Performance Evaluation Of Drip Irrigation System and Water Use Efficiency of Rock Melon (*Cucumis melo L.*) at Netted Rain Shelter House

Nurhayatie Binti Adnan

F15A0172

A thesis submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Agrotechnology) with Honours.

Faculty of Agro Based Industry

Universiti Malaysia Kelantan

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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.

____

Student Name: Nurhayatie Binti Adnan

Date:

I certify that the report of the final year project entitled Performance Evaluation of Drip Irrigation System and Water Use Efficiency of Rock Melon (*Cucumis melo L.*) at

Netted Rain Shelter House by Nurhayatie Binti Adnan, matric number F15A0172 has been examined and all the correction recommended by the examiners have been done for the degree of Bachelor of Applied Science (Agrotechnology) with Honours, Faculty of Agro-Based Industry, Universiti Malaysia Kelantan

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Approved by:

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Supervisor Name: Encik Mohd Fauzie Bin Jusoh

Date:

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LIST OF ABBREVIATION AND SYMBOL

%	Percentage
EC	Electrical conductivity
kg	Kilogram
PVC	Polyvinyl chloride
PE	Polyethylene
HDPE	High density polyethylene
CV	Coefficient of variation
m^3	Cubic meter
$Lmin^{-1}$	Litre per minute
m	Meter
SD	Standard deviation
ml	millimetre
avg	Average or mean
U	Uniformity
WUE	Water use efficiency

Performance Evaluation of Drip Irrigation System and Water Use Efficiency of Rock Melon (*Cucumis melo L.*) at Netted Rain Shelter House

ABSTRACT

Drip irrigation system distributes water to the plant root zone by drippers. This study emphasizes to evaluate water application uniformity during the rock melon cultivation and without crop cultivation of drip irrigation system by determine the discharge and pressure of the drip irrigation system. The result indicated operating pressure of drip irrigation system tested in the ranged between 0.8 psi and 3.0 psi with discharge rate around 0.14 $Lmin^{-1}$ and 0.25 $Lmin^{-1}$. Water application uniformity between laterals were in the range 66.06% and 89.72%. Water use efficiency (WUE) of rock melon was found to be 7.93294 kg/m3 indicated the low amount of water applied throughout the growing season. In general, if high yield is obtained with minimum use of irrigation water, the value of WUE obtained will be high. The result also revealed the controlling of valve does not give significantly difference of pressure and discharge at the head, middle and tail of selected drippers. Evaluation of irrigation performance can help the farmer in managing the farm as drip irrigation is more effective and rational use of limited supplies of water.

Keywords: Discharge, pressure, drip irrigation, water application uniformity and rock melon

Penilaian Prestasin Sistem Pengairan Titisan Dan Kecekapan Penggunaan Air Bagi Rock melon (*Cucumis melo L.*) di Rumah Lindungan-Hujan

ABSTRAK

Sistem pengairan titisan adalah sistem di mana air disalurkan ke akar pokok menggunakan penitis. Kajian ini memberi penekanan untuk menilai keseragaman penggunaan air semasa penanaman rock melon dan tanpa tanaman dengan menentukan pelepasan air dan tekanan pada sistem pengairan titisan. Keputusan data menunjukkan tekanan operasi sistem pengairan titisan yang diuji di antara 0.8 psi dan 3.0 psi dengan kadar pelepasan sekitar 0.14 $Lmin^{-1}$ dan 0.25 $Lmin^{-1}$. Keseragaman penggunaan air antara lateral adalah dalam lingkungan 66.06% dan 89.72%. Kecekapan penggunaan air (WUE) untuk penghasilan rock melon adalah 7.93294 kg/m^3 menunjukkan jumlah air yang digunakan adalah rendah sepanjang musim pembesaran pokok. Secara umum, jika hasil yang tinggi diperolehi dengan penggunaan air pengairan yang minimum, nilai WUE yang diperolehi akan tinggi. Keputusan menunjukkan kawalan injap tidak memberi perbezaan yang signifikan pada tekanan dan pelepasan pada penitis yng dipilih iaitu hadapan, tengah dan belakang.. Penilaian prestasi pengairan boleh membantu petani dalam menguruskan ladang kerana pengairan titis adalah lebih berkesan dan menggunakan secara rasional bekalan air yang terhad.

Kata kunci: Pelepasan air, tekanan, pengairan titis, keseragaman air and rock melon

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Irrigation is closely linked with agriculture. Irrigation has been around from ancient to modern era for as long as humans have been cultivating plants. Irrigation technology gradually improved along with the evolution in water technology, water transfer and agriculture system (Toriman & Mokhtar, 2009). Irrigation is designed to supply a sufficient amount of water in a timely manner to plants. Therefore, the effective and sustainable use of water for agriculture has become a global priority (Khalil, Mohammed, & Mohammed, 2017). Irrigation is necessary especially in agriculture sector as it is one of a major section to assist in the growing of agriculture crop (Azizi, Yasari, & Kakularimi, 2013; Toriman & Mokhtar, 2009).

Irrigation system needed to be chosen before design, equipment specification and installation. Drip irrigation system is one of the method that has been used because of its goodness, high uniformity and high water use efficiency (Guguloth, 2016; Mistry, Akil, Suryanarayana, & Parekh, 2017). So, adoption of high efficient irrigation system such as drip irrigation system is one of the efficient applications of irrigation water. Drip irrigation

system also known as trickle irrigation, micro-irrigation and low-volume irrigation which is applies water slowly to the roots of plants (Goyal, 2013). This system usually used to irrigate the orchard, rows crops and greenhouse plants. Therefore, drip irrigation also adaptable for almost soil type and topography with adequate design system (Goyal, 2013; Mistry et al., 2017) .

Drip irrigation system distributes the water to the field using the pipe network to the plant by the drippers. This system directly applied the water and fertilizer requirements by allowing water to drip slowly to the plants roots zone with minimum losses which is called fertigation (Guguloth, 2016; Mistry et al., 2017). However, a good filtration system is required as it is easily clogged by the suspended solids in the irrigation water due to small water hole (Prayong, 2013). Areas with drought can use drip irrigation system as the system is designed specifically for it. Moreover, this irrigation system suitable for less space area (Prayong, 2013).

Drip irrigation system typically use 30-50 percent less water than sprinkler system. So, this irrigation system enables to water only the needed plants and not the row alleys or roadways (A.Alabas, 2013). Drip irrigation working at low flow rates and operating pressure between 10 to 20 psi at the dripper. So, it let the system to irrigate with lower cost and the pump outlet typically needs about 40 psi (Megersa & Abdulahi, 2015). Goyal

(2013) mention properly designed and maintained drip irrigation is able to give high performance.

1.2 Problem Statement

There are some problems happened in Agro Techno Park of Universiti Malaysia Kelantan. Drip irrigation system located under netted rain shelter house which has been installed about one year ago and this new system installation not fully operate due to limited of electricity at Agro Techno Park. The electricity affect the application of water to the crop as the water pump require the energy to distribute the water to field (Karunarathne, 2014).

This research was conducted to evaluate the efficiency performance of this new system installation. Furthermore, drip irrigation system in Agro Techno Park was lacked of information about their installation. Guguloth (2016), stated the efficiency of drip irrigation is the uniform distribution of water which is one of the most important parameters in adoption of this system.

Drip irrigation systems are generally permanent and the requirement of labour is low. However, drip irrigation have low energy requirement as this system reduce the use of water and the requirement of operating pressure is low (Asif, Ahmad, Mangrio, Akbar & Memon,2015).

1.3 Hypothesis

H null:

Irrigation performance of drip irrigation system is not significant along the experiment. Thus, it will not affect the water use efficiency and pressure variation of the system. .

H alternate:

Irrigation performance of drip irrigation system is significant along the experiment. Thus, it will affect the water use efficiency and pressure variation of the system. .

1.4 Objective

1. To evaluate the water use efficiency (WUE) of drip irrigation system on rock melon (*Cucumis melo. L*.) cultivation.
2. To determine irrigation performance of drip irrigation during planting season and off planting season of rock melon (*Cucumis melo L*.).
3. To relate the opening and closing control valve with the discharge of drip irrigation system.

1.4 Scope of Study

The study will focus on the drip irrigation at netted rain shelter house. The study also focusing on water use efficiency and evaluating irrigation performances using the different parameter including operating pressure, flow rate or discharge, coefficient of variation and water application uniformity.

1.5 Significant of Study

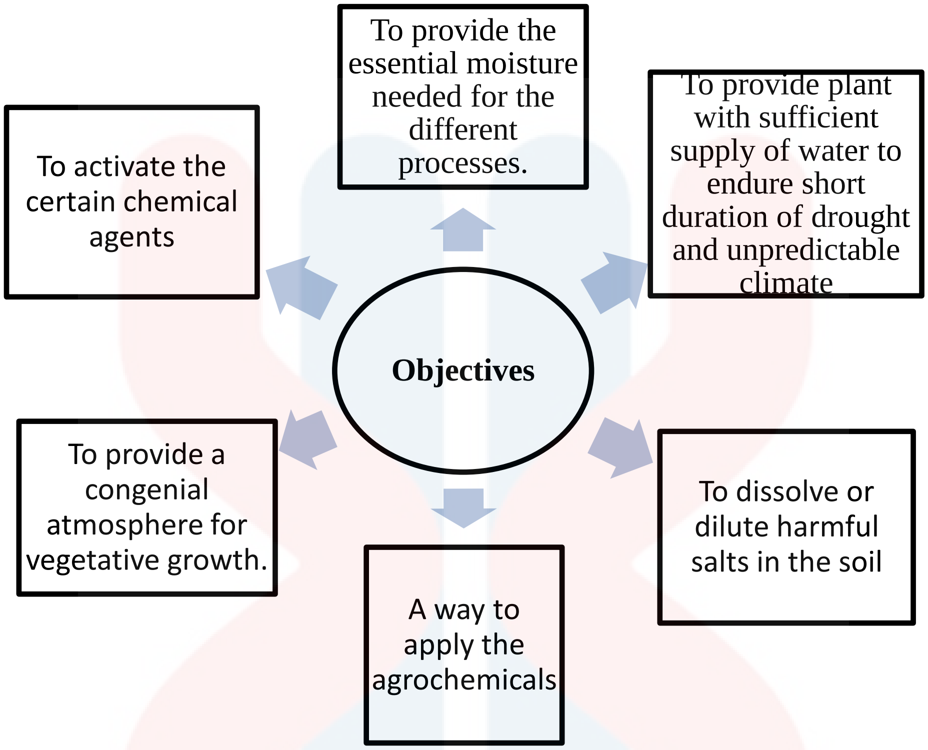
Drip irrigation system provides a better performance management of scheduling and irrigation to the cultivated crop. The better performance of the system can be achieved by a proper irrigation schedule to avoid the excessive irrigation that can cause the low quality and plant disease (Zeng, Bie, & Yuan, 2009). Crop water requirement also provides better performance as this system release slowly the sufficient amount of water to the crop root zone which match with the plant's needs. This study also conducted to observe the system contribute to save the water condition, less drop of water with high yield. Drip irrigation can save the water due to the small amount of water be applied on a frequent or daily basis.

CHAPTER 2

LITERATURE REVIEW

2.1 Types of Irrigation.

Toriman & Mokhtar (2009) defined irrigation is the replacement or supplementation of rainwater with another source of water. Surface and pressurized systems are implemented in irrigation which is characterized by the mode of transport of water to the point of application (Asenso, 2011). Scherer (2010) and Goyal (2013) mention that there are four basic methods of irrigation which are subsurface irrigation, surface irrigation, drip irrigation and sprinkler irrigation. The irrigation is applied to achieve the following objectives as mention in Figure 2.1.



(Goyal, 2013; Khalil, Mohammed, & Mohammed, 2017)

Figure 2.1 : Objective of irrigation

2.1.1 Surface Irrigation

Asenso (2011) defined surface irrigation is a technique that deliver water to crops and distributed over the soil surface by the gravity. This irrigation is simple and easy methods depends on suitable water source (Jondhale, Bhosale, & Takate, 2017). So, this irrigation is widely used because its requires no energy. Surface irrigation can be classified into three major types which are basin, border and furrow systems.

Basin system is used in small areas consists of level that surrounded by earth bank. The entire basin were distributed by the water and allowed to infiltrate. This irrigation method has low infiltration rates and favoured in soils (Asenso, 2011). Taghvaeian (2017) explain the crop that tolerate with inundation is appropriate to use the basin irrigation.

Border irrigation is rectangular in shape, having a sloping surface and fee drainage whixh are different from the basin. Almost all crops are appropriate to use this irrigation methods except those that require ponding conditions such as rice. Identified the large enough of inflow rate to allow water front advancement (Taghvaeian, 2017).

Furrow irrigation is conducted by creating the small parallel channels along the field length in the direction of predominant slope (Asenso, 2011). Top end of each furrow has applied the water and its flows down to the field under influence of gravity. Therefore, this irrigation method provides better control of water management (Asenso, 2011; Taghvaeian, 2017).

2.1.2 Sprinkler Irrigation

Sprinkle irrigation is a method of applying the irrigation water which is similar to natural rainfall. Pumping has been used to distribute the water through a system of pipes (Jondhale, Bhosale, & Takate, 2017). The applications of water is in the forms of sprays which is using several rotating sprinkler heads or nozzles or a single gun type sprinkler (Asenso, 2011; Jondhale, Bhosale, & Takate, 2017).

2.1.3 Drip Irrigation

Drip irrigation distributes the water using the lateral and transforms it from the lateral to the plant in the field by the drippers (Mistry et al., 2017). Drip irrigation system use low flow rates and low pressure at the emitters. So,this methods can saves the water because it typically designed to permit the water drip slowly direct to the root zone (Asenso, 2011; Jondhale, Bhosale, & Takate, 2017).

The design of this irrigation system is specifically for the drought areas and also for the limited or small space. Performance of drip irrigation system is better than the sprinkler irrigation system (Prayong, 2013). This irrigation is complex in design and management because the drip system need to be designed, install, manage and maintain correctly which is very expensive and only few of farmers use this irrigation (Asif, Islam-ul-haq, Mangrio, Mustafa, & Iqbal, 2015).

Drip irrigation commonly designed to include the fertigation and automation capabilities. This irrigation is important to use in the fertigation as drip irrigation can maximize the nutrient uptake by the crop while using the minimum amount of water and fertilizer. Although the drip irrigation system slowly and moderately wets the soil near the plant root zone but, it is difficult to distribute the equal amount of water to plants within the field (Arya, Purohit, Dashora, Singh & Mahesh, 2017).

2.2 Drip Irrigation System Components

A typical drip irrigation system consists of pumping unit, control head, main line, sub main line, lateral lines, and emitters or drippers. The typical component that been used is shown in Figure 2.2.

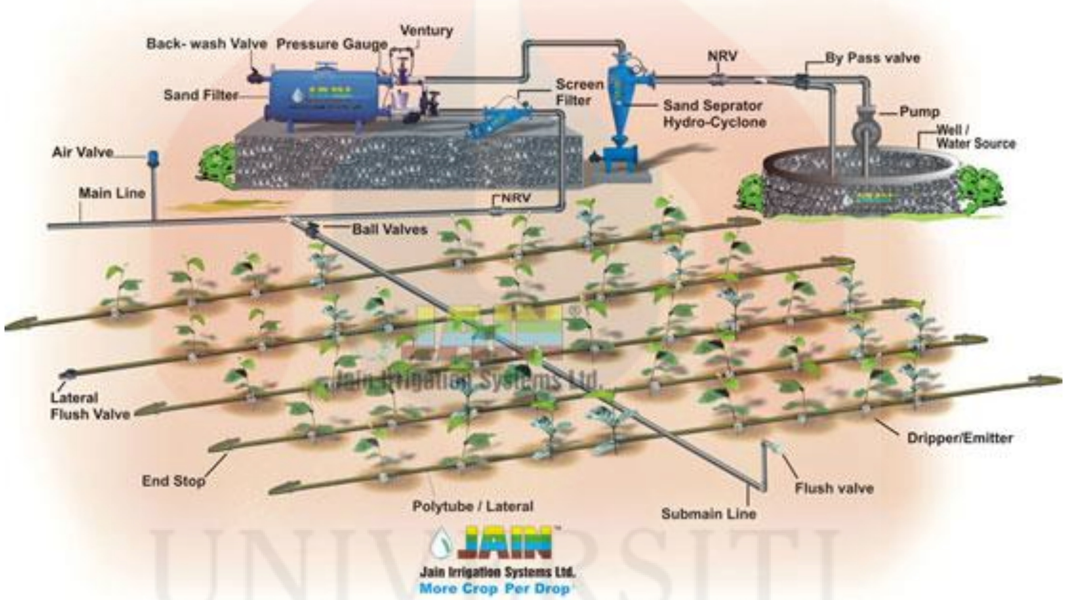


Figure 2.2: Typical drip irrigation layout and components (Source: Jain, 2014)

2.2.1 Pumping Unit

The pressure is necessary to force water through the component of the system including the fertilizer tank, filter unit, main line, laterals and dripper that obtained by a suitable capacity of pump (Khalil et al., 2017). The right pressure is used by the pumping unit to deliver the water into the pipe system (Brouwer, Prins, Kay, & Heibloem, 1985). A centrifugal pump is suitable for extracting water and preferable used with electrical motors. A desired pressure can be maintained by using the slightly greater capacity pump than necessary to ensure the sufficient water. Moreover, a good uniformity of water application can achieve if use the required size of pump (Goyal, 2013).

2.2.2 Control Head

Control head usually consist of valves to control the discharge and pressure. This component can maintain the demand and pressure per system design. Control head is the central of fertilization and filtration systems. The filtration system applied at the control head in order to filter and clean the water. Some control head units also contain a fertilization system or nutrient tank for the irrigation (Brouwer, Prins, Kay, & Heibloem, 1985).

2.2.3 Main Line, Sub mains and Laterals

Main line, sub main line and laterals are three component that needed in the drip irrigation system. Those are function to supply the water from the control head to the field. The pipes usually made from PVC or polyethylene hose. The pipes easily degraded when exposed to direct solar radiation so, they need to be buried below ground.

Sub main is the pipe that connects with the mainline of drip lateral lines. Khalil et al. (2017) explain that sub main lines usually do not use if the drip system is small. So, the drip tube connects directly to the valve. Furthermore, sub mains only been used when the multiple drip tubes are needed.

Emitters are mounted on the lateral lines. Laterals lines usually made from the polyethylene (PE) plastic. The diameter of the lateral pipes is between the range of 13 and 32 mm (Brouwer, Prins, Kay, & Heibloem, 1985).

2.2.4 Dripper or Emitter

Emitters or drippers are small-sized devices. The drippers are use to supply the water in small amount near the plants. Drippers is the devices that can control the discharge of water from lateral to the plants. In recent years, there are many production of emitter design. Furthermore, one or more emitters been used for a single plants when the space of plant is more than 1 meter apart (Khalil et al., 2017; Brouwer, Prins, Kay, & Heibloem, 1985).

2.3 Mechanism of Drip Irrigation System

Drip irrigation only wets the part of the soil root zone which is different from the sprinkler and surface irrigation. The discharge of water and soil type is importance in develop the wetting pattern of the system. The effects of the changes discharge on two different soil types (sand and clay) were shown in Figure 2.3.

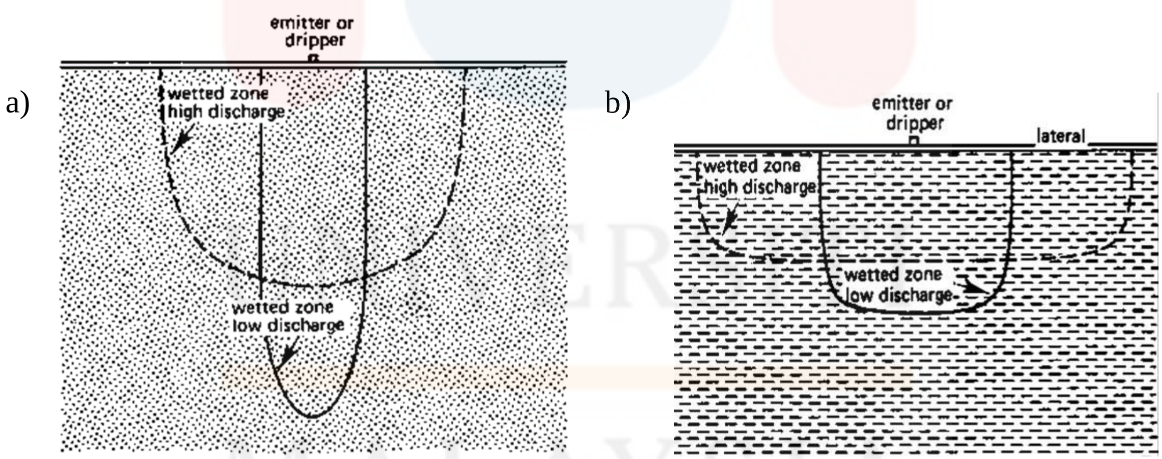


Figure 2.3: Wetting pattern of drip irrigation system with high and lower discharge rate at a) sand, b) clay , Source: (Brouwer, Prins, Kay, & Heibloem, 1985)

Full water needs of the crop are needed even though only the part of root zone is wetted. Apply the right amount of required water to crops not by reduce the amount of crop water need. This irrigation system is suitable for the crops that require frequent water applications (Brouwer, Prins, Kay, & Heibloem, 1985).

2.4 Water Application Uniformity

Water application uniformity is a measure of the hydrodynamic behaviour of the system (Zazueta, 2009). Irrigating system that has the disturbed water can be identified by uniformity of water application. Standard for uniformity of water application in drip irrigation has developed by American Society of Agricultural and Biological Engineers (ASABE). Minimum of acceptable uniformity was established for drip irrigation system design (Goyal, 2013). The uniformity can be classified as shown in Table 2.1.

Table 2.1: Classification of drip irrigation uniformity

Uniformity (%)	**Classification**
100-95	Excellent
90-85	Good
80-75	Fair
70-65	Poor
< 60	Not Acceptable

(Goyal, 2013)

2.5 Water Use Efficiency

Water use efficiency is defined as the crop yield divided by the amount of water used (Lamm, 1990). The increases of WUE is easy to achieve by increases the crop yield relative to volume of water used or vice versa. However, it is not beneficial in reducing the water use if the crop yield also reduced (Lamm, 1990).

2.6 Coefficient of Variation

Coefficient of variation generally used to measure of emitter flow variation which caused by variation in manufacturing characteristics of emission devices (Asif et al., 2015). Manufacturers usually publish the coefficient of variation for each of their product and the system designer must consider this source of variability (Dutta, 2008). Solomon (1979) provided the ranges of coefficient variation values and their appropriate interpretations (Table 2.2).

Table 2.2: Classification of coefficient of variation

Coefficient of variation, CV	Interpretation
< 0.1	Excellent
0.2 – 0.1	Very good
0.3 – 0.2	Acceptable
0.4 – 0.3	Poor
> 0.4	Unacceptable

(Solomon, 1979)

2.7 Origin and Botany of Rock melon (*Cucumis melo L.*)

Rock melon (*Cucumis melo L.*) is a morphologically diverse outcrossing species that belongs to the Cucurbitaceae family. Rock melon origin are Africa and Persia. Nowadays, there are many different types of melons cultivated around the world. Rock melon often called cantaloupe, muskmelon, melon netted, melon or melon Persian (Rana, 2018). Rock melon also have the same family with cucumber, watermelon and honeydew, Persian, casaba and crenshaw melon.

Rock melon is sensitive with the frost temperature and it is monoecious which produced both of female and male flowers on the same plant. Rock melon is almost has similar characteristic with honeydew however, it can be distinguish it from other melons as rock melon possess a fruit rind that is netted and their flesh is orange or green. The varieties of orange flesh give the excellent musky taste and aroma while the green flesh variety of rock melon give the strong and sweet taste (Melon Production Guideline, 2014). Rock melon are annual plants with a trailing vine growth.

2.7.1 Fertigation of Rock melon

Fertigation is derived from the word "fertilizer" and "irrigation". Fertigation basically supply the fertilizers via irrigation system to the crops (Kafkafi & Kant, 2005). Time is the major factor of irrigation process while the optimal water use for the optimal plant life is the key of fertigation. Drip irrigation system is well-suited with fertigation as the irrigation frequency of operation and water application can be easily controlled.

Cucumis melo L. or rock melon is suitable plants to be cultivated by using the fertigation system because of their high return and short period of growth. The EC between 1.5 dS/m to 2.5 dS/m is suitable for rock melon grown in closed fertigation system. The growth period for this crop is between 70 to 80 days (Salih, Adom, & Shaakaf, 2012).

The optimum temperature at day between 24 -30˚C while night is between 18-20 ˚C which is the best for rock melon to grow as this crop is warm-season crops. The growth and maturation of the crop can reduce if the temperature above 35 ˚C and below 10 ˚C. Rock melon planted under the rain shelter house with the drip irrigation system can minimise the quality of foliage and fruit disease as the water supply direct to crop root zone and maintain the ideal soil moisture level (Asenso, 2011).

2.8 Advantages of Drip Irrigation

The main advantage of this irrigation system is the efficiency of water use is high since it reduced or eliminated the direct water losses by evaporation. In addition, the risk of contamination water level is decreased since the deep percolation reduced the movement of the fertilizers and other chemical. The water is applied daily and irrigate to an exact root zone of crops with the specific amount of water (Megersa & Abdulahi, 2015).

Drip irrigation system offers the agronomic practices such as applied the accuracy of fertilizer without leaching to improve the efficiency in water application. Thus, the unnecessary of water losses can be reduced which also help in reduction of weed germination (Khalil et al., 2017; Megersa & Abdulahi, 2015).

Drip irrigation provides a better control of saline water. Drip irrigation keep the salts in solution which does not affect the root as this irrigation only applies the water to the soil. Salinity problem can be reduced by increasing the water flow since the salts is limited at the periphery of a wetted zone (Goyal, 2013).

The perfect design of drip irrigation system can reduce the irrigation water about 40% with application efficiency of 85%-95% compared with other systems. The energy costs also reduce since the less of operating pressure used.

2.9 Disadvantages of Drip Irrigation System

Drip irrigation system may need a high initial cost for crops with very narrow planting distance. So, this system particularly used for vineyards, tree orchards and row crop as it is more convenient. Drippers are easily clogged with the soil particles, algae or mineral salts since it is have a tiny hole. In addition, some components of drip irrigation system can easily damage by rodents or insects and the extreme temperature. So, extra careful technology management is needed (Goyal, 2013).

CHAPTER 3

MATERIAL AND METHODS

3.1 Location of Study Area

The field experiment was conducted under netted rain shelter house at Agro Techno Park of Universiti Malaysia Kelantan, Jeli. The study area specifically located at the coordinate of 5˚45'09.0"N latitude and 101˚52'27.6"E longitude as shown in Figure 3.1. Ambient temperature and relative humidity of study area were calculated by using the hygrometer (OEM, China) which installed inside the house along the study period.

The temperature outside the netted rain shelter house ranged between 30.2 ˚C and 37.1 ˚C. Meanwhile, the temperature measured inside the netted rain shelter house range of temperature between 30.1 ˚C and 41.7 ˚C during the crop growth period. The relative humidity during the crop growing period varied between 40% and 89%.

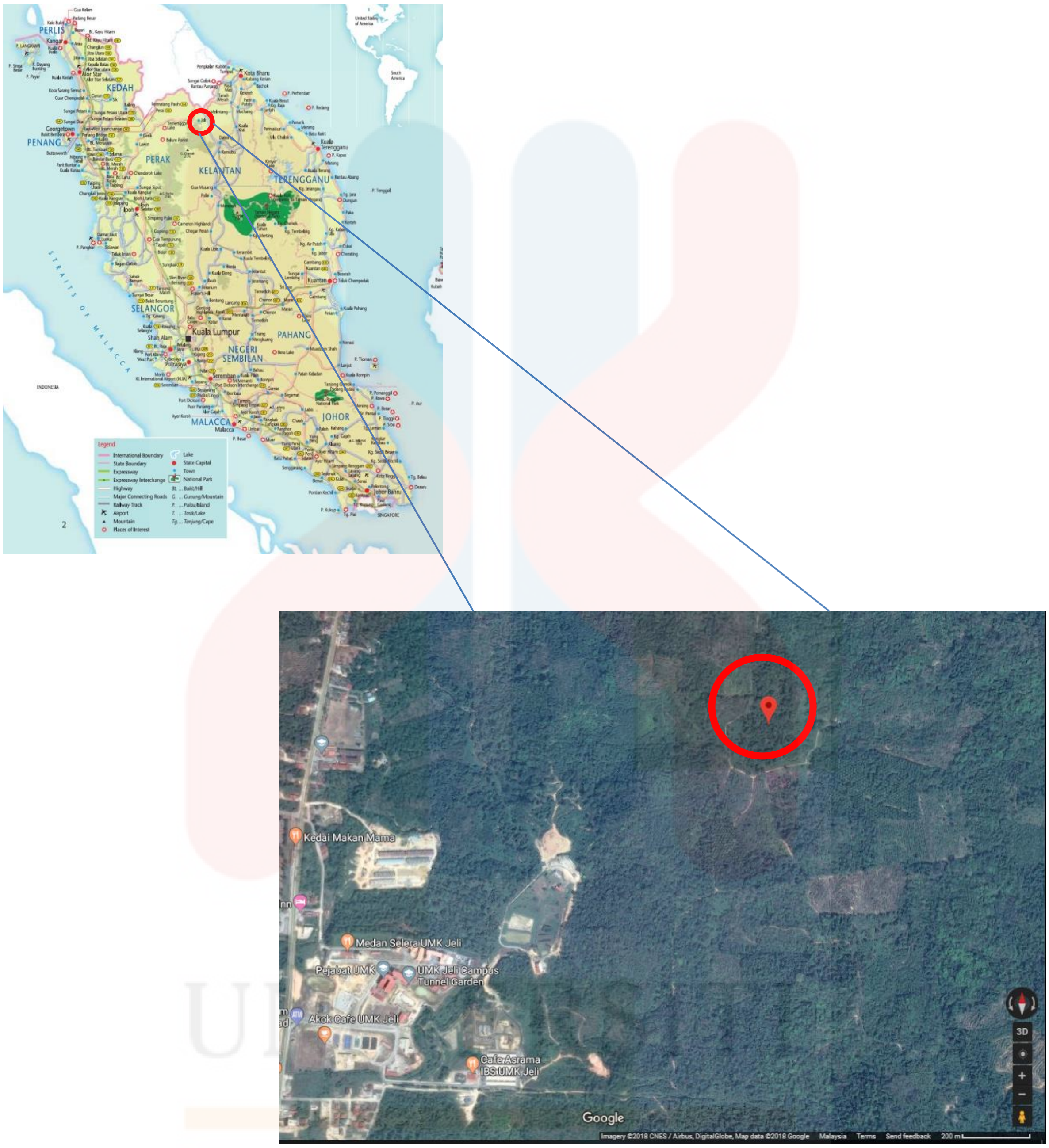


Figure 3.1: Peninsular Malaysia map and satellite view of Agro Techno Park. The circle in the map represents the exact location of study area. (Google map, 2018)

3.2 Layout of Drip Irrigation System

Figure 3.2 shows the arrangement of the laterals line of drip irrigation system inside the netted rain shelter house. Figure 3.3 shows the outside view of the study area. The dimension of the netted rain shelter house is 6 m × 30 m. The field layout plan of experiment was presented in Figure 3.4. Drip irrigation system used centrifugal pump with 2 horse power to supply the water from the tank to the point of discharge during the experiment period. Flow rate meter was used to measure the volume of weekly water applied. The system consists of four tanks to supply the water and fertilizer to field. The tanks were consists of two mixture tank and two water tank. The capacity of the tank is 0.3 m^3 and 0.4 m^3 respectively. The drip irrigation system consists of main line and each main line consists of 5 laterals. Each lateral consist a control valve. The main line of drip irrigation system was used the HDPE pipe type with diameter of 32 mm. Length of the main and lateral was 5.7 m and 13.4 m respectively. Each lateral has 30 drippers and were laid at 0.5 m apart. The netted rain shelter house was divided into three section dripper region which are head, middle and tail section (Figure 3.4).

Figure 3.2 Arrangement of lateral lines of drip irrigation system

Figure 3.3: The outside view of netted rain shelter house

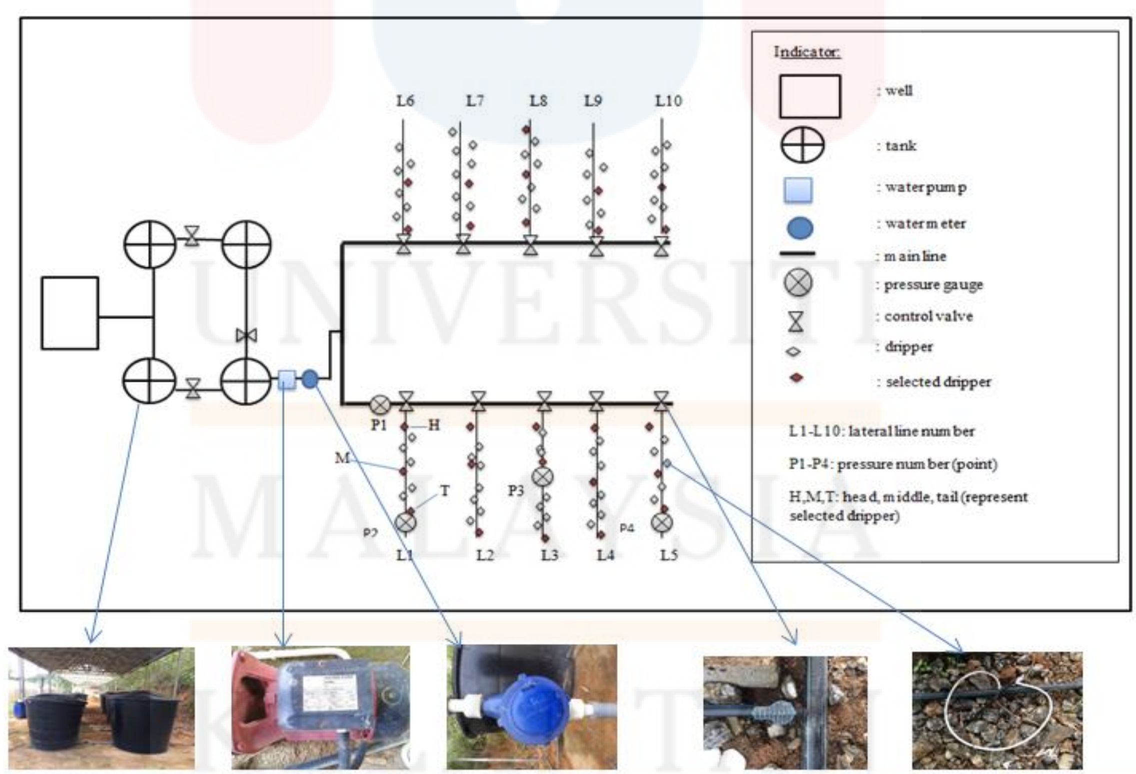


Figure 3.4: The layout of drip irrigation system at netted rain shelter house

3.3 Site Preparation for Rock melon Cultivation

The netted rain shelter house was cleaned and the weeding has been done prior to cultivation. The polybags were used as planting pot. The cocopeat was filled in the polybag as planting media. Polybags that contain cocopeat were soaked and weighed to gain 7 to 8 kg per polybag. The polybags were arranged in the netted rain shelter house. The Previcur N has been sprayed in the polybag to prevent from fungal infection.

The flow rate meter has been installed at the drip irrigation system to measure the water use during the cultivation. Pressure gauge (Appendix A) also is installed at the laterals to measure the water pressure during the cultivation period. The whole system has be tested 1 week before transplanting in order to ensure the laterals and drippers were function. The clogged or damage dripper was replaced with the new dripper. After that, the dripper was placed in the polybag.

The rock melon seeds were soak in the lukewarm water, plant growth regular and fungicide for 1 to 3 hours for seed treatment. The sowing tray was filled with the peat moss to sow the seedling. Peat moss is suitable for the planting seedlings as it contain the nutrient that required by the crops. After 3 hours, the seedling was sowed in the tray. One hole of the tray needs to sow one seedling. To keep the peat moss moisture, the tray has been sprayed using the hand spray. After that, the tray was wrapped using the black plastic and keep in the nursery.

The seeds take 1 week to germinate. The germinate seedlings were transplanting into the polybag (Appendix A). Each lateral has 30 rock melon plants. So, about 300 plants have been planted in the netted rain shelter house. Raffia string has been used as trellis to support its stem from breaking. The trellis was wrapped around the stem intertwined between its leaves and be done carefully to avoid the whole crop collapsed.

There were two types of fertilizer used consist of A and B type. The fertilizer was diluted in the blue barrel and left for 24 hours prior to use. Same amount of fertilizers which is 8.7 ml have been poured in the tank starting with fertilizer A and followed by fertilizer B. During the process, electric conductivity (EC) was measured until reaches the desired concentration using the EC meter. The value of EC meter is shown in Table B.1. The pH also recorded during the process. The best pH for the solution is between 5.5 and 6.5. After the pH and EC was set, the solution was pumped into the netted rain shelter house.

During the crop growth period, the pruning also been done. The vines between 1st until 5th and 14th until 21st leaves have been pruned. Vines that be kept was 6th until 13th for the fruiting purpose. It is suitable for fruit development as the fruit won't be too low and too high. The vines be cut using the scissor and knife that have been dip into the previcur N. Hand pollination been performed from one male to one female from different plant. The hand pollination be done at 8 am until 10 am.

Each plant only keeps one fruit in order to produce the bigger fruits. The fruits have been wrapped using the newspaper to prevent from the attack of insects. Rock melon has been harvested after 65 days. All the harvested fruits were weighed using the weighing scale.

3.4 Experiment 1: Calculation of Water Use Efficiency, WUE

Flow rate meter was installed at the 25 mm diameter of PVC pipe and it was located at the pipe after the mixture tank. The first reading was taken at the first day of transplant. Every week, the reading at flow rate meter was taken. Rock melon was harvested at the day 65 from transplanting day. All fruits yield were weighted by weighing scale and the data of yield was recorded.

The discharge was measured by placing the bottles at the selected dripper at head, middle and tail section on laterals line. The discharge of water was collected for 1 minute using the stopwatch and measured using the measuring cylinder. Data were recorded and repeated for seven weeks during the period of experiment.

Water use efficiency is the unit quantity of water consumed from the ratio of economic yield produced (Guguloth, 2016). Equation 3.1 was used to calculate the WUE of the rock melon crop in the experimental site.

$$\text{WUE}\ (\text{kg/m}^3) = \frac{\text{Y}}{\text{WR}} \qquad (3.1)$$

Where;

Y = Rock melon yield (kg)

WR = Total water consumed for rock melon production (m^3)

3.5 Experiment 2: Irrigation Performance During Crop Planting

Irrigation performance (discharge, pressure, coefficient of variation and water application uniformity) during rock melon cultivation has been measured and recorded for seven weeks. Before starting the experiment with crop, the whole system was not flushed with water but the dripper was tested individually in order to check the clogging. However, the system was flushed first during the experiment without the crop cultivation. This is a continuous experiment which is experiment with crop cultivation was conducted first.

3.5.1 Measurement of pressure

Figure 3.5 shows the pressure gauge was used to measure the water pressure of the drip irrigation system. There are 4 selected points on drip irrigation system during the experiments. First point located at the main lines, the second point located at the tail of the first lateral, third point located at the middle of third lateral and the fourth point at tail of fifth lateral (refer Figure 3.4)

Figure 3.5: Pressure gauge for measurement of pressure.

3.5.2 Measurement of Discharge

The discharge of drippers was collected using plastic bottle for duration of 1 minute. The volume of water was measured using the measuring cylinder. Three points were selected which are head, middle and tail of drippers for each lateral.

Figure 3.6: Collection of water discharge using plastic bottle

3.5.3 Calculation of Coefficient of Variation, CV

Coefficient of variation (CV) is the parameter used to measure the variability of flow in drip irrigation. CV value obtain was compared with the Table 2.2 to classify the drip irrigation performance. Madramootoo (1988) expressed the equation of coefficient of variation (CV) as shown in Equation 3.2.

$$CV = \frac{Sd}{avg} \quad (3.2)$$

Where;

CV = Coefficient of variation

Sd = standard variation

avg = mean for a sampled number

3.5.4 Calculation of Water Application Uniformity, U

Equation 3.3 was used to calculate the water application uniformity as the efficiency of drip irrigation system depends on the uniformity of water discharge. This equation also give the information which the water distributed efficiently in the field (Guguloth, 2016). Water application uniformity obtain was compared with the general criteria for uniformity value shown in Table 2.1.

$$U(\%) = 100 \times [1.0 - V] \quad (3.3)$$

Where;

U = Uniformity or the emitter discharge rate(%)

V = Coefficient of variation

3.6 Experiment 3: Irrigation Performance without crop

The data of irrigation performance (discharge, pressure, coefficient of variation and water application uniformity) was measured and recorded without the rock melon crop. The procedures for obtaining pressure and discharge for this experiment was same as mentioned in Section 3.5.

3.7 Experiment 4: Effect of Closing And Opening Valve On Discharge of Drip Irrigation System

The data of discharge was measured and recorded at the selected drippers and selected pressure points (refer Figure 3.4). The experiment consists of opening and closing the valve at the lateral lines. The lateral lines involved in this experiment were lateral 1 until lateral 5.

3.7.1 Measurement of Discharge

The discharge of drippers was collected using plastic bottle for duration of 1 minute using the stopwatch. The collected water was measured using the measuring cylinder. Three section were selected which are head, middle and tail of drippers for each lateral. The valve of lateral one was open and the others valve of each lateral was closed. This scenario was shown in Figure 3.7. The procedure was repeated for the lateral two to lateral five.

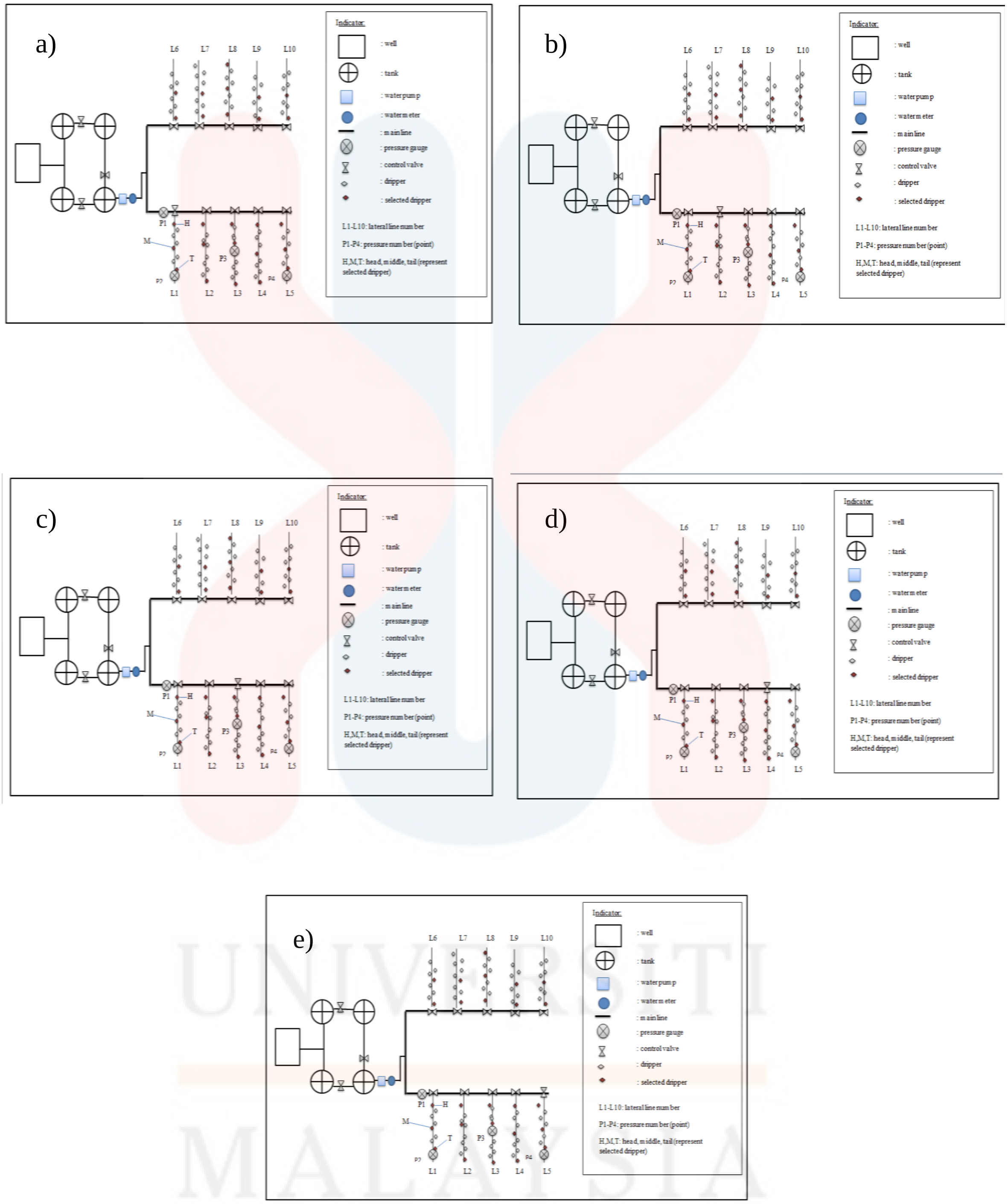


Figure 3.7: The scenarios of valve opening at a) lateral 1, b) lateral 2, c) lateral 3, d) lateral 4, e) lateral 5.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Water Use Efficiency Of The Tested Crop

Water use efficiency was used to calculate the water consumed from yield of crop produced. The total water consumed for rock melon production which is equal to 18.59335 m^3 as shown in Table 4.1. The yield of rock melon produced for this season was 147.50 kg. Based on this value and by using the Equation 3.1, the water use efficiency was found to be 7.9329 kg/m^3. In the research reported by Samarah, Shahera, and Al-ghzawi (2012) and Ertek, Sensoy, Küçükyumuk, and Gedik (2004), irrigation level with higher amounts of water generally have lower water use efficiency (WUE) values. Previous studies showed frequently applied low irrigation water amount increases the fruit yield because consumption of plant water was higher when irrigation begin at low soil water concentration (Ertek, Sensoy, Küçükyumuk, & Gedik, 2004).

Table 4.1: Amount of water consumed during cultivation of rock melon.

Week	Flowrate meter reading (m^3)	Amount of water consumed (m^3)
0	0	0
1	2.1819	2.1819
2	4.8512	2.6693
3	6.8486	1.9974
4	10.4582	3.6096
5	14.0629	3.6048
6	16.7609	2.698
7	18.59335	1.8324
Total	**73.7571**	**18.59335**

4.2 Irrigation Performance During Crop Planting

Table 4.2 illustrates the average of overall coefficient of variation and water application uniformity value. Coefficient of variation between lateral were in the range between 0.144733 and 0.453627. Lateral 2, 6 and 9 classified as very good and lateral 1, 3, 5, 8 and 10 classified as acceptable. Lateral 4 and 7 classified as poor of coefficient of variation. The result obtain might be due to the manufacturing variability, clogging due the suspended fertilizer and the damaged emitter (Abdallah, 2015).

Water application uniformity express how evenly the uniformity of water is spread over the irrigated area used. Water application uniformity between lateral were in the range between 54.63725% and 85.52665% with overall average of 73.70%. Lateral 9 was classified as good, lateral 1, 2 and 6 classified as fair, lateral 3, 5 and 10 classified as poor and lateral 4 was classified as unacceptable of uniformity. Goyal (2013) stated that uniformity of water application can reduce due to defective of irrigation pump, the distribution lines broken or twist, obstruction in the dripper or filters, corrosion of parts in irrigation system, defective pump and inadequate design which can be a factors of drip irrigation does not distribute the water uniformly.

Table 4.2: The parameter values that indicate the performance of lateral line in irrigation system with crop cultivation

Lateral	Mean	SD	CV	U
1	0.290429	0.064789	0.22308	77.69205
2	0.243905	0.050003	0.205012	79.49883
3	0.245619	0.073567	0.299519	70.04815
4	0.181857	0.082495	0.453627	54.63725
5	0.175905	0.044045	0.250389	74.96112
6	0.172429	0.034588	0.200595	79.94054
7	0.185476	0.059729	0.32203	67.79702
8	0.193857	0.052031	0.268397	73.16034
9	0.210429	0.030456	0.144733	85.52665
10	0.158857	0.041594	0.261836	73.81641
Average	**0.205876**	**0.05333**	**0.262922**	**73.70784**

4.3 Irrigation Performance Without Crop

Table 4.3 illustrates the coefficient of variation (CV) and water application uniformity (U) values. Coefficient of variations of the lateral line of study area was categorized as excellent, very good, acceptable and unacceptable. Out of this study, lateral 2 and 3 had excellent with CV below 0.1. Meanwhile, lateral 6 and 9 having between 0.33 and 0.34 which indicate to poor. Lateral 1, 4, 5, 7 and 8 were classified as very good and lateral 10 was classified as acceptable of coefficient of variation. In general, the CV values (ranging between 0.2 and 0.1) obtained from this drip irrigation system without cropping can be classified as good performance of irrigation system as proposed by Solomon (1979).

Water application uniformity between lateral were in the range between 66.06% and 89.72% with overall average of 81.36%. Lateral 1, 2,3,4,5, and 8 were classified as good and lateral 7 and 10 were classified as fair. Lateral 6 and 9 were classified as poor. In general, maintenance and repair works have to be performed with great care periodically. Acar, Yavuz, & Topak (2011) tested the performance of drip irrigation system and found the uniformity as an average of 80%. This value was almost similar or lower to study average which is 81.36%. The application uniformity was depend on the manufacturing variation in emitters and pressure variation in the system due to pipe fiction and elevation changes (Asif, M., M. Ahmad, A. G. Mangrio, G. Akbar, 2015)

Table 4.3: The parameter values that indicate the performance of lateral line in irrigation system without crop cultivation

Lateral	Mean	SD	CV	U
1	0.25	0.03	0.12	87.62
2	0.19	0.02	0.10	89.59
3	0.17	0.02	0.10	89.72
4	0.16	0.02	0.13	87.39
5	0.17	0.02	0.14	85.99
6	0.14	0.05	0.33	67.00
7	0.15	0.03	0.17	82.77
8	0.19	0.03	0.14	86.14
9	0.15	0.05	0.34	66.06
10	0.14	0.04	0.29	71.27
Average	**0.17**	**0.03**	**0.19**	**81.36**

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4.4 Relationship Between Flushing And Non Flushing Drip Irrigation System.

The experiment with crop was tested first without flushing the system and experiment without crop was tested after the cultivation period with flushing the system. From the result, it can be seen that time of experiment can affect the drip irrigation system. Related to time, coefficient of variation was decrease meanwhile the uniformity was increase.

It can be observed that the value of coefficient of variation without crop has lower value than coefficient of variation with crop cultivation as shown in Figure 4.1. The range of CV values without crop cultivation is between 0.1 and 0.14 than those CV values with crop cultivation between 0.21 and 0.45. According to the result, non-flushed lateral had smaller discharge than those lateral that had been flushed. Arbat, Elbana, & Duran-Ros (2010) reported flushing was needed to remove the accumulation of sediments in the lateral before the emitters become completely clogged. Therefore, it is important to flush the laterals as frequent flushing which contribute to better uniformity (Arbat et al., 2010).

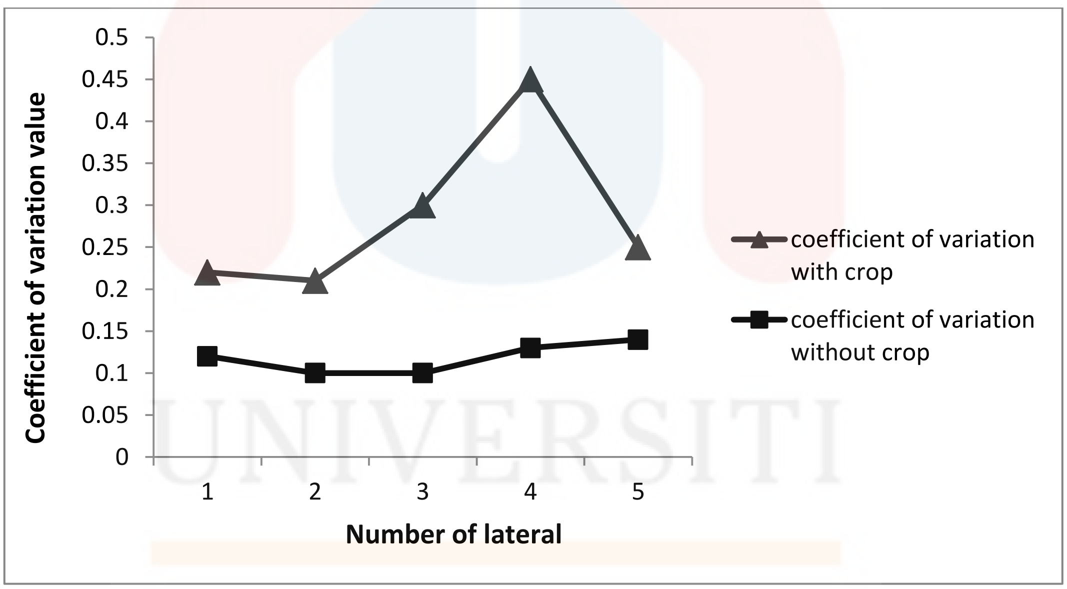

Figure 4.1: Coefficient of variation values with crop cultivation and without crop cultivation.

Figure 4.2 illustrates the uniformity between with crop and without crop cultivation. Uniformity without crop has higher value than uniformity with crop. The range of uniformity values without crop is between 85.99% and 89.72% than those uniformity with crop between 54.64% to 79.50%. Based on the result, it can be concluded that the water was distributed more uniformly from drippers due to flushing of drip irrigation. Al-Ghobari (2012) mentions the design and management of irrigation system not the only factor that influence water uniformity but it could be from hydraulic gradients existing within the wetted soil which affect the water movement.

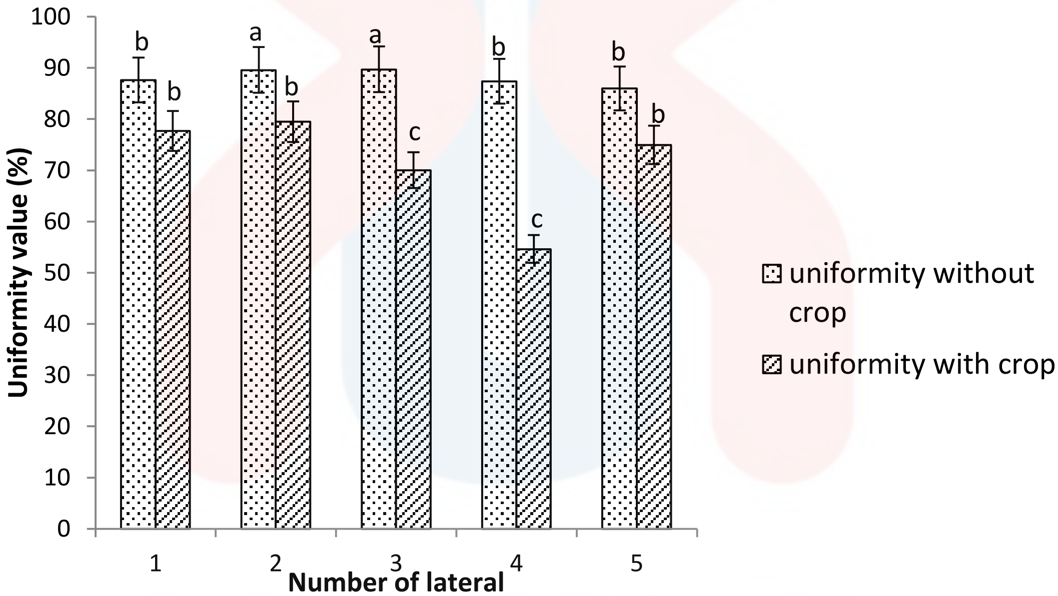

Figure 4.2: Uniformity values of with crop cultivation and without crop cultivation.

Note: Different letter at the bar chart on lateral number represent significant different (p<0.05).

Result of paired sample t-test shows significant values (P<0.05) which the value is 0.017 and 0.019 for the coefficient of variation and uniformity. Therefore, it can be concluded that flushing and non-flushing of the system can affect the coefficient of variation and uniformity of the drip irrigation system.

4.5 Effect of Closing And Opening Valve On Discharge of Drip Irrigation System

In the study, the mean of discharge for head (0.364) was reported to have highest value for the water discharge. The mean discharge recorded for middle is 0.317 while for tail is 0.257. From Figure 4.3, the mean of discharge was not significant among head, middle and tail section. Based on result, head dripper have higher discharge maybe due to the distribution of water that the water movement did not influence by the precipitation or sediments compared to the others drippers (middle and tail). The 'sig' value obtained was 0.203 and the value is higher than 0.05. Therefore, the H null failed to reject as there is no different between the drippers on the discharge of water.

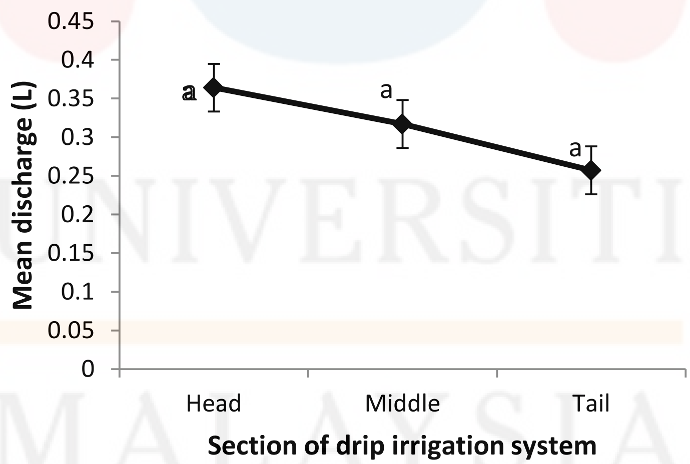

Figure 4.3: The mean discharge value at different section of drip irrigation system. Mean discharge valve with the different letter indicate significant different (P < 0.05).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Based on the result, water use efficiency (WUE) for the rock melon cultivation on drip irrigation system was 7.9329 kg/m^3. The discharge and pressure were used to calculate the coefficient of variation and water application uniformity. The flush and non-flush system influencing the coefficient of variation and uniformity of irrigation system. Therefore, it can be considered that first flushing can improve the drip irrigation performance.

For future study, it is recommended that different dripper or emitter type is used in order to investigate it effect to working pressure and discharge rate. Besides that, different pump power could be used in order to investigate pressure variation since it influence costing of drip irrigation system set up. Lastly, use the others crop such as chilli, leafy vegetables to determine the water use efficiency and compared with previous study.

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APPENDICES

Appendix A

Figure A.1: Seedling of rock melon germinated on planting tray.

Figure A.2: Fungicide (Previcur N) that used during polybag preparation

Figure A.3: Rock melon’s stem was tied with raffia rope on trellis.

Figure A.4: Rock melon seedling in polybag at the first day of transplanting.

Figure A.5: Installation of the pressure gauge

Figure A.6: Rock melon crop cultivated inside netted rain shelter house.

Appendix B

Table B.1: EC meter value

Date	EC Value (mS)
19/4/2018 – 21/4/2018	1.8
22/4/2018	2
23/4/2018	2.1
24/4/2018	2.2
25/4/2018	2.3
26/4/2018	2.4
27/4/2018	2.5
28/4/2018 - 30/4/2018	2.6
2/5/2018 - 7/5/2018	2.8
9/5/2018 – 14/5/2018	3
16/5/2018 – 21/5/2018	3.2
23/5/2018 – 28/5/2018	3.4
30/5/2018 – 31/5/2018	3.6
1/6/2018	3.7
2/6/2018	3.8
3/6/2018	3.9
4/6/2018	4

Appendix C

Table C.1: Coefficient of variation of drip irrigation system with crop and without crop cultivation

Lateral	Coefficient of variation with crop	Coefficient of variation without crop
1	0.22	0.12
2	0.21	0.10
3	0.30	0.10
4	0.45	0.13
5	0.25	0.14

Table C.2 Uniformity of drip irrigation system with crop and without crop cultivation

Lateral	Uniformity with crop	Uniformity without crop
1	77.69	87.62
2	79.50	89.59
3	70.05	89.72
4	54.64	87.39
5	74.96	85.99

Appendix D

Table D.1: Discharge values during closing and opening of the valve.

Lateral	Discharge (L)		
	Head	**Middle**	**Tail**
1	0.346	0.126	0.335
2	0.356	0.300	0.288
3	0.461	0.364	0.151
4	0.289	0.409	0.191
5	0.371	0.387	0.322
Average	**0.365**	**0.317**	**0.257**