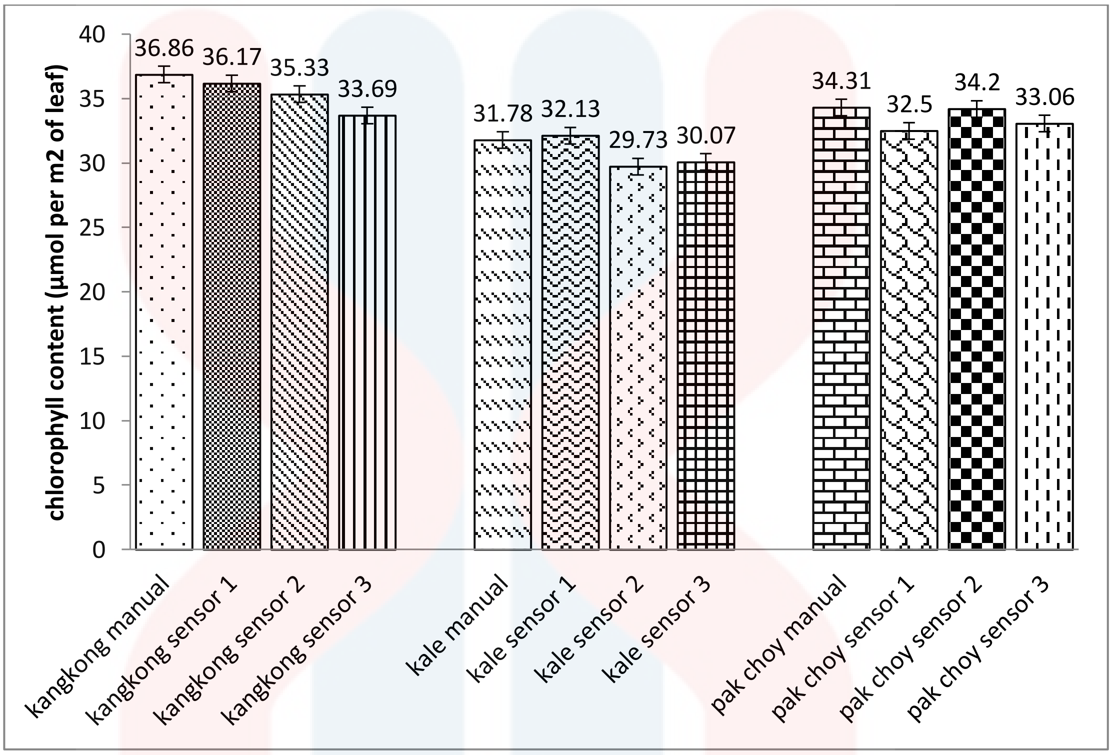

Figure 4.9 : Graph means of vegetables against leaf chlorophyll content (µmol per m^2 of leaf).

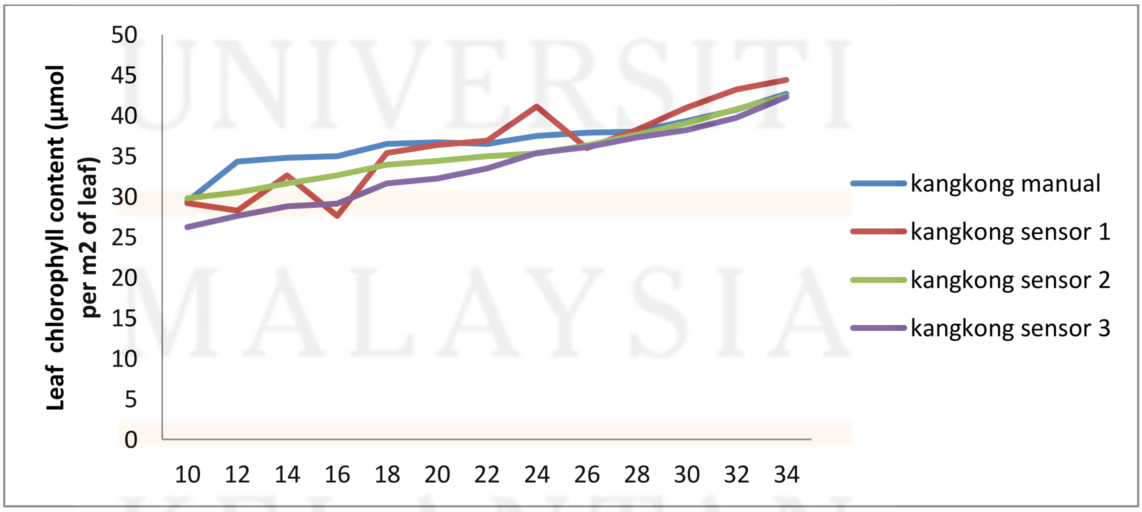

Figure 4.10 : Line graph of day after sowing against number of chlorophyll content in kangkong plant (µmol per m^2 of leaf).

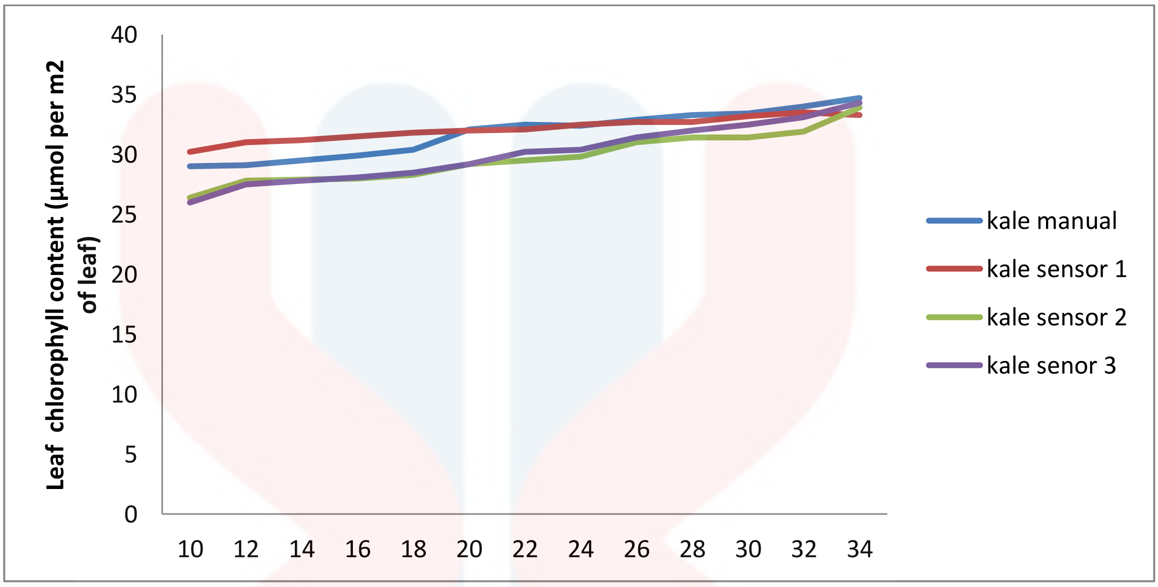

Figure 4.11 : Line graph of day after sowing against number of chlorophyll content in kale plant (µmol per m^2 of leaf).

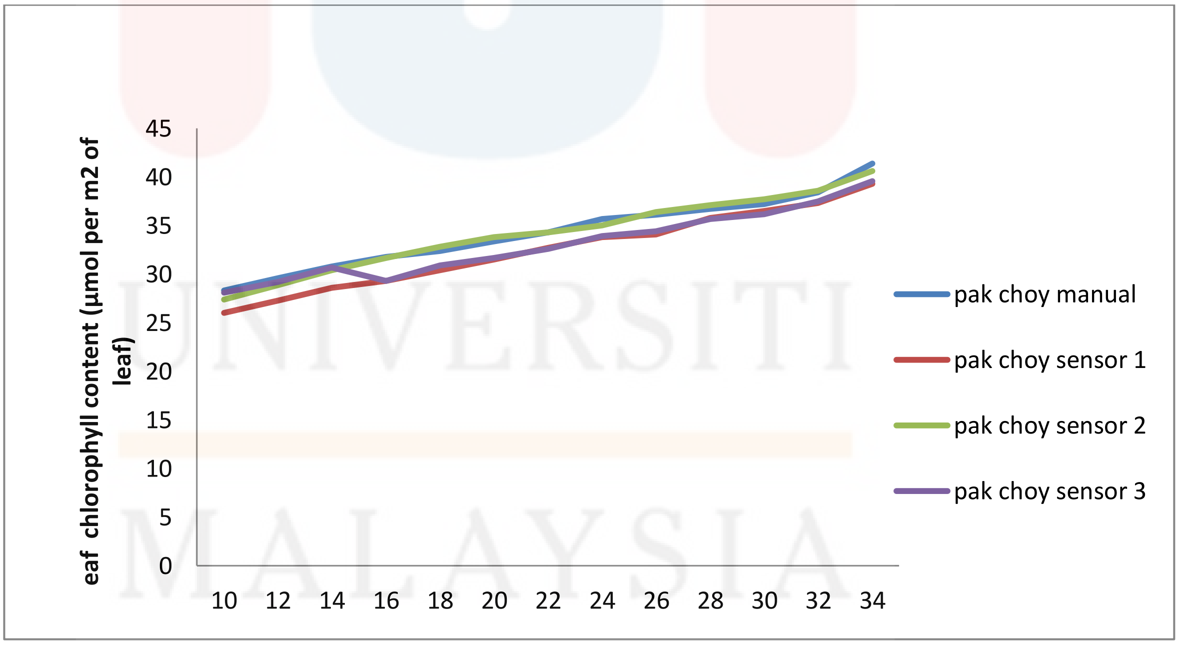

Figure 4.12 : Line graph of day after sowing against number of chlorophyll content in pak choy plant (µmol per m^2 of leaf).

Leaf chlorophyll content in mol per m^2 of leaf were measured using SPAD-502 meter. The data of the leaf chlorophyll content was recorded recorded once every two days from 10th day after sowing until 34th day after sowing at every 5pm-6pm . Figure 4.9 until Figure 4.12 shown the leaf chlorophyll content mean taken from the 10th day after sowing until 34th day after sowing.

From the collected data, the graph mean of leaf chlorophyll content against vegetables were created. For kangkong plants, the highest leaf chlorophyll content is kangkong control(36.85 mol per m^2 of leaf) and the lowest leaf chlorophyll content is kangkong sensor 3(33.69 mol per m^2 of leaf) . Next, for kale, the highest leaf chlorophyll content is kale sensor 1(32.13 mol per m^2 of leaf) and the lowest leaf chlorophyll content is kale sensor 2(29.73 mol per m^2 of leaf). For pak choy vegetables, the highest leaf chlorophyll content is pak choy control(34.31 mol per m^2 of leaf) and the least leaf chlorophyll content for pak choy is pak choy sensor 1(32.50 mol per m^2 of leaf).

4.4 Light intensity received by the vegetables(lx)

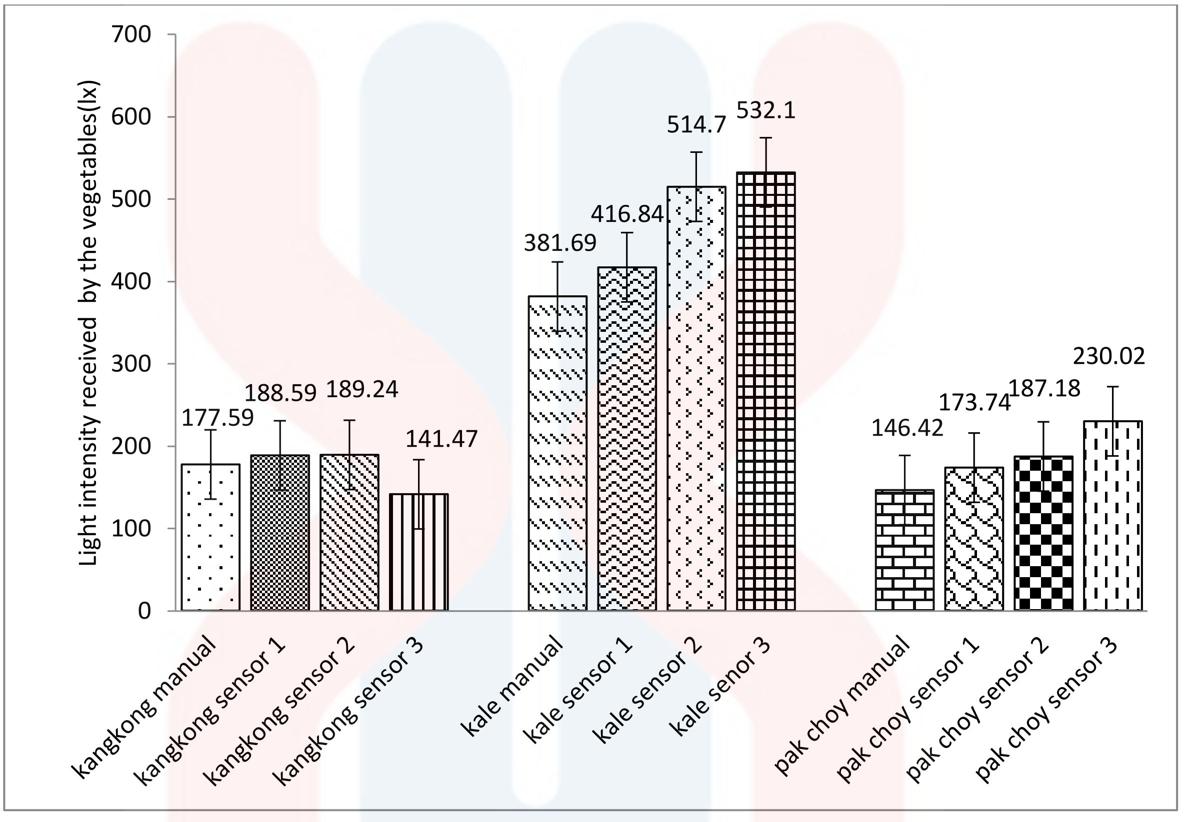

Figure 4.13 : Graph means of vegetables against light intensity received by the vegetables(lx).

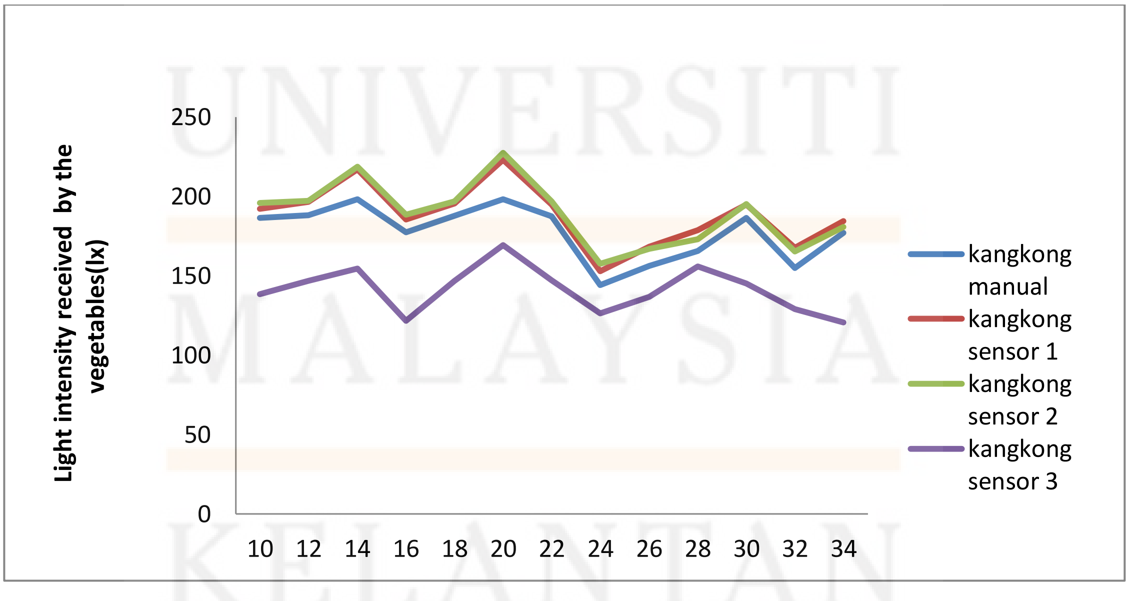

Figure 4.14 : Line graph of day after sowing against light intensity received by the kangkong plants(lx).

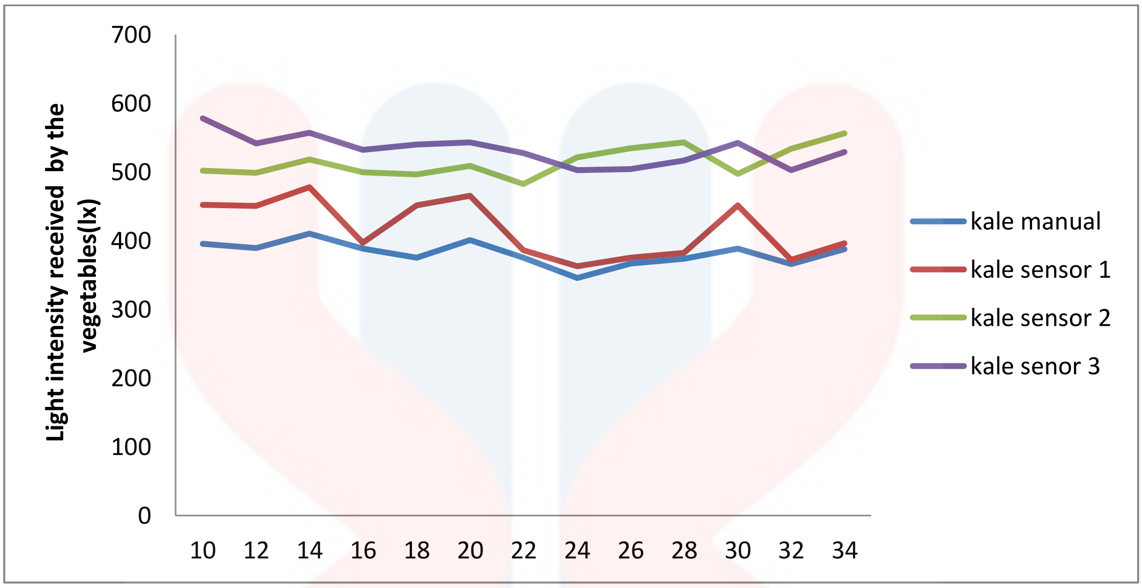

Figure 4.15: Line graph of day after sowing against light intensity received by the kale plants(lx).

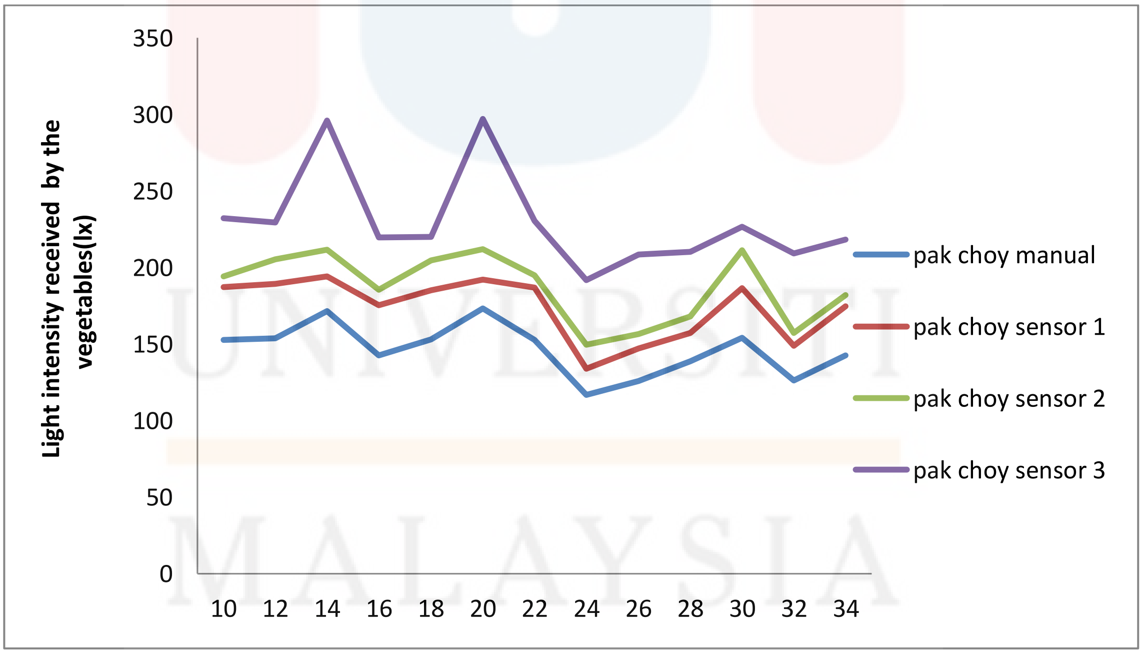

Figure 4.16 : Line graph of day after sowing against light intensity received by the pak choy plants(lx).

Light intensity received by vegetables in lx were measured using lux meter. The data of the light intensity received by vegetables was recorded once every two days from 10th day after sowing until 34th day after sowing at every 5pm-6pm . Figure 4.13 to Figure 4.16 shown the light intensity received by vegetables mean taken from the 10th day after sowing until 34th day after sowing.

Based on the mean graph, among all the vegetables grown in vertical garden system using Arduino Mega, kale received the highest light intensity range from 380-535 lx but kangkong and kale only received 140-230 lx. For kangkong, the highest light intensity received is by kangkong sensor 1(188.59 lx) and the lowest plant light intensity received by kangkong sensor 3(141.47 lx). For kale, the highest light intensity received is by kale sensor 3(532.lx) and the lowest plant light intensity received by kale control(381.69 lx). For pak choy, the highest light intensity was received by pak choy sensor 3(230.02 lx) and the lowest light intensity was received by pak choy control(146.42lx).

CHAPTER 5

DISCUSSION

The plant heights showed significantly difference between all the treatments ($P < 0.05$).The hypothesis is accepted where the growth of three types of vegetables which are pak choy(*Brassica rapa l. var. chinensis*) ,kale(*Brassica oleracea cv. group chinese kale)* and kangkong (*Ipomea reptans l. pior*) using manual watering and in micro fertigation system using Arduino Mega in outdoor vertical garden can be compared. From the height of plants mean graph showed, kangkong is the fastest growing vegetables compared to kale and pak choy. Based on a study by Susila, Prasetyo and Palada (2008), kangkong is preferred for cultivation because of its shorter growth cycle, and it is fast growing, widely adaptable, and better tolerant to disease.

Kangkong as the highest plant height obtained, could be attributed to sufficient support for growing seedlings by the medium and allowance of rapid gas exchange between the rhizosphere and atmosphere. According to Awang *et al.*, (2009), a high quality plant medium will provide adequate port or strong plant support, serves as plant nutrients and water reservoir, enabling oxygen distribution to the root zone and allowing the exchange of gas between roots and atmospheres that helps the plants grow rapidly. All manual watering vegetables resulted slightly low height compared to vegetables being applied fertilizer water based on soil moisture sensor. This can be supported by Wen *et al*., (2010) that the plant heights of roses controlled by a computer program for automatic watering were slightly higher than those manually irrigated. All vegetables manually irrigated and automatic irrigated by sensor system showed increasing height when time increasing. Increasing height of a plant is the result of growth of organ plant. Organ growth is not detached from its constituent cells. The increases in growth of the stem occurs in the intermediate meristem of the segment, the segment extends as a result of increasing the number and extent of the cell (Irawati and Salamah,2013).

From the number of leaves mean graph showed, all vegetable showed increasing in the number of leaves produced from 10th days after sowing until 34th days after sowing. The number of leaves showed significantly difference between all the treatments ($P < 0.05$). The hypothesis is accepted where the growth of three types of vegetables which are pak choy(*Brassica rapa l. var. chinensis*) ,kale(*Brassica oleracea cv. group chinese kale*) and kangkong (*Ipomea reptans l. pior*) using manual watering and in micro fertigation system using Arduino Mega in outdoor vertical garden can be compared. Kangkong have the highest number of leaves than kale and pak choy even though Kangkong was recorded to receive low light intensity in the system. This can be proven by a study carried out by Rajasekar *et al.,(*2003), leaves number per plant produced was highest when under shade condition in all vegetables during hot and cold seasons because taller plants increased its secondary branches number. Study by Edi (2014), increased number of leaves showed a quantitative increase along with increased plant age associated with cell growth. The larger and more number of leaves cause the amount of carbohydrate produced from the photosynthesis process also increasing. Carbohydrates require by plants for plant growth and development so that with the availability of enough carbohydrates, the formation of leaves goes faster and affects the number of leaves and the production quality of a plant.

Leaf chlorophyll content in all vegetables range about 29 µmol per m^2 of leaf until 37 µmol per m^2 of leaf. The plant chlorophyll content showed no significant difference between all the treatments ($P > 0.05$) at P-Value = 0.009. The hypothesis is rejected where the growth of three types of vegetables which are pak choy (*Brassica rapa l. var. chinensis*) ,kale(*Brassica oleracea cv. group chinese kale*) and kangkong (*Ipomea reptans l. pior*) using manual watering and in micro fertigation system using Arduino Mega in outdoor vertical garden cannot be compared. The highest leaf chlorophyll content recorded was in Kangkong control (36.86 µmol per m^2 of leaf). According to a research by Kurniawan, Izzati and Nurhayati (2010), shows that the kangkong vegetables have the highest chlorophyll content among the 10 types of aquatic plants studied. Thus, kangkong is declared to have economic potential as an alternative source of food supplements. The differences in chlorophyll content in plants is also due to the presence of the difference in acceptance of light received by plants, the more plants get light then plants will be green which results in easy nutrient decomposed while on plants that get irradiated less light will be subjected to the etiolation that causes the element nutrients absorbed by plants hard to be decomposed.

Based on the light intensity received by plants result, the light intensity received by vegetables showed significantly difference between all the treatments ($P < 0.05$). The hypothesis is accepted where the growth of three types of vegetables which are pak choy(*Brassica rapa l. var. chinensis*) ,kale(*Brassica oleracea cv. group chinese kale*) and kangkong (*Ipomea reptans l. pior*) using manual watering and in micro fertigation system using Arduino Mega in outdoor vertical garden can be compared. Among all the vegetables grown in vertical garden system using Arduino Mega, kale received the highest light intensity range from 380-535 lx but kangkong and kale only received 140-230 lx. This may due to the arrangements of the vegetables on the outdoor vertical garden rack system. The location of this project was outside building and under a gazebo. Kale vegetables were arranged facing to the outside of the gazebo but kangkong and pak choy were arranged facing inside of the gazebo. This can be explained that the location of the plants being cultivated whether under sunlight or under shade influence clearly on growing plants. This can be supported by Joseph (2002) that corn crop that is covered will be inhibited its growth, the cornstarch becomes thin and the bulbs are light and not even form the fruit so the production tends to decrease.

However, Kangkong received the least sun light but it has great high difference compared to Kale and Pak Choy. This can be supported by Rajasekar *et al.*,(2003), height of vegetables crop was the highest under shade compared to full light area due to favorable micro-climatic conditions under shade area that stimulate photosynthesis process and plant respiration process. Plus, the light intensity received by the plants can be affected by the environment factors. During this study, heavy rain and gloomy weather had caused the plant to received inadequate sunlight. The vegetables have been planted in last November till early December which generally known for rainy season and wettest month in East Coast Malaysia.

Moreover, high precipitation during the period of study caused low sun hours. Plant growth under shade or low sun hours are obstructed when the shade increases. While solar radiation, as a major source light for plants, is one of the main requirements for the continuity of the photosynthesis process. The difference can be occurs because the light on the agroforestry system is over complex (Sitompul,2003). According to Kalisz (2011), it is obvious that the development of the plants is affected not only by temperature, but also by sunlight. Therefore, correlation between leaf chlorophyll content in vegetables and light intensity received by the plants cannot be generated due to environmental factors and location of the vegetables planted.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

As a conclusion, micro fertigation system using Arduino mega based on soil moisture sensor in outdoor vertical garden can be compared based on the of height of plants, number of leaves produced, chlorophyll content and light intensity received by plant of three type vegetables which are pak choy(*Brassica rapa l. var. chinensis*) ,kale(*Brassica oleracea cv. group chinese kale*) and kangkong (*Ipomea reptans l. pior*). The objective of this study was achieved. From the result obtained, there are significance differences between all the treatments on the height of the plants, number of leaves and light intensity received by the plants ($P < 0.05$). But, there are no significant difference between all the treatments on the chlorophyll content of the vegetables ($P > 0.05$). Optimum height of plants is from Kangkong plant with value of 29.17cm. Next, the highest number of leaves produced is by Kangkong (7.15 units). Plus, the highest chlorophyll content recorded from Kangkong (36.86 µmol per m^2 of leaf). Lastly, highest light intensity received is by kale sensor 3(532lx).

6.2 Recommendations

Strongly recommended for future study, LCD displays should be installed in Arduino system to help in reading soil moisture, soil temperature and soil pH. Plus, future study should use LED light for plant light, water flow sensor and temperature sensor. Weather components such as environment temperature, precipitation and sunhours also need to be added as parameter for this research. In this study, each plants have its own soil moisture probe, its own water pump and drip emitter but the water pump is unsuitable because it has high water pressure so the water delivered was not as expected to be in drip form but strong shots and may cause injury or damage to the plants. So it is suggested to choose the right water pump with lower water pressure in future study. Plus, it is recommended to plant vegetables from the same family or same species in order to compare the growth efficiently. Lastly, is using strong and racks specific for vertical garden. It would be recommended to operate each replicate of different treatments independently in future experiment.

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APPENDIX

Appendice - A

Table A.1: Height of plants(cm) from 10th day after sowing until 34th days after sowing.

Day after sowing	Kangkong Manual	Kangkong Sensor 1	Kangkong Sensor 2	Kangkong sensor 3	Kale Manual	Kale Sensor 1	Kale Sensor 2	Kale Sensor 3	Pak choy Manual	Pak choy Sensor 1	Pak choy Sensor 2	Pak choy sensor 3
10	12.6	14.5	12.3	13.6	6.4	6.5	5	6.3	4.2	4.6	4.1	4.2
12	15.3	17.2	14.6	15.3	7.2	7.5	5.9	7.2	5.2	5.4	4.7	5
14	18.1	20.2	16	16.6	8.1	8.2	6.3	8.8	6.1	6.6	5.4	6.5
16	20.1	23.6	17.3	18.7	9.1	9.5	7.3	9.6	7.5	7	6	7.9
18	22.6	24.8	20.2	20.6	10.3	10.3	8.6	10.4	8.6	8.1	7.2	8.8
20	24.5	27.4	22.3	22.6	11.5	11.1	9.2	11.8	9.3	9.4	8.2	9.2
22	26.5	31.3	30.1	25.3	12	11.8	10.1	12.2	10.5	10.7	9.3	10.1
24	28.3	34.4	32.8	28.5	13.4	12.3	11.3	13.4	11.1	11.4	10	11.3
26	30.6	37.6	34.5	29.7	14.2	12.7	12.6	14.8	12.6	12.1	11.8	12.7
28	33.4	40.7	36.2	32.9	15.2	13.2	13.6	15.1	13.2	13.1	12.2	13
30	37	42.9	38.1	34.6	16.7	13.6	14.5	16.3	13.6	14.8	13.8	14.3
32	40.5	46.5	40.3	38.6	17.2	14.4	15.3	17.1	14.7	15.5	14.2	15.3
34	43.4	48.2	42.3	44.7	18.3	15.6	16.8	18	15.6	16.1	14.4	16.6

Table A.2: Number leaves produced(unit) from 10th day after sowing until 34th days after sowing.

Day after sowing	Kangkong Manual	Kangkong Sensor 1	Kangkong Sensor 2	Kangkong sensor 3	Kale Manual	Kale Sensor 1	Kale Sensor 2	Kale Sensor 3	Pak choy Manual	Pak choy Sensor 1	Pak choy Sensor 2	Pak choy sensor 3
10	2	2	2	2	2	2	2	2	2	2	2	2
12	3	3	3	3	2	2	2	2	2	2	2	2
14	4	4	4	4	2	2	2	2	3	3	3	3
16	5	5	5	5	3	3	3	3	3	3	3	3
18	5	6	6	6	3	3	3	3	4	4	4	4
20	6	7	7	7	4	4	4	4	4	4	4	4
22	6	7	8	8	4	4	4	4	5	5	5	5
24	7	8	8	8	5	5	5	5	5	5	5	5
26	7	9	9	9	5	5	5	5	6	6	6	6
28	8	10	9	9	6	6	6	6	6	6	6	6
30	8	10	10	10	6	6	7	7	7	7	7	7
32	9	11	10	10	7	7	7	7	7	7	7	7
34	9	11	11	10	7	7	8	7	8	7	8	8

Table A.3: Leaf chlorophyll content (µmol per m2 of leaf) from 10th day after sowing until 34th days after sowing.

Day after sowing	**Kangkong Manual**	**Kangkong Sensor 1**	**Kangkong Sensor 2**	**Kangkong sensor 3**	**Kale Manual**	**Kale Sensor 1**	**Kale Sensor 2**	**Kale Sensor 3**	**Pak choy Manual**	**Pak choy Sensor 1**	**Pak choy Sensor 2**	**Pak choy sensor 3**
10	29.4	29.2	29.8	26.2	29	30.2	26.4	26	28.3	26	27.4	28.1
12	34.3	28.3	30.5	27.6	29.1	31	27.8	27.5	29.6	27.3	28.9	29.2
14	34.8	32.6	31.6	28.8	29.5	31.2	27.9	27.8	30.8	28.6	30.4	30.7
16	35	27.6	32.6	29.1	29.9	31.5	28	28.1	31.8	29.3	31.7	29.3
18	36.5	35.4	33.9	31.6	30.4	31.8	28.3	28.5	32.4	30.4	32.8	30.9
20	36.7	36.4	34.4	32.2	32.1	32	29.2	29.2	33.4	31.5	33.8	31.7
22	36.5	36.9	35	33.5	32.5	32.1	29.5	30.2	34.3	32.7	34.3	32.6
24	37.5	41.1	35.3	35.4	32.4	32.5	29.8	30.4	35.7	33.8	35	33.9
26	37.9	36	36.3	36.1	32.9	32.7	31	31.4	36.1	34.1	36.4	34.4
28	38	38.2	37.6	37.3	33.3	32.7	31.4	32	36.7	35.8	37.1	35.7
30	39.3	41	39.1	38.2	33.4	33.2	31.4	32.5	37.2	36.5	37.7	36.2
32	40.7	43.2	40.8	39.7	34	33.2	31.9	33.1	38.4	37.3	38.6	37.5
34	42.7	44.4	42.4	42.3	34.7	33.3	33.9	34.3	41.4	39.3	40.6	39.6

Table A.4: Light intensity received by the vegetables(lx) from 10th day after sowing until 34th days after sowing.

Day after sowing	**Kangkong Manual**	**Kangkong Sensor 1**	**Kangkong Sensor 2**	**Kangkong sensor 3**	**Kale Manual**	**Kale Sensor 1**	**Kale Sensor 2**	**Kale Sensor 3**	**Pak choy Manual**	**Pak choy Sensor 1**	**Pak choy Sensor 2**	**Pak choy sensor 3**
10	186.4	192.2	195.8	138.6	395.2	452	502.1	577.8	152.6	187.3	194.1	232.2
12	188.2	196.7	197.2	146.7	389.4	450.4	498.6	541.8	153.7	189.2	205.3	229.4
14	198.4	217.1	218.6	154.6	410.3	477.6	518.2	557.2	171.5	194.3	211.8	296.2
16	177.3	185.6	188.5	121.8	388.2	397.2	499.2	532	142.6	175.3	185.5	216.7
18	187.9	195.6	196.8	146.8	375	451.1	496.2	539.7	153.2	185.2	204.8	219.9
20	198.1	223	227.4	169.5	400.8	465.2	509.2	543.3	173.3	192.1	212	297.3
22	187.5	194.8	197	147.2	375.5	386.4	482.7	527.6	152.7	186.8	195	230.5
24	144.3	152.8	157.5	126.4	345.5	362.7	521.1	502.9	116.8	133.9	149.4	191.7
26	156.3	168.4	166.9	136.7	366.8	375	534.1	504.2	125.8	147.1	156.6	208.5
28	165.8	178.6	173.2	156	373.3	382.5	542.8	516.7	138.6	157.4	168.2	210.4
30	186.5	194.8	195.2	145.3	388.3	451.1	497.1	542.3	154	186.6	211.4	226.8
32	155	167.7	165.2	129.1	366.1	371.8	533.8	502.8	126.2	148.9	157.2	209.3
34	177	184.4	180.9	120.5	387.6	396	556	529	142.5	174.6	182.1	218.4

Table A.5 : SPSS Normality Test

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Plant height	Control kale	1	12.2700	.	.	.	.	12.27	12.27
	Kale	3	11.3867	.94453	.54532	9.0403	13.7330	10.50	12.38
	Control pak choy	1	10.1600	.	.	.	.	10.16	10.16
	Pak choy	3	10.0200	.59758	.34501	8.5355	11.5045	9.33	10.37
	Control kangkong	1	27.1400	.	.	.	.	27.14	27.14
	Kangkong	3	27.6367	1.45308	.83893	24.0270	31.2463	26.28	29.17
	Total	12	16.3917	8.28122	2.39058	11.1300	21.6533	9.33	29.17
Number of eaves	Control kale	1	4.3000	.	.	.	.	4.30	4.30

	Kale	3	4.3800	.08000	.04619	4.1813	4.5787	4.30	4.46
	Control pak choy	1	4.7600	.	.	.	.	4.76	4.76
	Pak choy	3	4.7367	.04041	.02333	4.6363	4.8371	4.69	4.76
	Control kangkong	1	6.0500	.	.	.	.	6.05	6.05
	Kangkong	3	7.0733	.07506	.04333	6.8869	7.2598	7.00	7.15
	Total	12	5.3067	1.16018	.33492	4.5695	6.0438	4.30	7.15
Chlorophyll content	Control kale	1	37.7800	.	.	.	.	37.78	37.78
	Kale	3	30.6433	1.29867	.74979	27.4173	33.8694	29.73	32.13
	Control pak choy	1	34.3100	.	.	.	.	34.31	34.31
	Pak choy	3	33.2533	.86633	.50018	31.1012	35.4054	32.50	34.20
	Control kangkong	1	36.8600	.	.	.	.	36.86	36.86
	Kangkong	3	35.0633	1.26132	.72822	31.9300	38.1966	33.69	36.17
	Total	12	33.8192	2.50624	.72349	32.2268	35.4116	29.73	37.78

Light intensity	Control kale	1	381.6900	.	.	.	.	381.69	381.69
	Kale	3	487.9167	62.17370	35.89600	333.4686	642.3647	416.84	532.21
	Control pak choy	1	146.4200	.	.	.	.	146.42	146.42
	Pak choy	3	196.9800	29.39200	16.96948	123.9662	269.9938	173.74	230.02
	Control kangkong	1	177.5900	.	.	.	.	177.59	177.59
	Kangkong	3	172.9933	27.57905	15.92277	104.4832	241.5035	141.15	189.24
	Total	12	273.2808	145.79777	42.08819	180.6453	365.9163	141.15	532.21

Table A.6 : Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Plant height	.892[a]	2	6	.458
Number of leaves	.335[b]	2	6	.728
Chlorophyll content	.463[c]	2	6	.650
Light intensity	2.772[d]	2	6	.140

a. Groups with only one case are ignored in computing the test of homogeneity of variance for plant height.

b. Groups with only one case are ignored in computing the test of homogeneity of variance for number of leaves.

c. Groups with only one case are ignored in computing the test of homogeneity of variance for chlorophyll content.

d. Groups with only one case are ignored in computing the test of homogeneity of variance for light intensity.

Table A.7: SPSS One way ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Plant height	Between Groups	747.643	5	149.529	133.481	.000
	Within Groups	6.721	6	1.120		
	Total	754.364	11			
Number of leaves	Between Groups	14.779	5	2.956	648.831	.000
	Within Groups	.027	6	.005		
	Total	14.806	11			
Chlorophyll content	Between Groups	61.038	5	12.208	9.092	.009
	Within Groups	8.056	6	1.343		
	Total	69.094	11			
Light intensity	Between Groups	222846.776	5	44569.355	24.355	.001
	Within Groups	10980.126	6	1830.021		
	Total	233826.902	11			

Table A.8 : Post Hoc Tests

Homogeneous Subsets

Plant height (cm)

Duncan[a]

Treatment	N	Subset for alpha = 0.05	
		1	2
pak choy	3	10.0200	
Kale	3	11.3867	
kangkong	3		27.6367
Sig.		.165	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Number of leaves (unit).

Duncan[a]

Treatment	N	Subset for alpha = 0.05		
		1	2	3
Kale	3	4.3800		
pak choy	3		4.7367	
kangkong	3			7.0733
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Chlorophyll content of plants

Duncan[a]

Treatment	N	Subset for alpha = 0.05	
		1	2
Kale	3	30.6433	
pak choy	3		33.2533
kangkong	3		35.0633
Sig.		1.000	.104

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Light intensity received by plants (lx).

Duncan[a]

Treatment	N	Subset for alpha = 0.05	
		1	2
kangkong	3	172.9933	
pak choy	3	196.9800	
Kale	3		487.9167
Sig.		.518	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Appendice - B

Coding program of micro fertigation using Arduino mega

```
/*This Project component used:
 * Arduino Mega2560, L293D Motor Driver,Soil Hygrometer Sensor,12V WaterPump
 *
 * Coded by Arif (AR Team Electronics)
 */

//First Waterpump
const int IN1 = 41;
const int IN2 = 43;
const int EN1 = 52;

//Second Waterpump
const int IN3 = 48;
const int IN4 = 50;
const int EN2 = 46;

//Third Waterpump
const int IN5 = 37;
const int IN6 = 39;
const int EN3 = 35;

//Fourth Waterpump
const int IN7 = 42;
const int IN8 = 44;
const int EN4 = 40;

//Fifth Waterpump
const int IN9 = 36;
const int IN10 = 38;
const int EN5 = 34;

//Sixth Waterpump
const int IN11 = 31;
const int IN12 = 33;
const int EN6 = 29;

//Seventh Waterpump
const int IN13 = 32;
const int IN14 = 30;
const int EN7 = 28;

//Eighth Waterpump
const int IN15 = 25;
const int IN16 = 27;
const int EN8 = 23;
```

```
//Nineth Waterpump
const int IN17 = 24;
const int IN18 = 26;
const int EN9 = 22;



void setup()
{
  Serial.begin(9600);
  // 1st Waterpump
  pinMode(IN1 , OUTPUT);
  pinMode(IN2 , OUTPUT);
  pinMode(EN1,OUTPUT);
  //2nd Waterpump
  pinMode(IN3 , OUTPUT);
  pinMode(IN4 , OUTPUT);
  pinMode(EN2,OUTPUT);
  //3rd Waterpump
  pinMode(IN5 , OUTPUT);
  pinMode(IN6 , OUTPUT);
  pinMode(EN3,OUTPUT);
  //4th Waterpump
  pinMode(IN7 , OUTPUT);
  pinMode(IN8 , OUTPUT);
  pinMode(EN4,OUTPUT);
  //5th Waterpump
  pinMode(IN9 , OUTPUT);
  pinMode(IN10 , OUTPUT);
  pinMode(EN5,OUTPUT);
  //6th Waterpump
  pinMode(IN11 , OUTPUT);
  pinMode(IN12 , OUTPUT);
  pinMode(EN6,OUTPUT);
  //7th Waterpump
  pinMode(IN13 , OUTPUT);
  pinMode(IN14 , OUTPUT);
  pinMode(EN7,OUTPUT);
  //8th Waterpump
  pinMode(IN15 , OUTPUT);
  pinMode(IN16 , OUTPUT);
  pinMode(EN8,OUTPUT);
  //9th Waterpump
  pinMode(IN17 , OUTPUT);
  pinMode(IN18 , OUTPUT);
  pinMode(EN9,OUTPUT);
}

void loop()
```

```
{
  int soil_1 = analogRead(A0);
  Serial.print("Soil 1 : ");
  Serial.println(soil_1);

  int soil_2 = analogRead(A1);
  Serial.print("Soil 2 : ");
  Serial.println(soil_1);

  int soil_3 = analogRead(A2);
  Serial.print("Soil 3 : ");
  Serial.println(soil_3);

  int soil_4 = analogRead(A3);
  Serial.print("Soil 4 : ");
  Serial.println(soil_4);

  int soil_5 = analogRead(A4);
  Serial.print("Soil 5 : ");
  Serial.println(soil_5);

  int soil_6 = analogRead(A5);
  Serial.print("Soil 6 : ");
  Serial.println(soil_6);

  int soil_7 = analogRead(A8);
  Serial.print("Soil 7 : ");
  Serial.println(soil_7);

  int soil_8 = analogRead(A9);
  Serial.print("Soil 8 : ");
  Serial.println(soil_8);

  int soil_9 = analogRead(A10);
  Serial.print("Soil 9 : ");
  Serial.println(soil_9);

  if( soil_1 >700)
  {
  digitalWrite(IN1 , HIGH);
  digitalWrite(IN2 , LOW);
  analogWrite(EN1,200);
  delay(500);

  }
  else if (soil_2 >700)
  {
  digitalWrite(IN3 , HIGH);
  digitalWrite(IN4 , LOW);
  analogWrite(EN2,200);
```

```
delay(500);
}
  else if (soil_3 >700)
{
digitalWrite(IN5 , HIGH);
digitalWrite(IN6 , LOW);
analogWrite(EN3,200);
delay(500);
}
  else if (soil_4 >700)
{
digitalWrite(IN7 , HIGH);
digitalWrite(IN8 , LOW);
analogWrite(EN4,200);
delay(500);
}
  else if (soil_5 >700)
{
digitalWrite(IN9 , HIGH);
digitalWrite(IN10 , LOW);
analogWrite(EN5,200);
delay(500);
}
  else if (soil_6 >700)
{
digitalWrite(IN11 , HIGH);
digitalWrite(IN12 , LOW);
analogWrite(EN6,200);
delay(500);
}
  else if (soil_7 >700)
{
digitalWrite(IN13 , HIGH);
digitalWrite(IN14 , LOW);
analogWrite(EN7,200);
delay(500);
}
  else if (soil_8 >700)
{
digitalWrite(IN15 , HIGH);
digitalWrite(IN16 , LOW);
analogWrite(EN8,200);
delay(500);
}
  else if (soil_9 >700)
{
digitalWrite(IN17 , HIGH);
digitalWrite(IN18 , LOW);
analogWrite(EN9,200);
delay(500);
```

```
 }
 else
 {
 digitalWrite(IN1 , LOW);
 digitalWrite(IN2 , LOW);
 digitalWrite(IN3 , LOW);
 digitalWrite(IN4 , LOW);
 digitalWrite(IN5 , LOW);
 digitalWrite(IN6 , LOW);
 digitalWrite(IN7 , LOW);
 digitalWrite(IN8 , LOW);
 digitalWrite(IN9 , LOW);
 digitalWrite(IN10 , LOW);
 digitalWrite(IN11 , LOW);
 digitalWrite(IN12 , LOW);
 digitalWrite(IN13 , LOW);
 digitalWrite(IN14 , LOW);
 digitalWrite(IN15 , LOW);
 digitalWrite(IN16 , LOW);
 digitalWrite(IN17 , LOW);
 digitalWrite(IN18 , LOW);
}

delay(1000);

}
}
```