UNIVERSITI PUTRA MALAYSIA

DESIGN OF IRRIGATION SYSTEM FOR ORTHOSIPHON STAMINEUS (MISAI KUCING) CULTIVATED UNDER SOLAR PV

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By

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APPROVAL SHEET

This project attached here to, entitled "**Design of Irrigation System for *Orthosiphon Stamineus* (Misai Kucing) Cultivated Under Solar PV**" prepared and submitted by **Ain Farhana Binti Mohd Yusoff** in partial fulfilment of the requirements for degree in the Bachelor of Agricultural & Biosystem Engineering (Hons.) is hereby accepted.

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ABSTRACT

Irrigation required a good efficiency for the design system to ensure that crops receive a good water distribution. Agricultural sector usually used lots of water in order to gain maximum production of crop yield compare to other sectors. The problem occurs when they plant crop in large area or not flat topographic. But for planting crop under solar PV the temperature and sunlight receive are different compare planting at open space or under shade. Also, the height of panel PV is 1.5m and cannot use sprinkler system to deliver water. Thus, there will be different of water consumption needed and the system might not be run efficiently. To solve this problem, drip system is being used. This is because the crop being planted under the solar PV and the water distribute directly to crop root. This system can reduce water consumption. A design of irrigation system for *Orthosiphon Stamineus* had been calculated from the beginning of system. It consists of the surface water, pump, mainline pipe, lateral pipes, filter (if needed) and several emitters. The design using a drip system to irrigate 4 plots provided an acceptable basis of proper water scheduling, evaluation of the system and minimizing water waste. It was designed for one specific crop which is *Orthosiphon Stamineus* and considered with irrigation interval of 2 days. The result show that system design capacity, Qs is 15.88L//min. The pump required for the operation of the system is approximately 1Hp which is enough to supply adequate water the crop. The design was trying to fit all the specification of drip system.

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CHAPTER 1

INTRODUCTION

1.1 Background

Irrigation is the synthetic utility of water to land for the motive of agricultural manufacturing. Effective irrigation will influence the whole boom process from seedbed guidance, germination, root increase, nutrient utilization, plant increase and regrowth, and yield.

The important thing to maximizing irrigation efforts is uniformity. The manufacturer has quite a few manipulate over how a great deal of water to supply and when to apply it, but the irrigation system determines uniformity. Identifying which irrigation systems is nice on the operation requires an information of the system, system layout, plant species, root level, root structure, soil composition, and land formation. Irrigation structures ought to encourage plant increase even as minimizing salt imbalances, leaf burns, soil erosion, and water loss. Losses of water will arise because of evaporation, wind flow, run-off and water (and nutrients) sinking deep under the foundation quarter. Proper irrigation control takes cautious attention and vigilant observation.

Orthosiphon stamineus belongs to the Lamiaceae circle of relatives and is typically known as "Misai Kucing" or "cats' whiskers" in Malaysia. This plant is a popular medicinal herb in South-East Asia. The tree can develop up to a top of 1.5 meters and is a tree that has many nutrients. The *Orthosiphon stamineus* are a flowering shrub and regularly planted as a decorative plant. Since its flower are bluish white with a long filament.

Orthosiphon stamineus can be planted throughout the year and nearly these kinds of plants may be used for medical purposes. It been recognized at the beginning of their ancestors and it is said to assist get rid of excess fluid especially from the joints. It also can take away and wash the blood from immoderate pollutants.

Goetzberger and Zastrow (1982) proposed a configuration of the solar photovoltaic power plant, which permits for additional agricultural use of the land. They proposed that if the collectors aren't installed directly at the floor, however, are extended by way of approximately 2 m above the ground with the periodic distance among collector rows of about three instances the peak of the collectors, one achieves almost uniform radiation, at the ground of a price of approximately two-thirds of the global radiation without solar collectors. They were the primary to suggest the concept of a dual use of arable land for solar strength manufacturing and plant cultivation in order to improve usual manufacturing. They have been addressing the ongoing dialogue at the opposition for using arable land among sun electricity manufacturing and crop. The light saturation point is the most variety of photons absorbable by means of a plant species. As extra photons received an increase to the fee of photosynthesis.

1.2 General Overview

The point of an irrigation system to guarantee the supportability of farming exercises especially in accomplishing sustenance security. Hence, the difficulties to expand the profitability in inundated horticulture including both innovative and administration mediations. Utilizing the cutting-edge water system innovations suitably are the way to beat this test. Appropriate preparing and upkeep are additionally required with the utilization of cutting-edge innovation. Progression of water system framework has been accounted for from numerous nations around the world. A few practices have been embraced locally and more are normal soon. Be that as it may, a commonplace framework is normally involved in admission, transport and appropriation, field water system, field seepage, and transfer framework.

1.3 Problem Statement

The ideal irrigation system is where the crop receives water that being distributed equally. The poor management of irrigation system results in improper water control system. It must be done in a reasonable time and require a human source to irrigate the water. The problem was getting harder because the crop growth under solar panel is different than being under shade or open place. This is because the temperature under it is different and receive low sunlight. It also being irrigated without proper management and cause water loss. The crop is grown in coco peat as media not on soil so the water holding capacity is different with soil. As the crop grown it requires different water requirement every day for each growth stage. Since *Orthosiphon stamineus* is a new crop that has not been commercial widely and using solar panel as shade, the information is still lack for a proper irrigation system.

1.4 Objective

1. To determine the value of crop water requirement.
2. To design drip irrigation system that suits for *Orthosiphon stamineus*.

1.5 Scope of The Study

1. The study area is at Engineering Faculty in UPM.
2. Daily data collection for 1 weeks.
3. Using data collection to determine crop water requirement.

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of Irrigation

Irrigation is a process of transferring water from a conveyance system of channels or pipes into the field for the purpose of agricultural production. Irrigation systems are designed to supply an adequate amount of water in a timely manner to plants. It is, of course, necessary to choose an irrigation system before design, equipment specification and installation. To do a proper selection, one must consider both the environment in which the irrigation system must function and to the capabilities and limitations of all potential irrigation system alternatives. Efficient irrigation systems have a great influence on the entire growth process of crops. It requires proper design and operation along with experience, science, and even some art.

2.2 Type of Irrigation

Water is commonly applied to crops by the surface, sprinkler, micro irrigation or sub-irrigation systems. Comparison of three major irrigation systems in relation to site and situation.

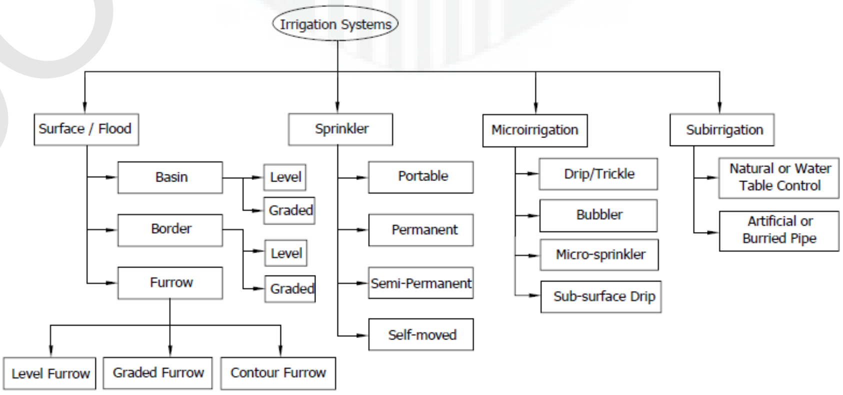


Figure 2.1: Irrigation system. Source from Kay M. (1986). Surface Irrigation, Equipment and practice.

2.2.1 Micro Irrigation

Micro irrigation systems are localized irrigation methods that slowly and repetitively distribute water uniformly to the plant root zone via emitters. It operates under low pressure with small-sized wetting patterns and low discharges. The systems ensure to apply water and fertilizer directly to individual plants or trees, reducing the wetted area by wetting only a fraction of the soil surface; thus, water is applied directly into the root zone. Some systems are capable of wetting only a fraction of the root zone while supplying adequate water to satisfy crop water requirements. Water discharge patterns differ because emission devices are designed for specific applications due to agronomic or requirements. Micro-irrigation saves water because of high application efficiency and water distribution uniformity.

Micro-irrigation is immensely popular because of its potential to increase yields and decrease water, fertilizer, and labour requirements if managed properly. It has gained more attention where water supply is limited and/or expensive. Systems are useful and suitable for sloping or irregularly shaped pieces of land that are impossible to flood, or sprinkler irrigate

Suitable Crops: Micro-irrigation is primarily suited only for high-value perennial crops, tree crops, fruits, vegetables and floriculture whereas almost all upland crops can be irrigated by micro irrigation systems. Application of micro irrigation for greenhouse, landscaping, and nurseries has also increased tremendously.

2.2.1.1 Drip or Trickle System

Drip irrigation or trickle irrigation is an irrigation method which minimizes the use of water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly into the root zone, through a network of valves, pipes, tubing, and emitters. Discharge rates are less than 12 liters per hour (L/hr) for widely spaced individual applicators and less than 12L/hr per meter for closely spaced outlets along a tube (or porous tubing). Micro irrigation systems are further classified into various categories in terms of installation method, emitter discharge rate, wetted soil surface area or the mode of operation. Arrangements of emitters on laterals determine the water distribution pattern in the soil.

1. Point source

Drippers are installed along the laterals at intervals to create a discrete wetted soil volume by each emitter without overlapping. This layout is suitable for orchard irrigation, trees and in widely spaced annual crops.

2. Line source

Drippers are installed closely along the lateral with overlapping of the wetted soil volumes by adjacent drippers. This layout is suitable for densely grown row crops.

Figure 2.2: Drip system

2.2.1.2 Subsurface Drip Irrigation

Subsurface drip irrigation (SDI), water is applied slowly below the soil surface through buried emitters, with discharge rates generally in the same range as drip irrigation. This method of application is not to be confused with sub-irrigation, in which the root zone is irrigated through water table control. SDI systems have gained wider acceptance since earlier problems of emitter clogging have been reduced and improved methods of installation have been developed. SDI is now being installed on small fruit and vegetable crops and field crops. Emitter outlets should be pointed upwards to avoid clogging. Maintenance requirements are like surface micro irrigation systems.

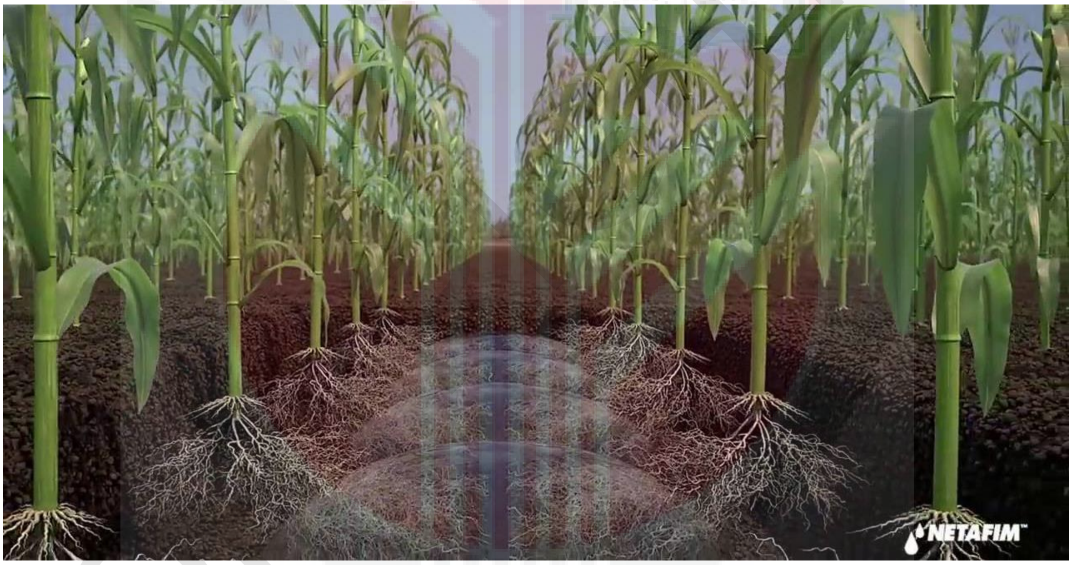


Figure 2.3: Subsurface Drip Irrigation (Netafim Irrigation,2017)

2.3 Coco Peat as media

Cocopeat is a suitable growing media with acceptable physical and chemical attributes such as pH, electrical conductivity, bulk density and others (Abad et al. 2002).

2.3.1 Available Water Holding

However, cocopeat has a very high-water holding capacity which causes poor aeration in the root zone. This will later affect the oxygen diffusion to the roots. Depending on the handling and processing technique, the physical properties of cocopeat can easily affect the air capacity and water retention (Abad et al. 2002). Incorporation of coarser material into cocopeat media will solve this problem and improve aeration (Yahya et al. 2009).

2.4 Misai Kucing Agronomy

Table below show the crop requirement for 1-hectare land. This include the crop distance from each other, fertilizer requirement, type of fertilizer and estimate yield.

Table 2.1: Crop Agronomy for 1ha. Source from 'Panduan Pertanian' by Jabatan Pertanian, 2006.

Crop distance (m)	Available crop	Fertilizer require	Time to fertilizer	Type of fertilizer	Total fertilizer (MT)	Growth stage (week)	Harvest time	Estimate yield (MT/y)
0.6 x 1.5	11,000	11,000	1 WB	Chicken dung	3-5mt	10-12	A whole year (harvest every 2-3 weeks)	30-40
			3 WA	8:8:8	500kg			
			6 WA	8:8:8	500kg			
			9 WA	8:8:8	500kg			
			12 WA	8:8:8	500kg			

*WA = Week after WB = Week before MT = Metric tan

2.5 Solar Photovoltaic

Photovoltaic (PV) solar run on daylight, however, water is required to take away dirt and dirt from the panels to make certain they perform at maximum performance. Water is also used to dampen the floor to prevent the construct-up and unfold of dust. plants planted beneath the solar panels might capture the runoff water used for cleansing the PV panels, therefore assisting to optimize the land. The flora' roots might also assist anchor the soil and their foliage could help lessen the potential of wind to kick up dust.

2.6 Power Generated

The consequences showed that the value of solar-generated electricity coupled to coloration-tolerant crop manufacturing created an over 30% growth in economic value from farms deploying agrivoltaic structures as opposed to conventional agriculture. utilizing shade tolerant plants enables crop yield losses to be minimized and hence preserve crop fee balance. similarly, this twin use of agricultural land may have a tremendous impact on countrywide PV production. (Harshavardhan Dinesh and Joshua M. Pearce,2016)

2.7 Agri-voltaic or Solar farming

Agri-voltaic system (AVS) has been proposed as a “mixed systems associating solar panels and crop at the same time on the same land area”. Considering the available land area between PV rows and wash out water from PV panels along with harvested rainwater from the panel, few crops which can be grown in the agrivoltaic system were screened based on their height, water requirement, and shade tolerance characteristics. (P. Santra et al.,2017)

2.7.1 Requirement of Land and Water

Sunlight based PV boards are by and largely introduced at settled tendency edge equivalent to the scope of the area for ideal saddling of sun-oriented light consistently. The arrangement may likewise be kept for a change of apex and azimuth edge of sun-based PV board apparatus to bridle more prominent measure of sunlight-based vitality considering the diurnal and occasional variety of sun-powered irradiance, yet the expense for establishment will be higher. All in all, 6-12 m spaces between two lines of PV exhibits are kept in ordinary sun-based power plants to maintain a strategic distance from the shadow of it on next line. Low tallness mounting structures are presently favoured due to minimal effort required for it with a space of 6 m between two rows. Two columns of sun based polycrystalline PV module of 200-250 Wp limit with vertical arrangement are proposed in the plan. The length of such PV cluster relies upon the number of PV modules associated in an arrangement. Ground leeway of 0.5 m is kept so trims developed in the middle of two lines of PV cluster infield can't make the shade over PV modules. Considering above trademark highlights of sunlight-based PV boards and their necessity for saddling sun-based vitality, the foundation of sun-based PV control plant requires around 2 ha arrive zone for every MW limit.

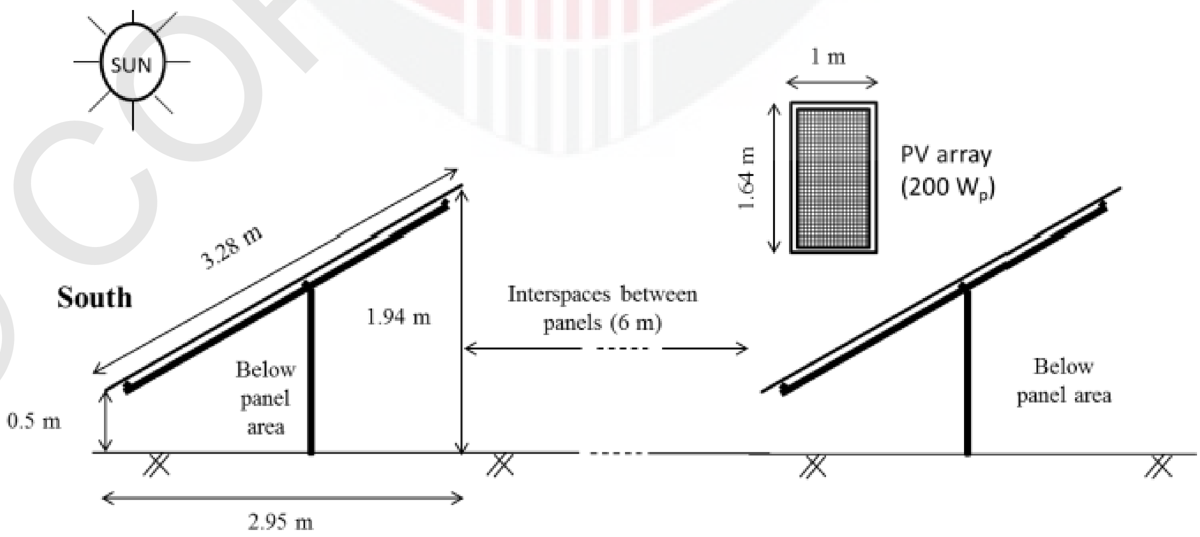


Figure 2.4: Basic design of solar PV installation in an agrivoltaic system

Also, the issues of residue affidavit on sun powered boards require customary washing with water, which is again a rare asset in the bone-dry locale. It was accounted for in writing that the measure of stored dust is higher amid summer periods in parched locale anyway its impact in lessening PV yield is more amid winter season in view of development of a sticky dusty layer on PV board top surface in the wake of blending with dew amid evening time (P.C.Pande,1992). From the field perceptions in a sun-based power plant at Jodhpur, it was noticed that to keep up PV age at practical level four times cleaning for every month is required amid summer season and two times amid winter, though for one-time cleaning around 20,000 litres of water is required per 0.5 MW square.

2.7.2 Crop Production Options in Agri-voltaic System

There is an accessibility of somewhat shaded space and repetitively accessible washout water in sunlight-based PV control plants, which can both be an outfit for developing products in the agrivoltaic framework. In a perfect world, crops for these destinations ought to be to such an extent that it isn't tall, ideally enduring (life cycle is over a year), spreading, and don't meddle in any capacity with the useful effect of the sun-oriented power plant. In a parched zone, incomplete or full shading fills in as a help by ceasing dissipation of water and decreasing transpiration misfortunes. Stature and separating of the boards may likewise be acclimated to develop diverse sort of products in an agrivoltaic framework.

PV board water wash will require to be collected in reasonably structured inclines as catchments with plastic or another fixed surface. Such water can be ponded, reused and appropriated through dribbles for water system reason. Considering field execution, edit stature, and water necessity, few yields and vegetables are screened as reasonable for development in the Agri-voltaic framework. Chosen yearly products require under 200-250 mm water in their life cycle with the goal that accessible unnerve water through precipitation, which is around 285 mm every year at the locale, might be utilized for developing these yields by effective water gathering framework. The greatest tallness of these yields amid its pinnacle vegetative development organize does not cross 0.75 m stature with the goal that the product shade on PV modules might be dodged. Maybe a couple of the chose products and vegetables are additionally shade cherishing or endure shade too some degree.

2.8 Crop Water Demand

Available Water (AW): Available water is the amount of water that a soil can store that is available for use by plants. It is the amount of water released between field capacity and a permanent wilting point within a crop root zone depth.

$AW = D_{rZ}\ (\theta fc - \theta wp)/100$

Where,

AW = available water (cm)

Drz = depth of root zone (cm) [Appendix 5.A]

θfc = field capacity in percent by volume (%)

θwp = permanent wilting point in percent by volume (%).

The soil sample is taken from undisturbed soils if possible and the moisture content is determined by drying in an oven at 105°C. The field capacity than can be determined by using:

$\Theta fc = (\text{Loss in weight}/\text{Final dry weight}) \times 100$

The available water or soil water storage can be also determined using:

$AW = D_{RZ} \times AWHC$

Where AWHC is the depth of available water per meter of the soil depth.

Soil Texture	Water Holding Capacity	
	Range (mm/m)	Average (mm/m)
1 Very coarse texture – very coarse sand	33 - 62	42
2 Coarse texture – coarse sands, fine sands and loamy sands	62 - 104	83
3 Moderately coarse texture – sandy loams	104 - 145	125
4 Medium texture – very fine sandy loams, loams and silt loams	125 - 192	167
5 Moderately fine texture – clay loams, silty clay loams and sandy clay loams	145 - 208	183
6 Fine texture – sandy clays, silty clays and clays	133 - 208	192
7 Peats and mucks	167 - 250	208

Table 2.2: Ranges in Available Water Holding Capacity (AWHC) of different Soil Textures. Source by Keller and Bliesner,1990.

2.9 Crop Evapotranspiration (ETc)

Crop water use is determined by the crop evapotranspiration (ETc), which is the amount of water a crop uses during a period. The determination of irrigation water demands, and irrigation schedules requires an accurate estimate of the crop water use rate. The major climatic factors that influence the crop water needs are sunshine, temperature, humidity and wind speed. Crop water use (ETc) is computed using the reference crop evapotranspiration (ETo) and a crop coefficient (Kc).

ETc =Kc x ETo

Where,

ETc = Crop evapotranspiration (consumptive water use), mm/day.

Kc = Crop coefficient.

ETo = Reference or potential crop evapotranspiration, mm/day.

2.9.1 Crop Coefficient (Kc)

When using the coefficients, it is important to know, how these were obtained. Appropriate crop coefficient values are provided (Doorenbos and Pruitt, 1977) to estimate the ET for specific crops. The following is an empirical relation between ETc and ETo:

$Kc = ET_C/ET_O$

2.9.2 Mathematical Models for Estimating ETo

Many investigators have developed the equations that are already established. The Penman-Monteith formula is considered the most precise which is recommended by the FAO and the USDA–Soil Conservation Service (Allen et al. 1998). Nevertheless, the Penman, Class A Pan Evaporation, Blaney-Criddle, and Hargreaves-Samani equations, can also be used. More reliable results can be obtained with local calibration for the given method.

2.9.3 Blaney-Criddle Method

Jensen, et al. (1990) found that the Blaney-Criddle method modified by Doorenbos and Pruitt (1997) was the most accurate temperature-based method evaluated for estimating crop ETo. They recommended individual calculation for each month. This method is not very accurate, and it provides a rough estimate. This technique is commonly referred to as the FAO-Blaney-Criddle method.

The equation is given as follows:

$ETo = C \times P \times (0.46 \times T + 8)$ (5.10)

Where,

ETo = Potential evapotranspiration (mm/day)

T = Monthly average temperature (°C)

P = Percentage daily sunshine (%)

C = Correction factor (0 to 0.40) which depends on the local climatic condition.

2.9.4 Penman-Monteith

The FAO Penman-Monteith method for prediction of Reference Crop Evapotranspiration (ETo) is the sole standard method (Allen et al. 1998). The FAO Penman-Monteith method requires radiation, air temperature, air humidity, and wind speed data.

2.9.5 Calibration of ETo for Local Conditions

Local calibration is always necessary to obtain reliable and good estimates of the crop water demands. The Penman-Monteith equation can provide accurate estimations from a month to an hour depending on the calibration method. For short periods, lysimeters can provide the necessary data for the crop evapotranspiration (ETc)

2.9.6 Pan Evaporation Method

Evaporation pans provide a measurement of the combined effect of temperature, humidity, wind speed and sunshine on the reference crop evapotranspiration ET_O. Many different types of evaporation pans are being used. The best-known pans are the Class A evaporation pan (circular pan) and the Sunken Colorado pan (square pan).

When using the evaporation pan to estimate the ET_O, in fact, a comparison is made between the evaporation from the water surface in the pan and the evapotranspiration of the standard grass. Of course, the water in the pan and the grass do not react in the same way to the climate. Therefore, a special coefficient is used (K pan) to relate one to the other.

CHAPTER 3

METHODOLOGY

Orthosiphon stamineus is one of plant that needs a lot of water in order to produce a good production of yield but now water is main factor in crop production. Drip system is used to help it gain a daily water balance.

3.1 Location of study

The picture below shows the location of study at Engineering Faculty in Universiti Putra Malaysia. There are about 8-10 plots of solar PV at there and only a few being used to cultivate plant under it.

There is one water source at there which is big pond. But for this study, the surface water that being used is rainwater that been harvested with solar PV also being used.

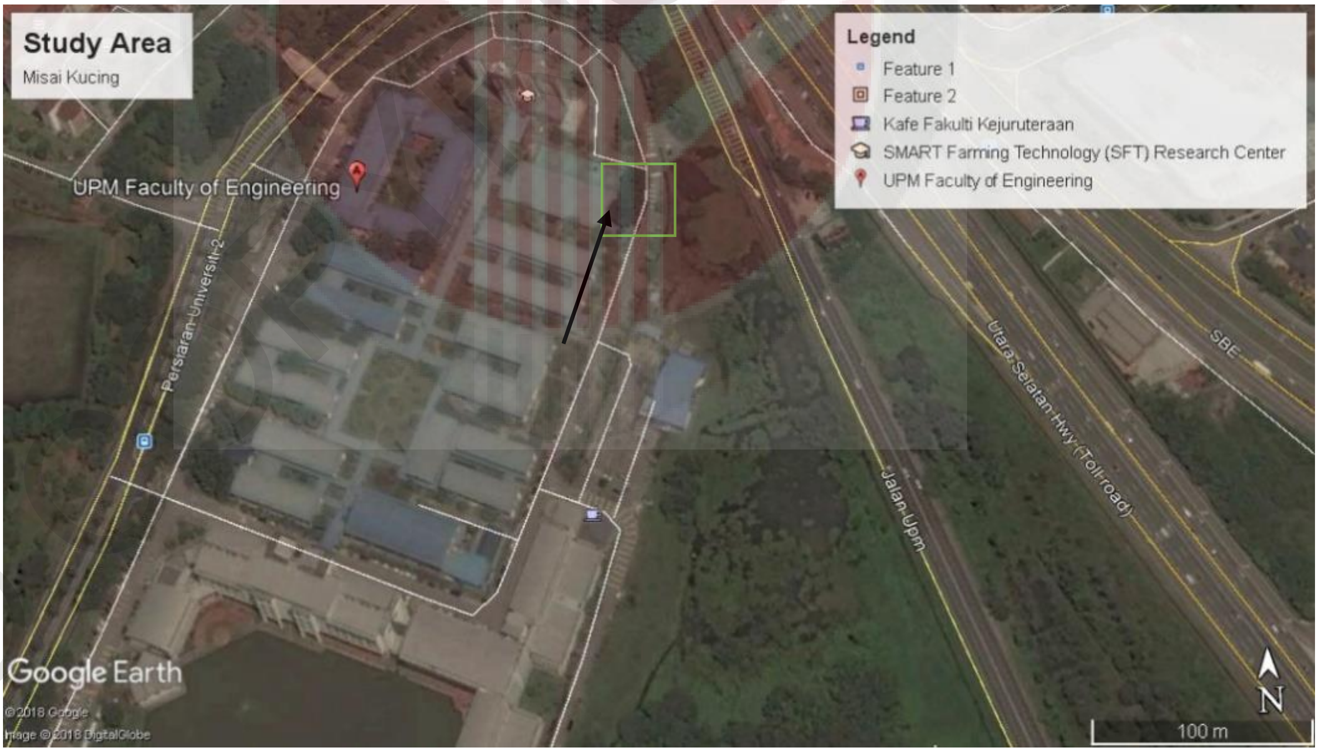


Figure 3.1: Study Layout

3.2 Layout of the crop under the solar panel

Orthosiphon stamineus crop that has been planted under the solar PV. It still under construction and only a few panels being install.

Figure 3.2: Agri-Photovoltaic panel

3.3 Method

3.3.1 Collection Data

From figure 3.1 below show the flow of work that use to as guide to collection data. It also shows which software to use for different method.

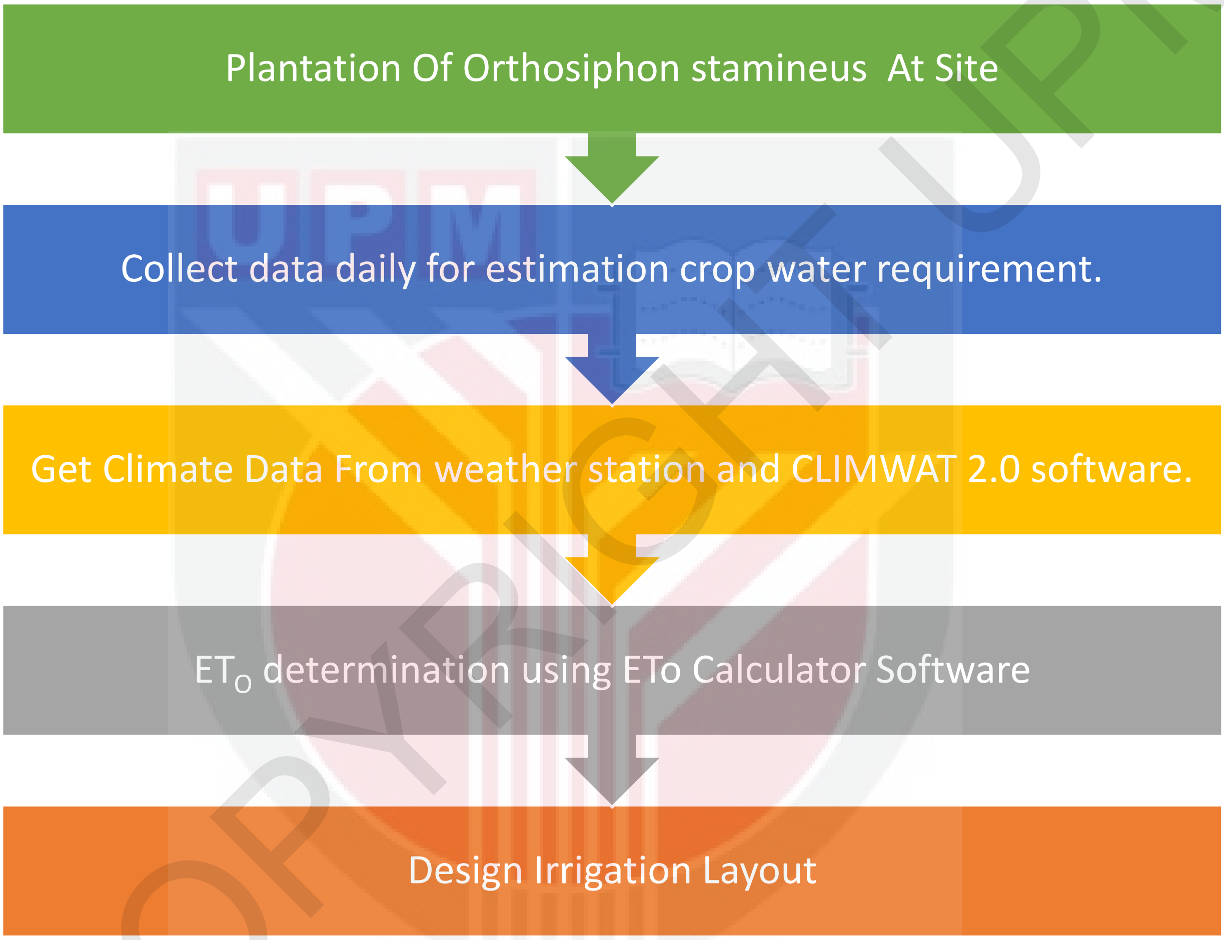


Figure 3.3: Workflow chart

3.3.2 Crop Water Requirement

Crop water requirement was determined by the crop evapotranspiration (ETc), which is the amount of water a crop uses during a period (mm/day). The determination of irrigation water demands, and irrigation schedules requires an accurate estimate of the crop water use rate. The major climatic factors that influence the crop water needs are sunshine, temperature, humidity and wind speed. Crop evapotranspiration (ETc) is computed using the reference crop evapotranspiration (ETo) and a crop coefficient (Kc).

3.3.2.1 ET_C Value

To get the value by using weighing method. 2 condition was chosen because to see the if differences of temperature will affect crop water requirement or not.

1. 12 sample of crop uses to determine the moisture content value.
2. 6 samples from each stage were grown under different condition (under shade and under solar PV).
3. The polybag was weighed every day before irrigating under the same water value, 500ml (usually 24 hours) and take temperature value. For example, each morning at 8 o'clock a measurement is taken.
4. After 24 hours, the polybag was measured.
5. The amount weight was calculated and get the value in mm/day.

3.3.2.2 ETo Value

CLIMWAT is a climatic database to be used in combination with the computer program and allows the calculation of crop water requirements, irrigation supply and irrigation scheduling for various crops for a range of climatological stations worldwide.

The data can be extracted for a single or multiple station in the format suitable for their use in. Two files are created for each selected station. The first file contains long-term monthly rainfall data [mm/month]. Additionally, effective rainfall is also included calculated and included in the same file. The second file consists of long-term monthly averages for the seven climatic parameters, mentioned above. This file only contains the coordinates and altitude of the location of main weather station of each city.

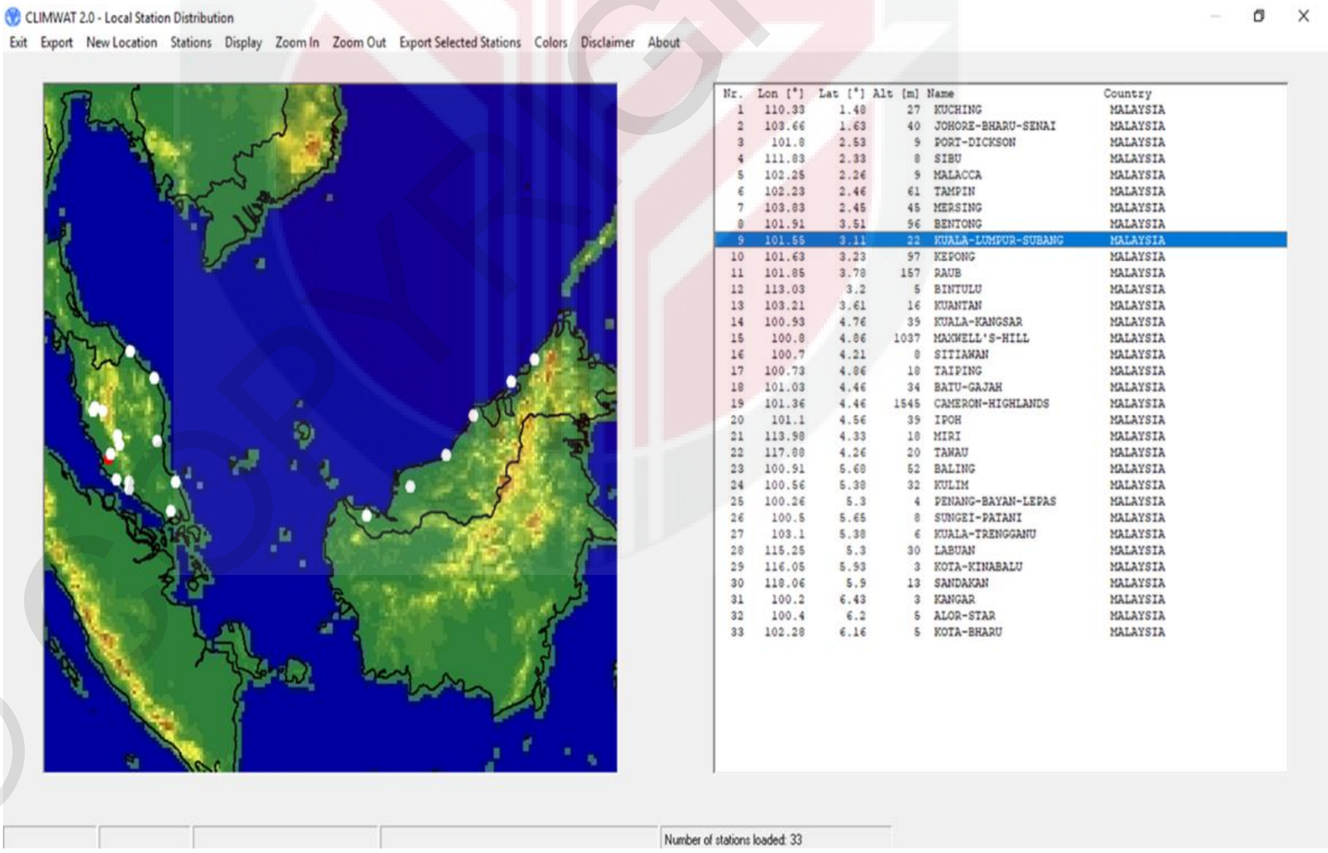


Figure 3.4: CLIMWAT 2.0

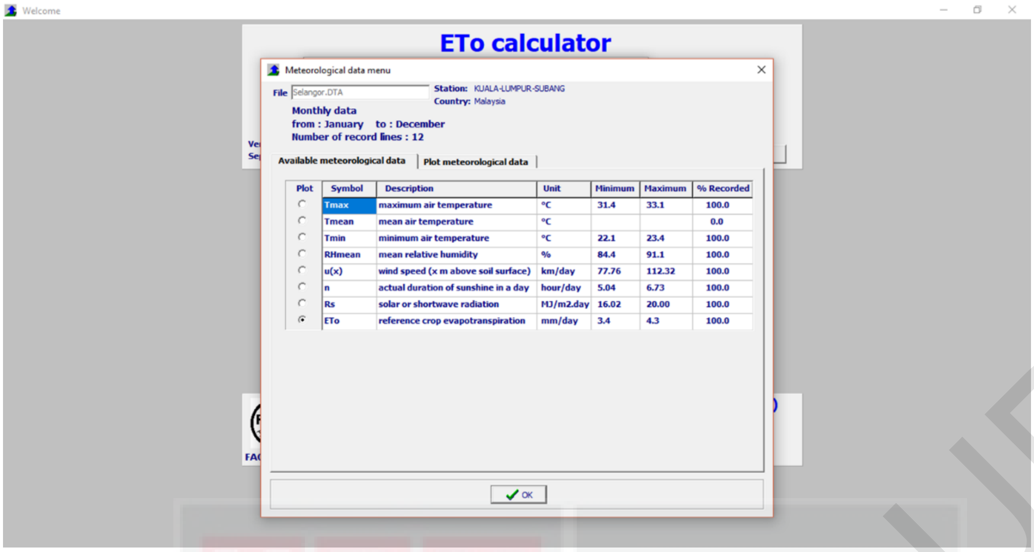


Figure 3.5: ETo Calculator

Based on data gain from CLIMWAT 2.0 from Kuala Lumpur-Selangor weather station, enter the data in ETo calculator to get the value for each month.

3.4 System Component

A micro irrigation system consists of emitters, distribution system, control and automation, filtration and pumping unit. The essential components are:

3.4.1 Emitter

Emitters are used to dissipate pressure and discharge water. They are placed along laterals which are designed for uniform water distribution. Emitters are operated under pressure to discharge water in the form of water jets by sprinklers, spray or mist by sprayers, continuous drops by drippers and small stream or fountain by bubblers.

3.4.2 Water Delivery or Distribution Networks

The water delivery system is a network of pipes and tubes used to convey water from source to the laterals. It can range in size from 10 mm to 150 mm in diameter. Water from the pump may be carried to the edge of the field by a single large main. Smaller submains may then carry the water to laterals and ultimately to the emitters.

3.4.3 Mainline

Mainlines supply water from the pump or other water source to sub mains. The mainline is usually constructed by PVC pipe which is usually buried beneath the soil surface for protection against harmful sunlight. The pipe should be properly rated for the application and able to withstand the design pressure in the system. The nominal working pressure must be higher than that of the drip lateral. The common working pressure of delivery and distribution lines is 60 – 80 m.

3.4.4 Lateral

Laterals are the smallest diameter pipelines of the system. They are fitted to the submains or manifolds perpendicularly at fixed positions laid along the plants rows and equipped with emitters at fixed frequent spacing. The lateral line is generally constructed of flexible polyvinyl chloride (PVC) or polyethylene hose (PE). It is often placed above the ground, but it can be buried.

3.4.5 Filter

Filtration is essential for successful operation of micro irrigation systems. The best possible irrigation system design using the best micro irrigation technology will have little chance of success without careful filtration and treatment of any contaminants that are present in the water. Filters remove sand and larger suspended particles before they enter the distribution network. The filters cannot remove dissolved minerals, bacteria and some algae.

3.4.6 Pump

Micro irrigation systems are typically designed to make the best use of the amount of water delivered. The selection of type and size of pump depends on the amount of water required, the desired pressure and the location of the pump relative to the distribution network. Electric power units or internal combustion engine driven pumps are equally adaptable. However, the electric power unit is preferred because it is easier to automate.

3.4.7 Water Source

Micro irrigation uses pressurized irrigation technology where water is delivered from the source by gravity and pumped or conveyed by the inbuilt pressure of the supply network. There are two alternative sources of water supply:

1. Direct withdrawal from an on-surface source (such as river, reservoir, pond) or from underground sources (such as a well).
2. Connection to a commercial, public or co-operative supply network.

3.5 Irrigation Design

The picture below shows a design that being consider using for this project. There will be a few modifications that need to be done so it suits with *Orthosiphon stamineus* crop and layout under PV.

Figure 3.6 Planting Arrangement

CHAPTER 4

RESULT AND DISCUSSION

4.1 Crop water requirement

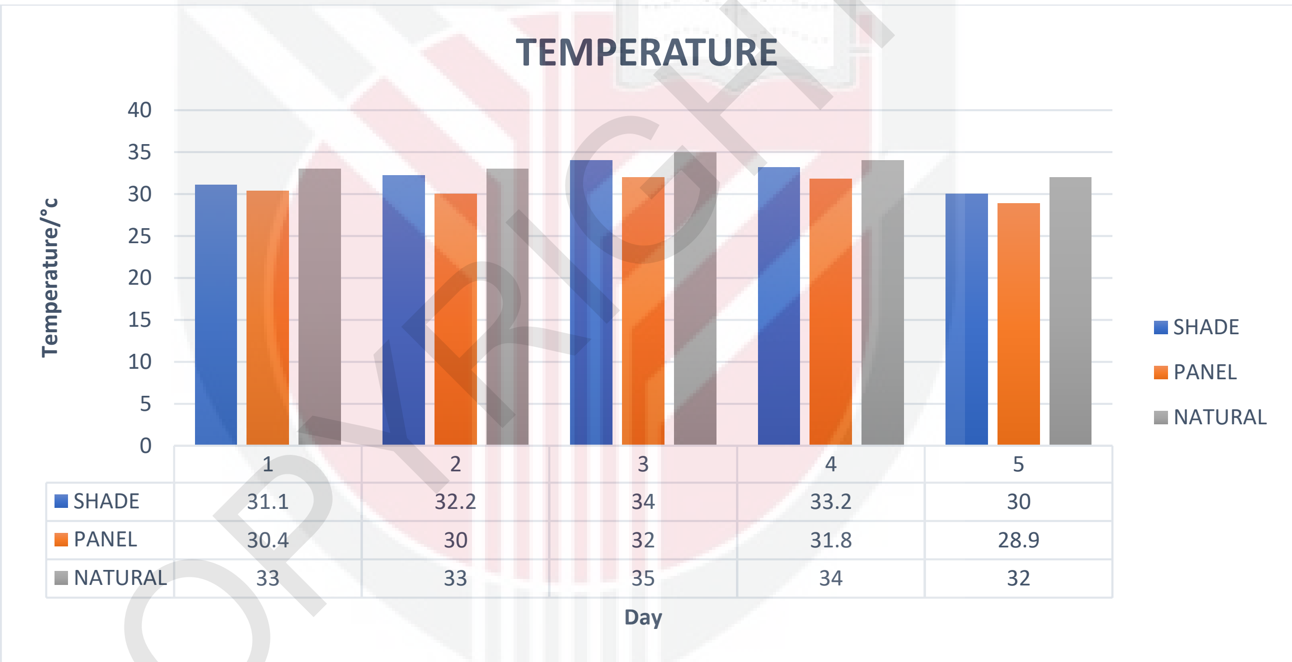
The total crop water requirement is 0.001283mm^3/day/plant, with a value of Etc 5.5 mm/day get from 5 days of collecting data.

CROP WATER REQUIREMENT

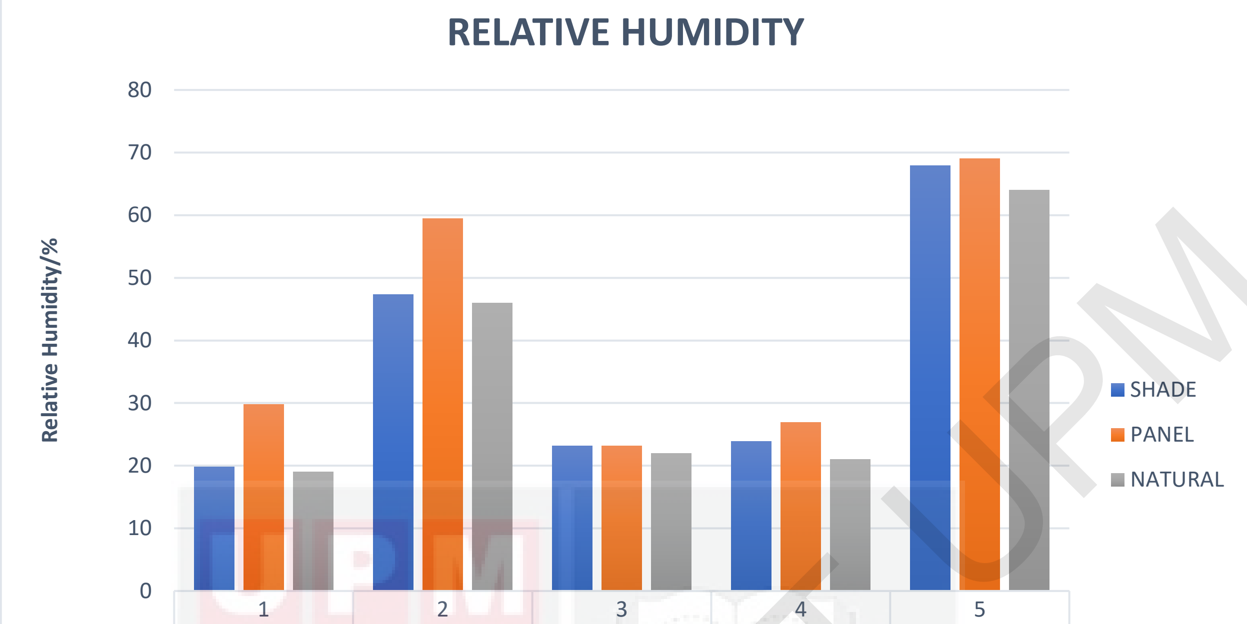
Crop Type	***Orthosiphon Stamineus* (Misai Kucing)**		
Area	5.6	m^2 per plot	
Plant Spacing	0.3x 0.3	(m x m)	
Total Number of Tree/Plants	62	per plot	
I. Area of Root Zone, Δza	24	**mm**	
Ii. Crop Coefficient, Kc	1.34		
Iii. Depth of Root Zone, Drz	300	mm	
I. Crop Evapotranspiration, ETc	5.5	mm/day	
Ii. Irrigation Efficiency	10%		
III. Reference Crop Evapotranspiration, ETo	4.1	mm/day	**Appendix 1**
Crop Water Requirement	**0.001283**	mm^3/day/plant	

Table 4.1 Crop Water Requirement

Generally, plants grow faster with increasing air temperatures up to a point. Extreme heat will slow growth and increase moisture loss. The temperatures for optimal growth vary with the type of plant. Some annual flowers and vegetables are extremely sensitive to cold, and transplants should not be planted until temperatures are consistently warm. Based on Graph 4.1 the temperature under shade higher than under panel PV. Day 3 record highest value of temperature 35 °C for natural (no tree area) and 34°C for under shade while temperature under panel PV only 32°C. Since the temperature is lowest it contains highest relative humidity compare other condition.



Graph 4.1 Temperature



Day	1	2	3	4	5
SHADE	19.8	47.3	23.2	23.9	67.9
PANEL	29.8	59.5	23.2	26.9	69
NATURAL	19	46	22	21	64

Graph 4.2 Relative Humidity

4.2 Drip irrigation system design

As a suitable spacing in order to ***Orthosiphon Stamineus*** to growth well, they need 0.3m x 0.3m area meter square. For 1 plot panel PV area the total number of plants can be planted is 62 plant. As for 4 plot there is 248 plants. Crop areas are divided into 4 plots consist of 5 plant row each. For 1 row, approximately about 12 can be planted to achieve a good product of yield. The PVC pipe are used to avoid rusting and can endure high pressure of water from pump.

The applied volume for a plant is 0.001283m^3 per hour. As calculated the time interval for the crop to be irrigate is 2 days. This show that the water consume can be reduce because this crop does not need to irrigate daily.

The drip system requirement shows in table below.

SYSTEM REQUIREMENT

Crop water requirement	0.001283	mm^3/day/plant
Time Interval	2	day
Number of drip Emitters	1	per polybag
Actual System Operation Time	0.083 @ 5 minutes	hr/day
System Design Capacity, Qs	15.88	L//min
Pump	1	Hp

Table 4.2 Drip System Requirement

A drip system, to suit the condition of ***Orthosiphon Stamineus***, this layout is specially designed in order to achieve high efficiency in its performance.

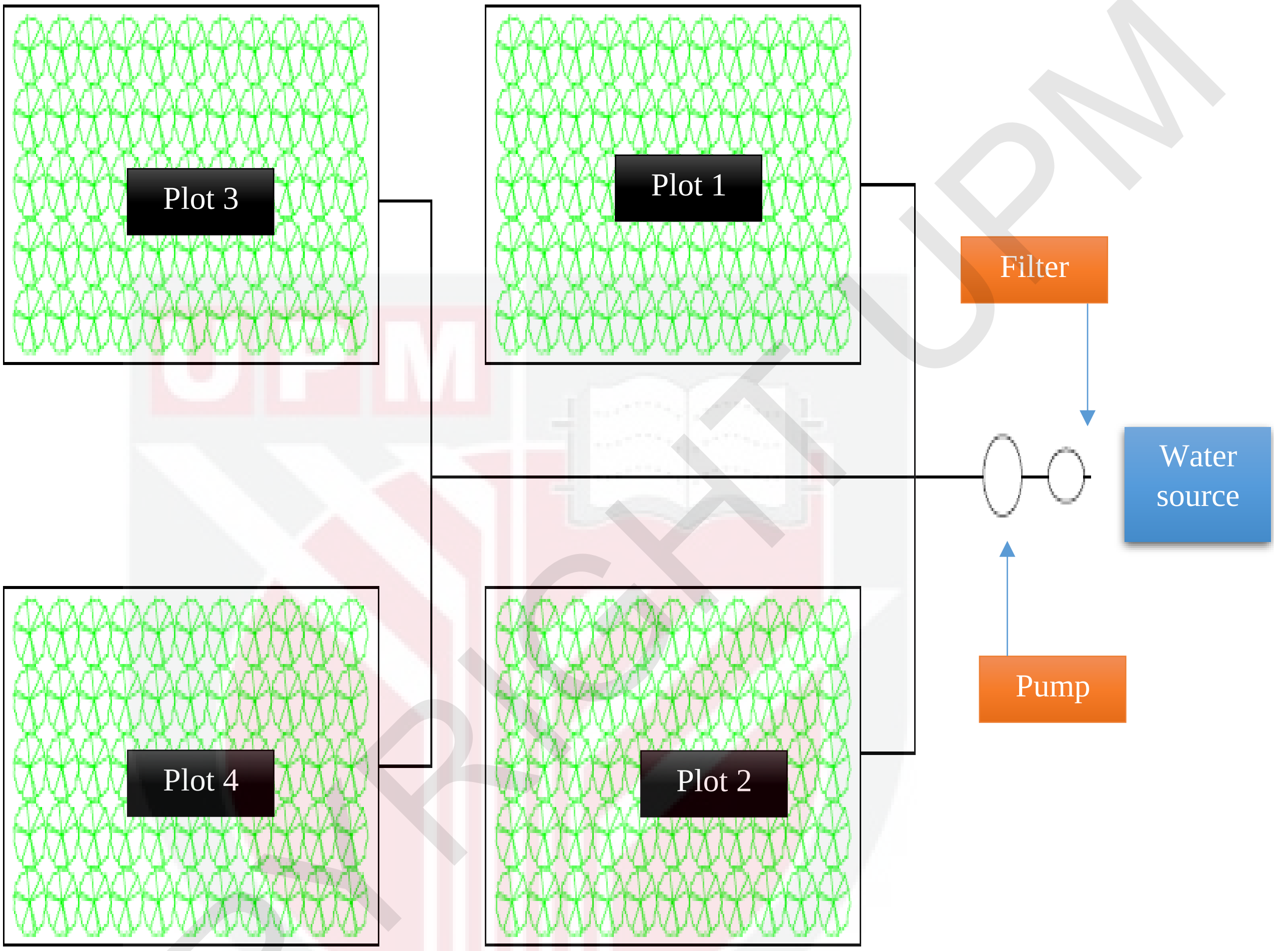


Figure 4.1 Layout for whole plot area

From Figure 4.4, 62 crops in polybag can cover the whole area underneath (3.5m X 1.6 m). By using nursery polybag with size 13inch x13 inch. This crop requires a close spacings (0.3m) because the closer the distance between the plant would further encourage the growth rate.

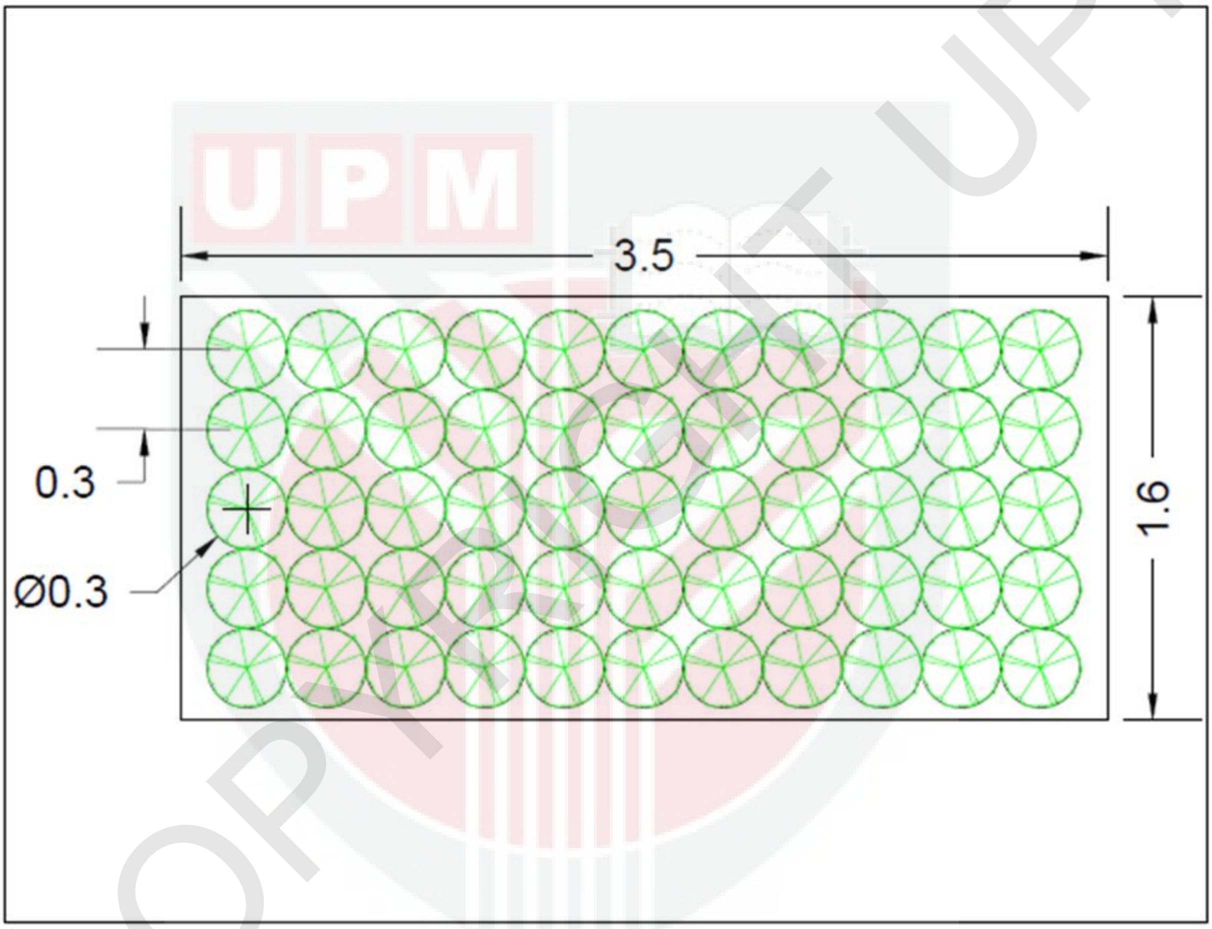


Figure 4.2 Layout under solar PV per plot

All crop divided into 5 rows because the number of lateral available after calculation of the number crop can be plant per row. One crop consist 1 emitter and it can irrigate the water directly to crop root via drip tubing.

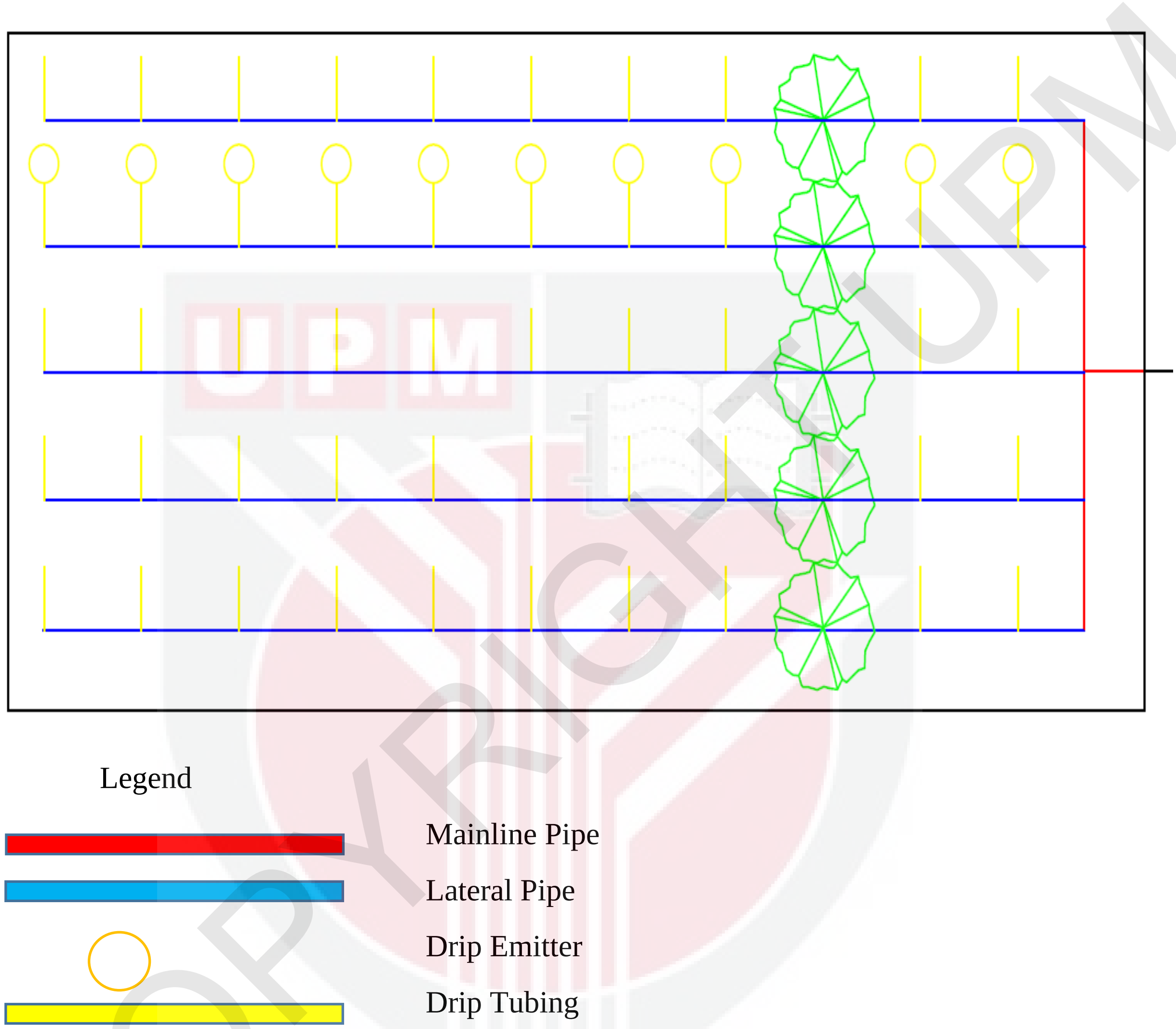


Figure 4.3 Layout of system component

CHAPTER 5

CONCLUSION

The results of study conducted show that more attention needs to be paid to distribute uniformity of an irrigation system. Drip system could be planed and managed well, in order to conserve water resources. The system should be evaluated on a regular basis no clogging occurs at an emitter to ensure that system is well maintained and performing according to design. The distribution uniformity of a system can ensures higher yields and the efficient application of water. It also including in the maintenance of panel PV to harvest more rainwater as water source.

This methodological approach and especially the result provide a guide by P. Santra (2017) for the future of irrigated agriculture to develop.

The using of tools such as CLIMWAT and ETo Calculator helped to design a complete drip irrigation system adaptable to crop under panel PV.

The final system works with a very low request of energy by pumping (power generate by panel PV) and only 1Hp of operating pressure. This performance increases substantially water saving in irrigation, therefore, allows extension of irrigated areas with the same resource and its sustainable use. The system also has the advantage of being designed entirely with irrigation facilities available in the study area, which makes its eventual implementation feasible and quite easy.

This design was made for the cultivation of ***Orthosiphon Stamineus,*** but the same approach might be applied to other crops on different agricultural fields.

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APPENDICES

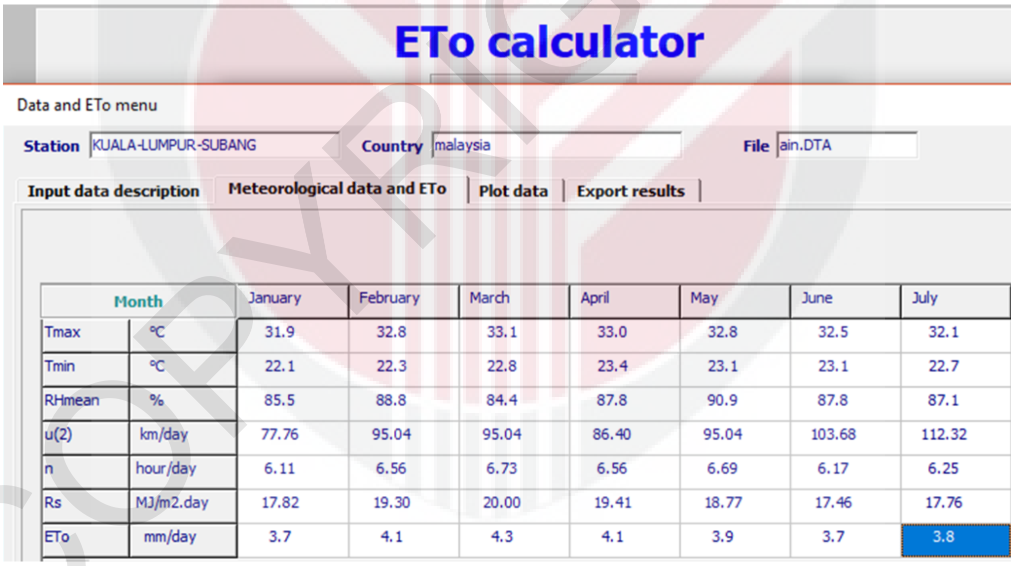
Appendix 1

ETo Value

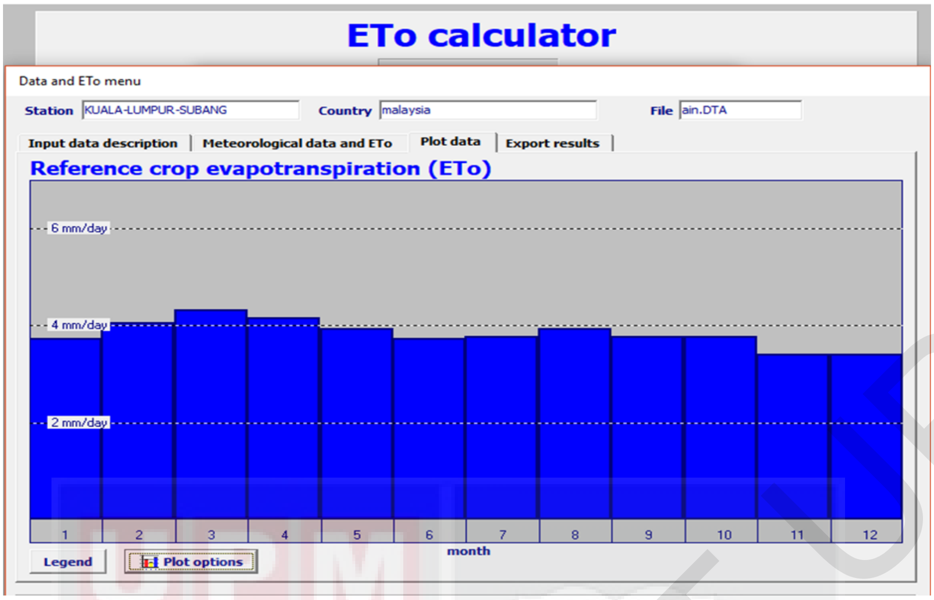
The data can be extracted from Kuala Lumpur-Subang since these two stations are main weather station. The Table 4.5 shows that monthly rainfall data [mm/month] for February is 4.1 mm/day. Additionally, the temperature and relative humidity also include in this data. The figure 4.1 below consists the estimated of long-term monthly averages for the seven climatic parameters for next month.

Month		February
Tmax	°C	32.8
Tmin	°C	22.3
RHmean	%	88.8
ETo	mm/day	4.1

Table: ETo based on ETo calculator



Month		January	February	March	April	May	June	July
Tmax	°C	31.9	32.8	33.1	33.0	32.8	32.5	32.1
Tmin	°C	22.1	22.3	22.8	23.4	23.1	23.1	22.7
RHmean	%	85.5	88.8	84.4	87.8	90.9	87.8	87.1
u(2)	km/day	77.76	95.04	95.04	86.40	95.04	103.68	112.32
n	hour/day	6.11	6.56	6.73	6.56	6.69	6.17	6.25
Rs	MJ/m2.day	17.82	19.30	20.00	19.41	18.77	17.46	17.76
ETo	mm/day	3.7	4.1	4.3	4.1	3.9	3.7	3.8



Appendix 2

System	overall efficiency (%)
Surface	
a) Average	
b) Land Levelling and Delivery Pipeline Meeting Design Standard	50-80
c) Tail water recovery with (b)	80
d) Combination level and graded flow irrigation (Max 0.1%	70
Grade and Block Ends)	80
e) Surge	
Sprinkler	55-75
Centre Pivot	55-75
Lepa	
a) Bubble Mode	95-98
b) Spray Mode	80-85
Drip	80-90

Typical overall On-Farm Efficiency for Various Types of Irrigation System (James,1988)

Types of Microirrigation Systems	Pressure (kPa)	Discharge Rates (L/hr)
Drip or Trickle Irrigation		
• Single-outlet point source emitters	100 ~103	< 12
• Line-source emitters	100 ~103	< 12 per m of strip
Subsurface Drip Irrigation (SDI)	100 ~103	7.5
Bubbler Irrigation	14 ~ 550	12 > Discharge > 250
Microsprinklers	50 ~ 250	< 175

Table Recommended Discharge Rates for Various Micro Irrigation System (Lamm et al. 2007)

Crop Coefficient, Kc

$Kc = ET_C/ET_O$

Crop Evapotranspiration, ETc = 5.5mm/day

Reference Crop Evapotranspiration, ETo = 4.1 mm/day

$$Kc = \frac{5.5}{4.1}$$

Kc = 1.34

Step 1: Plant Layout

Plant spacing = 0.3m x 0.3 m

No of plant row =5.6m^2/ 0.3m x 0.3m = 62 plant row

No of plant per row = 12

Step 2: Crop Water Requirement

Peak Misai Kucing water requirement/day is 5.5mm.

Thus 0.0055m x 5.6m^2=0.0308m^3/day/plant=0.001283m^3/hr/plant.

Effective soil water storage (ESWS)

AWHC x Drz x 50%

208 x 0.1 x 0.5 = 10.4mm

The water to be applied 2 times a day.

f_x=ESWS/ETo x Kc

10.4mm / (4.1 x 1.34) = 2 days (irrigation need to be applied every 2 days interval)

System Design Capacity, Qs

Qs = (K x ETc x A)/ (EI x HPD)

K = unit constant = 16667

EI = Irrigation efficiency =85% (refer appendix 2)

HPD = Actual System Operation Time, 0.083hr

Qs= (16667 x 12 x 0.00056)/ (0.85 x 0.083) = 15.88 L/min

Step 3: Emitter and Microtube Selection

Emitter type = pressure compensating arrow

Emitter flowrate =2 L/hr

No of emitter per bag = 1

Irrigation period = 0.083/hr/day

I_{time} = Cd/Emitter no. x $Q_{emitter}$

Microtube size= 4 mm internal diameter

Step 4: Lateral Line Sizing

Lateral flowrate = 12 plant x 1 emitter per plant x 0.083 L/hr = 0.996 L/hr (0.0002767L/s)

The lateral size choose = 16 mm diameter

Step 5: Manifold Design

Crop areas are divided into 4 sub-plots consist of 5 plant row each

Manifold flowrate = 12 plant x 1 emitter per plant x 0.083L/hr x 5 row = 4.98 L/hr (0.0013833L/s)

Select manifold diameter with flow velocity <1.5 m/s. The selected OD diameter is 60.3 mm.

Step 6: Mainline Design

a) The amount of water to be supplied = 12 plant x 1 emitter per plant x 0.083 L/hr x 62 plant row = 61.75 L/hr (0.0172L/s)

b) Select mainline diameter with flow velocity <1.5 m/s and head loss <0.2 m.

The selected OD diameter is 88.9 mm.

Step 7: Filtration System Design

The amount of water to be supplied as calculated above = 61.75 L/hr (0.0172 L/s). As preventive measure disc filter is recommended to be installed. The selected disc filter is 200 microns (80 mesh) with inlet size of 85 mm diameter and capacity 50,000 L/hr.

Step 8: Pump and Power Requirement

a) The system flowrate = 61.75 L/hr or 0.0172 L/s. The sub-unit can be irrigated simultaneously or in rotation.

Calculate the TDH.

TDH = Hs + He + Hf + Hp

Hs = static suction head (water level to pump) = 0.5 m (assumed)

He = static discharge head (pump to irrigation emitter) = 0.5 m (assumed)

Hf = friction head loss (in pipe, fitting, filter) = 0.966 + 3(0.455) = 2.331 m

Hp = pressure head required to operate emitter = 5.6 m

Calculated TDH = 8.931 m

Calculate waterpower WP

WP = (Q x TDH)/102

Q = Total pump discharge =0.0172 L/s L/s + 10% = 0.0189 L/hr

TDH = 8.931 m

Calculated WP = 0.001655 KW

Calculate brake horsepower BHP as follows:

BHP = WP/n

n = pump efficiency = 70%

Calculated BHP = 0.0024 KW ≈ (1 hp) since it can use to irrigate more crop if panel PV install more for future.