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Performance Evaluation of Sprinkler Irrigation System and Water Use Efficiency of Pak Choy(*Brassica chinensis var juliennius*) at Netted House ,UMK AgroTechno Park

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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.

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I certify that the report of the final year project entitled " Performances Evaluation Of Sprinkler Irrigation System and Water Use Efficiency of Pak Choy (Brassica chinensis var juliennius) Cultivation at Netted House" by Fitriyyah Khalida Binti Mohd Fauzi, matric number F15A0044 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, University Malaysia Kelantan

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Performances Evaluation of Sprinkler Irrigation System and Water Use Efficiency of Pak Choy (Brassica chinensis var juliennius) Cultivation at Netted House, UMK Agro Techno Park.

ABSTRACT

Sprinkler irrigation system is a method of applying irrigation water which is similar to natural rainfall. This study emphasizes to evaluate the coefficient of uniformity of the water discharge and measurement of pressure during Pak Choy cultivation from sowing to its maturity stage. Performances irrigation system is evaluated in three series experiment for this sprinkler system. In this netted house structure, there are nine benches. Each bench equipped with four fixed head sprinkler. This study revealed that uniformity distribution found in this study are in the range between 81.66% and 83.26% . The average coefficient of uniformity distribution of all benches is 75.61%. This study also revealed that Water Use Efficiency (WUE) for Pak Choy cultivation is 3.460 kg/m^3 .This values implies normal growth performances, where the Pak Choy cultivation received enough water supply which can produce maximum yield production. Controlling of valve on this system does not significantly different in term of pressure. Controlling of valve on opening and closing on this system also does not significantly different in term of discharge. In conclusion, evaluation performances for this sprinkler irrigation can help the farmer in managing their farm as sprinkler irrigation is considerable efficiency and distribution water more evenly across crops helping to avoid wastage.

Keyword : Sprinkler Irrigation, discharge of water, uniformity

Penilaian Prestasi Saliran Pemercik dan Kecekapan Penggunaan Air terhadap Penanaman Sawi Pak Choy (Brassica chinensis var juliennius) di Rumah Terjaring.UMK Agro Techno Park.

ABSTRAK

Sistem pengairan pemercik adalah kaedah pengairan yang sama dengan hujan semula jadi. Kajian ini menegaskan untuk menilai pekali keseragaman pelepasan air dan pengukuran tekanan semasa penanaman Pak Choy daripada proses menyemai hingga proses kematangannya. Sistem pengairan prestasi dinilai dalam tiga percubaan siri eksperimen untuk sistem pemercik ini. Dalam struktur rumah yang terjaring, terdapat sembilan bangku. Setiap bangku dilengkapi dengan empat pemercik kepala tetap. Kajian ini menunjukkan bahawa pengagihan keseragaman yang terdapat dalam kajian ini adalah antara 81.66% dan 83.26%. Pekali purata pengagihan keseragaman pada semua bangku adalah 75.61%. Kajian ini juga mendedahkan bahawa keberkesanan Penggunaan Air (WUE) untuk penanaman Pak Choy adalah 3.460 kg / m^3. Nilai ini menunjukkan prestasi pertumbuhan pembesaran penanaman Pak Choy yang normal, di mana penanaman Pak Choy mendapat bekalan air yang mencukupi yang dapat menghasilkan pengeluaran hasil yang maksimum. Mengendalikan injap pada sistem ini tidak jauh berbeza dari segi tekanan. Mengawal injap pada sistem ini juga tidak jauh berbeza dengan pelepasan air. Kesimpulannya, penilaian sistem,dapat membantu petani dalam menguruskan ladang mereka sebagai pengairan pemercik adalah kecekapan dan pengedaran air yang lebih banyak merata tanaman untuk membantu mengelakkan pembaziran.

Kata kunci : Sistem pemercik air,kecekapan air,koefisien keseragaman

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LIST OF ABBREVIATION AND SYMBOL

%	Percentage
EC	Electrical conductivity
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
Avg	Average or mean
U	Uniformity

CHAPTER 1

INTRODUCTION

1.0 Background of the study.

In previous decades, water is used for variety types of purpose. Water is usually used for irrigation, industrial, domestic supply and fisheries. Irrigation water demand had increased from 7.4 billion m^3 in 1980 to 10.4 billion m^3 by the year 2000 (Keller, 1990). Irrigation is the process of applying water to the soil to meet crop water demands. The role of irrigation is to improve production and input efficiency in areas where the climate limits production potential (Ahaneku & Isiguso, 2010).

One of the types of irrigation in agriculture that commonly used is sprinkler irrigation. Sprinkler irrigation system is a method of the providing rainfall like irrigation to the crop where the system represent the broad class of "pressurized" irrigation methods, in which water is carried through pipe system to point near it will be consumed (Demir, 2016).Usually ,water from sprinkler distributed the water through pipes system by pumping

process. Sprinkler irrigation also deliver efficient of coverage for small to large area and are suitable to all types of crops.

A good irrigation system performance is the result of a carefully considered of the design, prudent equipment, maintenances and proper water management. All of the sprinkler system needed basic components such as pump, mainline, laterals, risers, sprinkler and valves in order to adapt the system with variety of soil scenario and crops.

An ideal irrigation system should apply the correct amount of water, minimize the losses, and apply the water uniformly. Sprinklers can be a good investment when properly designed, installed, maintained and managed. Sprinklers apply water more efficiently and uniformly than typical surface irrigation systems, thus they produce more yields for each quantity applied per unit area (Hill & Hinton, 2001). The necessary tool in irrigation project management is evaluation of the system. This evaluation involves the measurement and analysis of key aspects of irrigation performance and management of the system.

The uniformity of sprinkler irrigation is a central design goal (Ahaneku & Isiguso, 2010). Uniformity relates to how evenly water is applied over a given area. Since no irrigation system can apply water precisely to all areas of the field, it becomes necessary to estimate the uniformity of water application in order to assess the performance of the system. The suitable crop that can use sprinkler system for irrigation are cereals, heat, sugarcane, groundnut, cotton, vegetables, fruit and flower (Narayanmoorthy, n.d).The sprinkler irrigation system also suitable for cultivating of paddy crop (Kundu, 1998).

1.1 Hypothesis

H null

Irrigation performances of fixed head sprinkler are not significant along the experiment. Thus, it will not affect the water use efficiency and pressure variation of the system.

H alternate.

Irrigation performances of fixed head sprinkler is significant along the experiment .Thus, it will affect the water use efficiency and pressure variation of the system.

1.2 Problem Statement

Sprinkler irrigation has wide range uses for irrigation purpose. Long unused of sprinkler irrigation reduce irrigation performances. This is due to the location of the sprinkler irrigation installation is far away and difficult to reach there especially when rainy season. Then, irrigation performances of the sprinkler irrigation need to re-evaluate continuously to prevent clogging. Clogging related to algae and bacteria is common when water with high biological activity is used for irrigation where it is increased in iron , manganese and sulphide are present in the water (Mark, 2017).Clogging problem usually happen when the nozzle of the sprinkler head not washed frequently.

1.3 Objective

1. To evaluate water use efficiency of Pak Choy cultivation by using sprinkler irrigation inside netted house.
2. To measure the irrigation performance of the fixed head sprinkler installation.
3. To determine the effect of valve controlling toward discharge of sprinkler irrigation system.

1.4 Scope of study

The study is focusing on the sprinkler system at netted house. The study also focusing on fixed head sprinkler system and how the system performance will be evaluated using different parameter including operating pressure, flow rate meter discharge, coefficient of variation and coefficient of uniformity toward sprinkler irrigation system.

1.5 Significant of study

Management of water in sprinkler is very important since water is the main source for irrigation and is needed during the growing stage. A system can be said efficient if the production of agriculture procedure is high compared to the water consumption. Less use of water with high production shows that the system is able to work properly. One of the indicator used to show the efficiently of irrigation system is by calculating water use efficiency.

By knowing the water use efficiency value, farmer can evaluate the level of water use in their farm either the water is used properly or there is a waste in water consumption. Water use efficiency is often enhanced in efforts of managed demand in agriculture, with effort aimed at reducing water losses in irrigation distribution system (Unver, Bhaduri, & Hoogeveen, 2017). Irrigation scheduling of the sprinkler irrigation system need to re-evaluate at the netted house by calculating the water uniformity distribution .By knowing

the water uniformity distribution ,farmer can determine either the sprinkler system apply enough water to fully wet the plant's root zone while minimizing overwatering and then allow the soil to dry out in between watering .Irrigation scheduling also is the process used in irrigation system managers to determine the correct frequency and duration of watering.

CHAPTER 2

LITERATURE REVIEW

2.1 Components of Sprinkler System.

Components of sprinkler system consist of water source, pump unit, tubing, couplers, sprinkler head and fittings and accessories. Water sources are the main components of the system where water sources either from lakes, river or groundwater. Pumping unit is the components where the pressure forces the water through sprinkler or through perforation or nozzles in pipelines and then forms sprays. There are two types of pumps that usually used which are centrifugal pump and submersible pump. Centrifugal pump is used when the distance from the pump inlet to the water surface is less than eight meters while submersible pump consists of a water-proofed electric motor and a pump combined in a single unit. Typically a larger size submersible pump and motor will be shaped like a long narrow cylinder so that it can fit down inside of a water well (Stryker & Jess, 1997).

Next components is tubing which consist of main line, sub mains and lateral. Main line conveys water from the sources and distributes it to the sub mains. The sub mains convey water to the laterals which in turn supply water to the sprinkler. While for the laterals usually asbestos, cement, PVC and wrapped steel are usually used for buried lateral and main lines (Virajain, 2012).

Moreover, couplers are also one of the components where couplers are used for connecting two pipes and uncoupling quickly and easily. Sprinkler head is also one of the components in order to use sprinkler irrigation where sprinkler head distribute water uniformly over the field without excessive runoff loss due to deep percolation (Virajain, 2012).Last but not least, fitting and accessories that are usually used in sprinkler system such as water meters, flange, pressure gauge, bend, tees, reducers and fertilizer applicator.

2.2 General Planning of designing Sprinkler Irrigation.

Planning and design of the sprinkler irrigation system is one of the important steps to fulfil the consideration of the functional system. There are several steps that need to be considered in order to design sprinkler irrigation. First step in designing sprinkler irrigation system is to decide the type of crop that will cultivated. Then, based on the type of crop decided ,there are some data are required such as depth of irrigation to be applied, peak water requirement, maximum infiltration rate of soil characteristic of water sources ,discharge capacity area to be covered, type of topography of the area, irrigation efficiency, operating hours of pump, efficiency of the pump, water level for pumping and shifting of a whole system per day (Virajain, 2012) .All this data is required in order to make sure efficiency of the sprinkler irrigation.

Prior to the system running, discharge need to be calculated. Some data are required for this step are number of days after which irrigation must be applied ,depth of water to be applied for irrigation and discharge of water in lit/sec (Virajain, 2012).Data required such as length of main pipe, frictional loss for assumed diameter of pipe, length of lateral pipe and lastly is diameter of lateral pipe are needed to be calculated in order to determine the main line and the lateral for sprinkler system (Virajain, 2012).

Furthermore, to determine lateral spacing where each lateral should be done trial for assumed spacing in metre ,the spacing which is most economical is selected (Virajain, 2012).Moreover, for step five is head loss in the lateral where it determine for size of lateral

pipe head loss in frictional is determine. The last step is calculation for determine horse power that require for pumping process (Virajain, 2012).All this steps need to be consider in order to planning and designing during installation of the sprinkler system.

2.3 Cultivation of Pak Choy.

Pak Choy comes from a family of cruciferae that is commonly grown for domestic use and export purpose. The scientific name of the Pak Choy is *Brassica chinensis var juliennius* (Anem, 2011) .Pak Choy is believed to have originated in china and brought to Japan further spread to Southeast Asia in the 15 century (Anem, 2011). The preparation of the soil for planting Pak Choy is the soil should be ploughed and drained as deep as 15-20 cm (MOA, 2003).

Then, the planting bed should be 1.2 m wide, 7.5 m long and 20-30 cm high. The seed of Pak Choy seed can be planted directly on the planting bed (MOA, 2003). Before planting, treated seed were mixed with fine sand and evenly distributed at the planting bed. After 10-14 days, transplant of the plant was made according to recommended size of planting distance between trees is 20 cm and 10 cm (MOA, 2003).Pak Choy is a type of shrub which has a height of 15-30 cm during the growing process (Anem, 2011).

Pak Choy can be harvested from 28 to 30 days after sowing. Usually, range yield is between 10-16 tons / ha for 1.0 kg seed (MOA, 2003). Pak Choy needs plenty of water for its growth. Watering should be done twice a day in the hot day either manually by hand using watering cans or using automatic system (MOA, 2003).

2.4 Advantage of the sprinkler irrigation

There several advantages of using sprinkler irrigation system. Firstly, sprinkler irrigation system is water saving irrigation where intensity can be changed in accordance with infiltration capacity of soil and crop water requirements (Keller, 1990). Secondly, is system commonly used because of high efficiency system due to uniform water distribution and crop water requirements can be adaptable (Keller, 1990).

Not only that, sprinkler irrigation also will ease the application of the fertilizer or pesticides through irrigation system. Furthermore, sprinkler irrigation is an easy mechanization and automation system so we do not need require more labour to running this system (Virajain, 2012).

Soil water can be easily maintained at a favourable tension for optimum growth and yield. Crops can be saved from frost damaged too. Uniform application of the water can be made in highly porous soil and used of this sprinkler irrigation can also produce high in yield or good quality fruits and vegetable (Virajain, 2012).

2.5 Disadvantage of the sprinkler irrigation

The disadvantages of the sprinkler irrigation more towards high capital investment (Virajain, 2012).When installation of the sprinkler irrigation, it require more equipment such as pump ,tank, tubing ,sprinkler head ,fitting and accessories. So, all this type of the components are usually high in cost for each components.

Next, climate scenario such strong wind can reduce the effectiveness the system where the water will change to distributing pattern and water droplet according wind direction (Virajain, 2012).Clean water is needed in order to avoid clogging the nozzle when the system is on.

2.6 Water Use Efficiency (WUE)

In irrigation, Water Use Efficiency (WUE) is method to assess the value of agricultural production per unit volume of irrigation water used directly for crops (Harrington, 2000). The Water Use Efficiency (WUE) sub-indicator will be calculated as the value of crop production (all crops) per unit volume of irrigation water used (Harrington, 2000).Water use efficiency is usually measured by harvesting plants, determining dry weight of the cultivation and dividing by the irrigation applied (Tollefson, 2005).Water use efficiency also was measured in different type of plant group such as C4 plant ,C3 plant and CAM plant (Kirham, 2005).There are different value range of WUE between C4,C3 and CAM plant species. In major of summary of photosynthetic pathway differences, Larcher (1995) noted that C3 WUE range between 1.4 to 3.6 g dry matter (DM),whereas C4 range between 3.0 and 5.0 (Ferit & Rowan, 2005).Meanwhile ,WUE for CAM plant species generally ranges between 6.0 and 15.0 (Larcher & Zotz, 1997).These differences in WUE substantially lower transpiration rates and water transport need in C4 and CAM relative to C3 plant which assuming equivalent, growth form and environmental scenario (Ferit & Rowan, 2005).

2.7 Coefficient of Uniformity(CU)

Coefficient of uniformity expresses the water distribution pattern. Most of the test to evaluate sprinkle irrigation system uniformity and efficiency is done with can (Keller, 1990).Coefficient of uniformity less than 75% are generally considered as relatively low of sprinkler distribution uniformity while coefficient of uniformity more than 84% is recommended (Keller, 1990).However ,optimum of uniformity of the system depend on economic of the crops ,values of applied water the crop response to water and drainage economics. Standard uniformity of water application in sprinkler irrigation system has develop by American Society of Agricultural and Biological Engineers(ASABE).The uniformity can be classified as shown in Table 2.1.

Table 2.1: Classification of Irrigation uniformity

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

(Goyal, 2013)

2.8 Coefficient of Variation (CV)

Coefficient of variation generally used to measure sprinkler irrigation pressure and discharge variation. Coefficient of variation can be computed as standard deviation of all catch can measurement divide by the average catch can volume for the test (Tayel & Mansor, 2015) .Solomon (1979) provided the ranges of coefficient variation values and their appropriate interpretation in 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

(Goyal, 2013)

CHAPTER 3

MATERIAL AND METHODS

3.1 Location of study Area

The study was conducted at netted house, University Malaysia Kelantan Agro Techno Park that as shown in Figure 3.1. Specifically, the study area is located at coordinate of 5°45’09.0° North and 101°52’27.6 East. Three series of experiments were conducted during October-November 2018. Relative humidity and temperature of the study area were measured by using hygrometer (OEM,China) which installed outside the netted house along the study period. The temperature at the netted house ranged between 30.2°C and 37.1°C during growing period. The relative humidity during the crop growing period varied between 40% and 89%.

Figure 3.1: Satellite image of study area (Source Google Map,2018)

3.2 Layout and Description of Sprinkler Irrigation System

Figure 3.2 shows the outside view of the netted house. The layout of sprinkler irrigation system is shown in Figure 3.3.The length and wide of the netted house is 6.2m × 30 m respectively. The system consists of one unit of water tank with capacity of 450L.

A 2 horse power centrifugal pump is equipped to the system and supply the water from the tank to the discharge point. The netted house consists of 13 concrete benches with length and wide of 4m and 2m respectively. Each bench equipped with four fixed head sprinkler and a control valve to switch on and off the flowing water. In total, there are 52 sprinkler were installed inside the netted house. The pressure gauges were installed at concrete bench number one, five and nine only for measuring pressure of water discharge during irrigation.

Figure 3.2: Outside view of netted house.

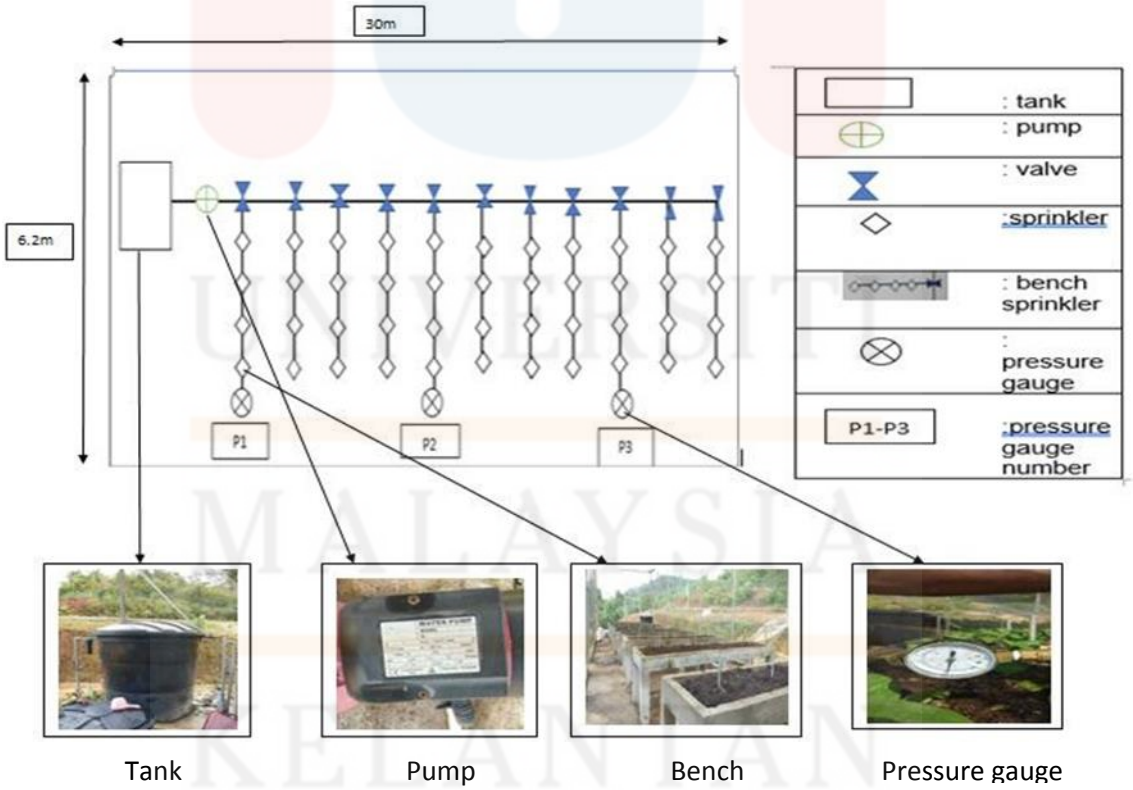

Figure 3.3: The layout of sprinkler irrigation system at netted house.

3.3 Land Preparation of Pak Choy cultivation.

3.3.1 Planting bed Preparation.

Planting bed preparation is one of the steps to cultivate Pak Choy. Firstly, topsoil is required for crop because the topsoil contains all nutrients that can support for germination of the crop. The topsoil was obtained from soil at Agro Techno Park. Then, the goat manure, coco peat and peat moss were added and mixed uniformly to the planting bed.

3.3.1 Spraying the herbicide.

Before cultivation of the Pak Choy, the planting bed was sprayed with the herbicide to kill or prevent the weed from growing. Next, proper safe attire were needed where need to wear apron, mask, gloves and boots. Figure 3.4, shows the proper attire for safety purpose when spraying process.

Figure 3.4: The proper attire for safety purpose during spraying process.

3.3.2 Lining, sowing and transplant the seed of Pak Choy.

Treated seed was obtained from private fertilizer shop. The expired date for the seed is on 2020.The seed was mixed with fine sand and evenly distributed at the planting bed. After 10-14 days, the seedlings was transplanted according to recommended size of planting distance of 20 cm × 10 cm. Figure 3.5 ,shows the lining activity was done before transplant the germination seed. So that the seedling is line up at straight line and according to the planting distance set up. With the stated planting distance, there are 22 plant occupied in one bench. Figure 3.6, shows transplanted of the Pak Choy to the planting bed.

Figure 3.5: The lining activity before transplant the germination seed.

Figure 3.6: Transplanted of the Pak Choy to the planting bed.

3.3.3 Irrigation of Pak Choy

Pak Choy need more water requirement per day. So the irrigation using sprinkler system operated two times per day .First irrigation was at 9 am in the morning and second irrigation at 4 pm at evening. Duration of spraying of each cycle was one minute.

3.3.4 Harvesting of Pak Choy.

At week 22, the plant is ready to be harvested as shown in Figure 3.7 .Harvesting of the Pak Choy crops can be made by cutting the root using scissor or clippers. The overall yield then was weighted using weighing scale and data of yield for each bench was recorded.

Figure 3.7: Pak Choy cultivation is ready to be harvested.

3.3.5 Installation of the flow rate meter.

Flow rate meter was installed near the tank and pump of the sprinkler irrigation. The purpose of the installation of the flow rate meter toward the sprinkler irrigation is to measure water use during irrigation purpose. Figure 3.8 shows the flow rate meter used in this experiment.

Figure 3.8: The flow rate meter used in this experiment.

3.4 Experiment 1: Measurement of Water use efficiency(WUE)

Water uses efficiency is a parameter that can show the effectiveness of irrigation system applied toward the crop and how irrigation can affect the growth performances of the plant (Irmak, 2011). Measurement of water uses efficiency requires a crops where have been planted on the planting bed throughout the period from planting to its maturity stage. The yield of Pak Choy for each bench was harvested and weighed using weighing scale and the amount of yield obtain is recorded. The volume of water is

monitored and the reading by flow rate meter was recorded weekly. The amount of water used can be calculated by comparing was the reading of the flow rate meter along the experiment. Calculation for water use efficiency can be calculated by using equation 3.1.

$$WUE=\frac{\text{yield per unit area(kg/ha)}}{\text{Irrigation water applied}(m^3/ha)} \quad (3.1)$$

3.5 Experiment 2: Calculation of irrigation performances during Pak Choy cultivation.

In this experiment, nine benches of planting beds in netted house were used. Pressure and discharge parameter were measured in this experiment.

3.5.1 Measuring of pressure

There are three selected point for pressure gauge was installed on sprinkler irrigation system. First point located at bench number one, the second point located ate bench number five and third point located at bench number nine. The sprinkler head was modified in order to fit the pressure gauge on the sprinkler head. The upper part of the sprinkler head was cut and T-junction, valve and pressure gauge were attached 30 mm diameter pipe sprinkler head between two locations.

3.5.2 Measurement of water discharge

The water discharge from the sprinkler head was measured by using cups and measuring cylinder .The time taken to fill up the cup is taken by using stop watch. There are 16 plastic cup used in this experiment with diameter of 30 cm between each plastic cup. The measurement of water discharge was repeated two times per day at morning and evening.

3.5 .3 Coefficient of Variation (CV)

Coefficient of variation measurement was calculated as standard deviation of volume dividing by the average volume of water from the plastic cup.

$$\mathrm{CV} = \frac{\mathrm{sd}}{\mathrm{avg}} \tag{3.2}$$

Where, sd is standard deviation and avg is the mean of the sampled number.

3.5.4 Coefficient of Uniformity

The collected water from the plastic cups was calculated by dividing the volume caught by the open area of each cup. Uniformity coefficients are used to quantify uniformity of water distribution resulting from the volume of cup data. In this study the coefficient of uniformity CU, the low quarter distribution uniformity, and the coefficient of variation CV were used .The coefficient of uniformity depends on the amount of the water collected for each individual cup where the cup are distributed over the field. Equation 3.3 was used to calculate coefficient of uniformity of the sprinkler irrigation.

$$CU = [1.0-[CV]] \times 100 \quad (3.3)$$

Where, CU is uniformity of the sprinkler discharge rate (%) and CV is coefficient of variation.

3.6 Experiment 3: Relationship Sprinkler Irrigation between controlling valve and discharge at different scenarios.

In this experiment, nine benches of planting beds in netted house were used. Pressure and discharge parameter were measured in this experiment. For experiment three, there are seven scenarios for valve opening and closing. There are 9 concrete benches involves in this experiment. This experiment was divided to three sections which were bench 1-3 known as head, bench 4-6 known as middle section and bench 7-9 known as tail section.

Figure 3.9,(a) shows the first scenario where all the system is running simultaneously, (b) shows the second scenario where head section valve is off,(c) shows the third scenario where head and middle section valve is off,(d) shows the fourth scenario where tail section valve is off.(e) shows the fifth scenario where middle and tail valve is off,(f) shows the sixth scenario where middle section valve is off,(g)shows the seventh scenario where head and tail section valve is off.

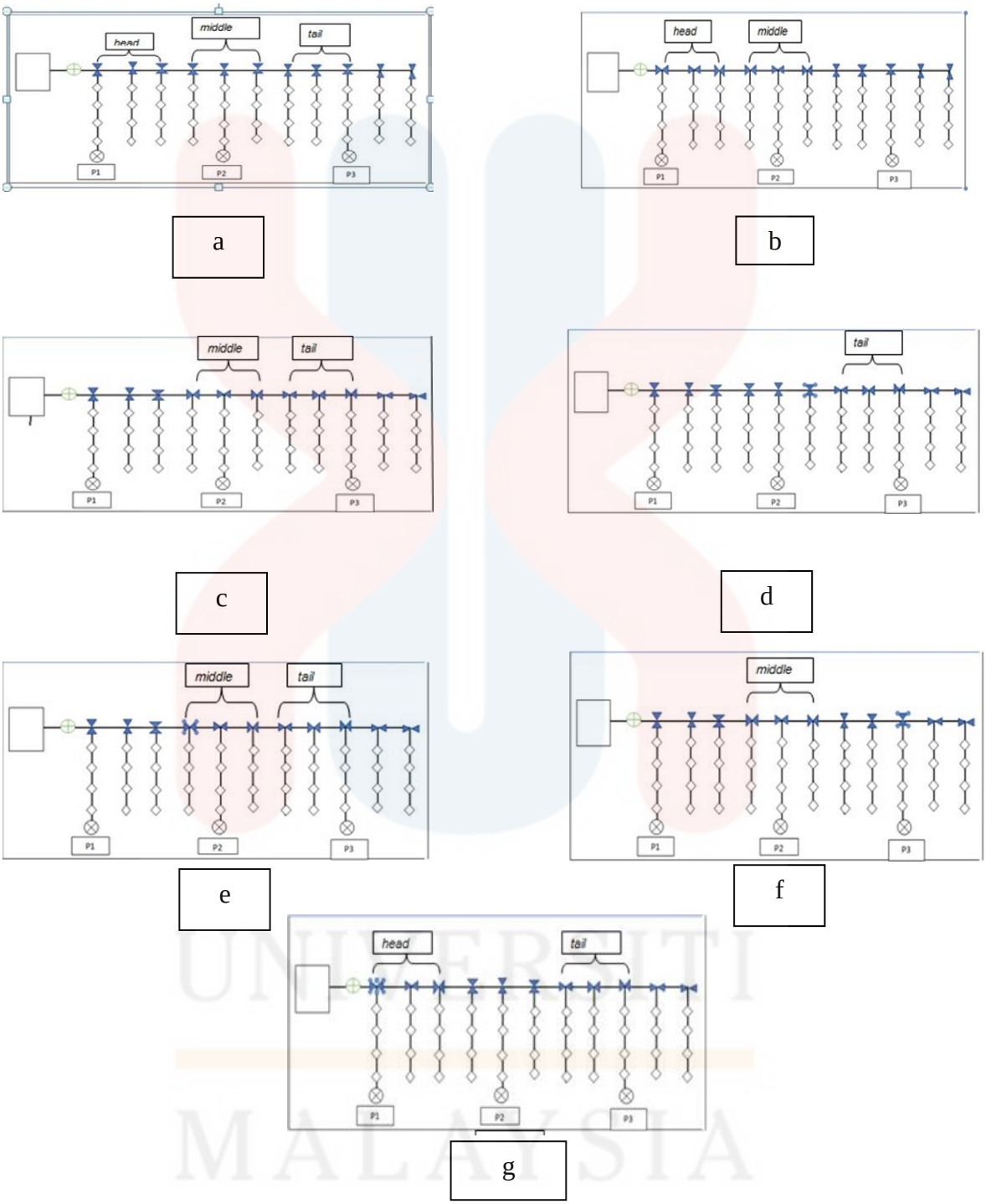

Figure 3.9 :The scenario of testing where (a) first scenario where all the system is running simultaneously,(b) second scenario where head and middle section valve is off,(c) third scenario where middle and tail section valve is off ,(d) fourth scenario where tail section valve is off,(e) fifth scenario where middle and tail valve is off,(f) the sixth scenario where middle section valve is off,(g) the sixth scenario where middle section valve is off.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Water Use Efficiency (WUE) of Pak Choy Cultivation.

Water uses efficiency is a method to determine the irrigation effectiveness in term of crop yields. Table 4.1 shows that the total yield of Pak Choy cultivation from each bench at netted house. At harvesting stage ,which at 28-30 days ,the yield of Pak Choy that produced from 2gm germination seed is totally about 91.13 kg from 13 bench that have been planted .At the harvesting stage ,it can be said that average yield produce for each bench sprinkler is 7.01 kg. However there is bench that produces high yield which bench number four. These is maybe bench number four get excessive water supply, nutrient, good soil requirement and not tend to disease (MOA, 2003). In this study also shows that bench number four had good absorber of soil properties and not overwatering so that why bench number four has the highest production of yield compared to the other bench.

Not only that, there is also lower yield produces for Pak Choy cultivation which is bench number five where is only 2.00 kg .This is maybe due to the plant did not get excessive water supply and attack by insect or competition between the weed so the crop cannot survive during cultivation (MOA, 2003).

Table 4.1: Pak Choy yield from each bench in netted house.

Number of bench sprinkler	**Yield produce for each bench(kg)**
1	5.93
2	5.96
3	7.62
4	11.29
5	2.00
6	7.31
7	7.88
8	9.94
9	3.50
10	7.30
11	8.10
12	6.80
13	7.50
Total	**91.13**

At the earlier stage germination, the flow rate meter reading is 37.88 m^3. So the total amount of water applied for seven weeks during Pak Choy cultivation is 26.35 m^3 . So the average of amount of water used for every week is 3.764 m^3. Based on this value and by using equation 3.1, the value of water use efficiency is 3.460 kg/ m^3 for Pak Choy cultivation using sprinkler irrigation system. This value indicate that, Pak Choy is one of the plant that categorized in C4 plant (Kevin, 2011).This indicate that WUE value for this Pak Choy cultivation is include in C4 WUE plant range between 3.0 and 5.0 kg/ m^3 (Ferit & Rowan, 2005).So ,it means that Pak Choy cultivation received enough water supply ,and the sprinkler system irrigate properly (Ferit & Rowan, 2005).This WUE value of Pak Choy cultivation also show that the plant have normal growth development which get enough fertilizer applied. Table 4.2, shows the amount of water discharge from flow rate meter (m^3).

Table 4.2: Amount of water discharge from flow rate meter.

Week	**Flow rates meter Reading (m^3)**	**Amount of water use (m^3)**
1	37.88	0.78
2	38.66	2.53
3	41.18	3.00
4	44.18	1.18
5	45.36	7.91
6	53.27	10.95
7	64.22	Total Amount of water used =**26.35**

4.2 Irrigation performances during Pak Choy cultivation.

The uniformity of water application describes how evenly an irrigation system. Irrigation performances during Pak Choy cultivation can be illustrated by the value of coefficient of uniformity and coefficient of variation. Table 4.3 shows the performances for individual bench with sprinkler. The average of the coefficient of uniformity recorded is 75.61% while the average of the coefficient of variation in sprinkler irrigation system recorded is 0.224.

This indicate that sprinkler head system at netted house classified as fair performance which include in range 75%-80% classification of sprinkler irrigation uniformity as stated by (Goyal, 2013) in Table 2.1.Meanwhile ,for average of the coefficient of variation recorded is 0.224 ,it is classified as acceptable classification of sprinkler variation according to (Goyal, 2013) in Table 2.2. Although, coefficient of variation and coefficient of uniformity in fair performance and acceptable value, there are several bench show poor performances of sprinkler head distribution in term of uniformity and variation.

As example bench number five ,coefficient uniformity is only 58.78% where it is classified as not acceptable value because the uniformity value less than 60%.Apart from that, coefficient variation in bench number 5 is 0.412 .This value show that it is unacceptable value for coefficient of variation because the variation value more than 0.4.It is maybe due to bench number 5 had problem with uniformity distribution pattern which is when running the experiment it may be strong wind scenario affect the water distribution

pattern so the water droplet from the sprinkler head went away toward wind direction and did not irrigate the crop.

However, the sprinkler head system at bench number five also may be damaged or not functioning well .It is because maybe due to long unused of sprinkler irrigation system so the clogging problem occur .Clogging occur when the water failed to come out from the sprinkler head which is typically sign of the blockage (Swett, 2016).Clogging is because of accumulation of dirt in regular use of sprinkler head can cause dirt and mud to infiltrate the holes of the sprinkler head and causing it to not work properly (Swett, 2016).A sprinkler head can also become clogged when debris finds its way into the nozzle or directly into the spray head. Cleaning the nozzle will typically remove blockages, but if sand or dirt has infiltrated the sprinkler head.

Table 4.3: Performance indices for bench sprinkler irrigation system.

Number of bench	Mean of the water discharge (ml)	coefficient of variation (CV)	Coefficient of uniformity (CU)(%)
1	65.80	0.253	74.74
2	72.20	0.205	79.52
3	87.20	0.247	75.27
4	66.40	0.183	81.66
5	59.00	0.412	58.78
6	52.00	0.241	75.87
7	73.40	0.168	83.19
8	68.80	0.167	83.26
9	61.40	0.318	68.22
Average	67.36	0.244	75.61

4.3 Relationship Sprinkler Irrigation between controlling valve and discharge at different scenarios.

Valves are an essential part of any sprinkler system. They are the link between the brains of the system which is controller and the sprinkler head to turn the water on and off (Author, 2016).Statistically, mean pressure value of sprinkler irrigation system with different scenario show not significant different in term of pressure. It can be said that ,it doesn't matter ,the controlling valve in head, middle and tail section not affect the pressure because the pressure value show not so much different in every section. The highest value recorded when the head and middle section valve is switch off. Then, the lowest is recorded when all valve is switch on when the normal scenario of all bench sprinkler is operating at the same time.

Apart from that, when scenario two section valve where is when head and middle valve is switch off, middle and tail valve is switch off and head and tail valve is switch off the pressure of the sprinkler system range between 17 psi to 18 psi compared to the normal scenario when the normal valve is switch on which is 12 psi. It may be due to the consideration of the distance from the pump and tank where the distance from pump at head is and middle section is 10 m, so it considers that head and middle section has high pressure compared to tail when valve control at section tail is switch off. The scenario, when one valve only is switch off where the head valve off ,tail valve off and middle valve off the range pressure value is between 14 psi to 16 psi. The value indicates that there is not much different when all scenario valves are switch on when compared to the normal

scenario. It is because maybe due to consideration in time to take the water to reach the sprinkler head is take long time .This result also show that when the two valve is switch off is higher pressure than the scenario only one valve is switch off. This result show that it is true that when one section only valve is switch on , the pressure must be higher compared to the scenario when two section valve is switch on it has lower value in term of pressure. This is because, when two sections is switch on it required high pressure to distribute every section so the pressure is low. Meanwhile for the scenario where one section valve is switch on, the water distributed will be focused on one section only so the pressure is high at that section.

From the result also ,mean discharge value of sprinkler irrigation system are shown in Table 4.4.Statistically,mean pressure value of sprinkler irrigation system with different scenario also show not significant in term of water discharge. It can be said that, there is different between every section valve is off in term of water discharge. The highest value recorded when all valve is switch on which is 88 ml where is the normal scenario of all bench sprinkler is operating at the same time. The lowest is recorded when head and middle valve is switch off which water discharge is 15.67 ml.

In this study also, there is also different of water discharge between one section valve is switch off and two section valve is switch off which is for one valve only switch off the mean value of water discharge is 44 ml to 55ml range value while for two section valve is switch off is range between 15ml to 50 ml. It is maybe to the water clogging problem when running the experiment where affect the nozzle.

Clogging cause by regular use of the sprinkler can cause dirt and mud to fill the holes of the sprinkler head (Andy, 2010).Clogging also cause by debris in sprinkler head where the sand and dirt getting into the spray head so the water is clogged so cannot distributed the water. Moreover, the clogging problems also caused by the sprinkler stem leaks. The sprinkler stem leaks often happen when incorrectly installed sprinkler head .Normal wear and tear will also eventually damage the wiper seal of the sprinkler head which resulting in leaks around the stem of the spray head (Swett, 2016).

Table 4.4: Mean value of the pressure and discharge of the sprinkler irrigation.

Treatment/Scenario valve control	Mean of pressure value(psi)	Mean discharge value (ml)
All valve on	12.67±1.33 [b]	88.00±5.50 [a]
Head valve off	14.67± 0.66 [ab]	44.33±22.83 [a]
Head and middle valve off	18.67±1.33 [ab]	15.67±15.67 [a]
Tail valve off	16.00±2.00 [ab]	55.00±27.50 [a]
Middle and tail valve off	17.33±1.66 [a]	50.67±50.67 [a]
Middle valve off	16.00±0.00 [a]	54.00±28.02 [a]
Head and tail valve off	17.67±0.33 [a]	26.00±26.00 [a]

Note: Value means in the same column with different letter indicate significant different between treatment ($p < 0.05$).

Figure 4.1, shows that there is no significant different between the pressure and water discharge. For the mean pressure value, head and middle scenario and head and tail scenario is switch off recorded the highest pressure which is 18 psi and 17 psi. However, the water discharge value for both scenarios recorded the lowest which is 15.67ml and 26.00 ml. It can be said that when the scenario one section valve is switch on the pressure is too high. It is because ,the pressure focused on the valve which valve is on only so it recorded higher pressure compared to normal condition when the all system valve is switch on which 12 psi. The water discharge from the sprinkler head become the lowest one maybe because of the strong wind scenario effect the water distribution pattern so the water droplet follow the wind direction and disturb the uniformity of the sprinkler system.

From the study also , scenario when one valve only is switch off which are tail section is switch off ,middle section is switch off and head section is switch off ,it shows that pressure range between 15 psi and 16 psi. Meanwhile, for the water discharge it can be said that water collected in volume range between 35 ml and 50 ml. The values indicates that it is higher pressure compare to the control scenario where is 12 psi when all valve control is switch on simultaneously. In term of water discharge the discharge of water from sprinkler head show quite low than the control condition which is 90 ml .It is may be because of the pipes crimped by tree roots (Glenice, n.d).

Sometimes this is due to pipes that have not been trenched correctly and used low density (LDPE) pipe and fittings are too weak to handle the pressure of tree's root system affect in lower pressure and lower water discharge (Glenice, n.d).Crimped pipes can lead to burst pipes,because there is no longer any release of pressure via the sprinklers (Glenice, n.d).

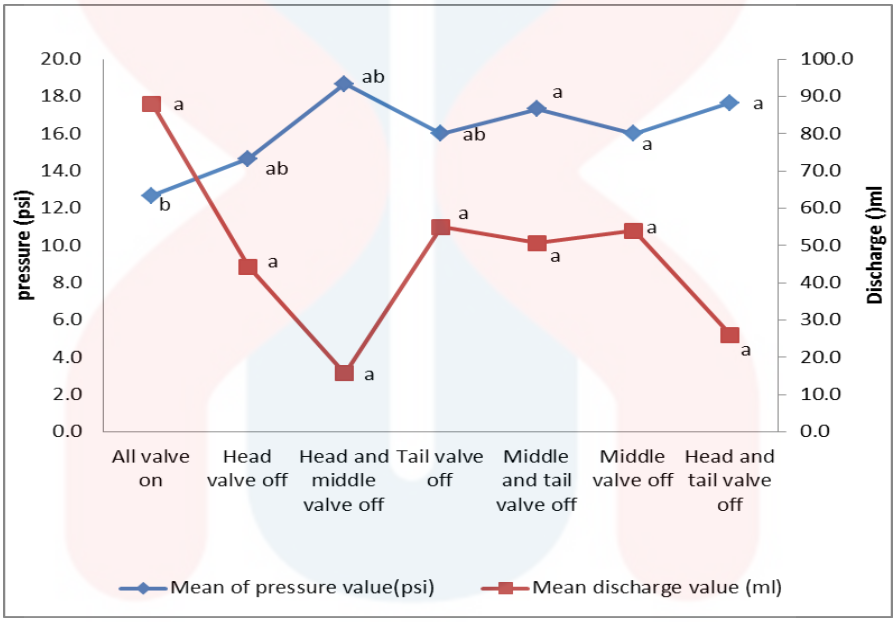

Figure 4.1: Effect of valve opening and closing on pressure and discharge. Different letter at the different treatment mean show significant different by Duncan test by ($P< 0.05$).

CHAPTER 5

CONCLUSION

5.1 Conclusion

Based on the result of the study, the opening and closing control valve with discharge is evaluated. Based on the result, WUE for the cultivation of the Pak Choy using sprinkler irrigation system is 3.460 kg/ m^3. The discharge and pressure were used to calculate the coefficient of variation and coefficient of variation. Average of the coefficient uniformity of this sprinkler system is 75% while average of the variation is 0.224. So according to this study, it can conclude that sprinkler irrigation system at netted house is fair and acceptable according classification performance for coefficient uniformity and coefficient of variation. Therefore, it can consider that clogging problem toward sprinkler head can be avoided by flushing frequently can improve the sprinkler irrigation performances.

5.2 Recommendation

For the future and further research, it is recommended that further studies should use different sprinkler head type in order to cultivate variety type of crops. Moreover, adjust pattern of the sprinkler irrigation system in order to avoid sprinklers sprays directly to the trees, as water streams may damage the plant. Last but not least, use the others crop such as fruit like rock melon and vegetables such as cucumber, brinjal to determine the water use efficiency and compared with previous study.

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Appendix A

Figure A1: The cultivation of Pak Choy at the netted house.

Figure A2: Cup that has been used for data collection.

Figure A3: Harvested Pak Choy in the plastic.

Figure A4: Plastic cup were placed on the bench along the experiment.

Figure A5: Pak Choy was weighing using weighing scale.

Figure A6: The view inside the netted house when sprinkler system was operating.

Appendix B

Table B.1: Pak Choy yield from each bench in netted house.

Number of bench sprinkler	Yield produce for each bench(kg)
1	5.93
2	5.96
3	7.62
4	11.29
5	2.00
6	7.31
7	7.88
8	9.94
9	3.50
10	7.30
11	8.10
12	6.80
13	7.50
Total	**91.13**

Table B.2: Flow rates meter reading.

Week	**Flow rates meter Reading (m^3)**	**Amount of water use (m^3)**
1	37.88	0.78
2	38.66	2.53
3	41.18	3.00
4	44.18	1.18
5	45.36	7.91
6	53.27	10.95
7	64.22	Total Amount of water used =**26.35**

Table B.3: Coefficient of variation and coefficient of uniformity of sprinkler irrigation system at netted house.

Number of bench	coefficient of variation (CV)	Coefficient of uniformity (CU)(%)
1	0.253	74.74
2	0.205	79.52
3	0.247	75.27
4	0.183	81.66
5	0.412	58.78
6	0.241	75.87
7	0.168	83.19
8	0.167	83.26
9	0.318	68.22

Table B.4: Average mean for pressure and discharge of sprinkler irrigation system at netted house.

Treatment/Condition of the valve control	Mean of pressure value(psi)	Mean discharge value (ml)
All valve on	12.7	88.0
Head valve off	14.7	44.3
Head and middle valve off	18.7	15.7
Tail valve off	16.0	55.0
Middle and tail valve off	17.3	50.7
Middle valve off	16.0	54.0
Head and tail valve off	17.7	26.0