Drip irrigation system on Pakcoy (*Brassica rapa* subsp.) Based on Microcontroller in open land, Bolo District, Bima Regency

Ida Ayu Widhiantari[1,*] Joko Sumarsono[1] M Daniawan[1]

[1]*Study Program of Agricultural Engineering, Faculty of Food and Agroindustrial Technology, University of Mataram, Indonesia*
[*]*Corresponding author. Email: ida.ayuwidhiantari@unram.ac.id*

ABSTRACT
Dry land productivity can be increased by building irrigation networks, one of which is microcontroller-based drip irrigation. The purpose of this study was to determine the performance of the drip irrigation system on mustard pakcoy (*Brassica rapa* Subsp. *chinensis*) automatically using the Arduino uno (ATMega328) microcontroller, and to determine the response of mustard pakcoy to irrigation methods applied in open land. The method used in this study is an experimental method with an open field experiment with 12 pakcoy mustard plants. Parameters observed were soil texture, soil moisture content, soil temperature, humidity, and emitter uniformity. While the growth of pakcoy plants in the form of plant height and leaf area as a response. The setting point for the moisture content is the lower limit of 30.10% and the upper limit of 38.30%. The data on the average growth response of mustard pakcoy until day 30 were plant height of 17.29 cm and leaf area 106.14 cm^2 which shows that the use of microcontroller-based drip irrigation can be utilized to support the growth of pakcoy plants in terms of ensuring the availability of sufficient water for plants. plant.

Keywords: *Drip Irrigation, Microcontroller, Pakcoy plant.*

1. INTRODUCTION

Bima Regency is an area where the land condition is dry, the climate factor is the temperature of the area is high enough to be one of the main factors and also the availability of water is quite limited. The area of irrigated rice fields is quite large, namely 28,703 hectares, it is very unfortunate if it is not used properly for cultivation activities. One technique that can be done to increase the productivity of dry land is by building irrigation networks. Irrigation water drainage with conventional methods is not able to drain water quickly and precisely. Farmers are quite difficult if they have to monitor the condition of soil moisture every time [1]. The ideal water supply is the amount of water that can wet the soil throughout the root area to the state of field capacity. If water is given in excess, it will cause puddles in certain places which can interfere with soil aeration.

Drip irrigation is a method of providing water around plant roots and the soil surface directly, continuously, and slowly. The use of drip irrigation system results in water use efficiency of 80-95% [2]. The basic principle of drip irrigation is to pump and circulate water to the plants by means of pipes that are leaked at a certain distance according to the distance between plants. This gravity system delivers water slowly and accurately to the plant roots, drop by drop [3]. The drip irrigation system can provide high efficiency and effectiveness in meeting the water needs of plants. In addition, drip irrigation can be used on land that is not too large and can take advantage of minimal water resources [4]. Provision of water for the drip irrigation system is carried out by dripping water through pipes around plants or along plant lines. With this method, all added water can be absorbed quickly in conditions of low soil moisture [5].With the use of a drip irrigation system, control can be carried out from the time the water is flowed until the water is absorbed by the plants. With the use of this drip irrigation system, the evaporation process of plants can be reduced. In general, irrigation systems are very suitable to be applied to plants that are planted in a row and have a high economic value, so as to reduce the depreciation cost of drip irrigation equipment.

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The drip irrigation watering system has the advantage that it can regulate the time of giving water to plants so that the amount of water given to the plants can be according to their needs, so that plant growth can be optimal [6]. In addition, the use of drip irrigation in cultivation activities can save the use of water, labor, management costs, use of appropriate fertilizers, energy, can control pests and diseases in plants, and can be used for uneven and not too wide land [7].

Pakcoy is one of the most popular types of horticulture, so it is necessary to cultivate it to improve the quality and quantity of the product, one of which is by using effective and efficient watering techniques such as drip irrigation technology. In general, all types of plants require proper care, as well as pakcoy. If the water is cloudy, it can cause the growth of the pakcoy to be disturbed, and vice versa if the excess water is given it can cause the pakcoy to rot. The application of microcontroller-based drip irrigation in pakcoy cultivation is expected to increase productivity and water use in pakcoy cultivation can be more efficient.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in this research to make a drip irrigation system are mariotte tube, inch PVC pipe, emitter, araldite glue, PE hose connector, transparent hose, and 7 mm PE hose. The materials used to make the automation system are jumper cables, DHT22 (temperature and humidity sensor), Arduino uno, SDcard module, RTC module, servo, soil temperature sensor (DS18B20), soil moisture sensor, and rainbow cable. While the materials needed as research objects include pakcoy plants, soil, and water.

2.2. Methods

The research method used is an experimental method in the form of designing a series of soil moisture control systems in drip irrigation of pakcoy plants in open land. The parameters observed in this study included soil physical properties (soil texture and soil moisture content), soil temperature, air humidity, emitter uniformity, pressure height, and plant height). Soil moisture was measured using a soil moisture sensor. Soil moisture data is recorded and stored in the Data Logger every 1 hour for 30 days. Soil temperature was measured using the DS18B20 Sensor. Soil temperature values are recorded and stored in the Data Logger every 1 hour for 30 days. Air humidity is measured using the DHT22 Sensor. Soil moisture, soil temperature, and humidity values are recorded and stored in the Data Logger every 1 hour for 30 days. The calculation of emitter uniformity is done by determining the value of each emitter. Testing the emitter equation is by placing a container in each of the emitter holes. To determine whether the water supply through the emitter is uniform or not, which is given to the plants before being placed. Measurement of water output from each emitter was carried out for 60 seconds with 5 repetitions. The uniformity calculation can be done by equation 1.

$$EU = 100\% \left(\frac{\mathrm{qn}}{\mathrm{qa}}\right) \tag{1}$$

Description:
EU = Emission Uniformity (%)
qn = Lowest quarter average debit (liter/s)
qa = Overall average discharge (liter/s)

3. RESULTS AND DISCUSSION

3.1. Drip Irrigation Equipment Assembly

The system design consists of several 1/2 size PVC pipes, mariotte tube, 7 mm PE hose connector, 7 mm PE hose and emitter as a dropper. The pipe network of the drip irrigation system has an L pipe connection, a T pipe and a tap (valve). The main material that supports the drip irrigation network is a holding tank or mariotte tube. The reservoir used is a used jerry can with a capacity of 35 liters which serves to accommodate the water used as irrigation water. While the faucet used is used to open and close the flow of water to the dividing pipe, the faucet used is installed on the main pipe. From the main pipe flows to the sub main pipe and the main sub pipe to the lateral pipe. The emitter is installed from a PVC pipe through a PE connector and hose that serves to distribute water to the land or to plants.

3.2. Drip Irrigation System Test

From the test results, the EU value is 89.05%, which means this tool has good emitter uniformity and is suitable for use (ASAE). The area used in this study was 8 m^2 (4 x 2 m) with a plant distance of 30 cm. The drain hose is under pressure to produce a less rapid drop of water. The drip irrigation system is a system that uses tubes and drippers to deliver water at low pressure directly to the plant roots aiming to prevent plants from being waterlogged, the drip irrigation water supply will flow a drop. by drop at a very slow rate and retains the soil and air used by plant roots for healthy growth.

3.3. Program Language Creation

The first step in making the programming language is the installation of supporting software. The temperature and humidity controller programming language consists of 3 blocks, namely header, void loop, and void setup. The first block programming language is header. The header section is the section for writing definitions which are then used in the program, for example writing libraries and defining variables used in programs. void setup contains command codes to define the function on a pin. Not only that, variable initialization can also be done in this block. The void loop block is a block that will run the main program on the Arduino continuously (repeatedly) until the Arduino is turned off or reset.

3.4. Control System Working Principle

This drip irrigation automation control system works based on soil moisture, where the soil moisture value is obtained using the Soil Moisture Sensor SEN0308 planted at a distance of 7 cm from the plant and the emitter. The servo motor will rotate 0 (tap on) if the soil moisture value read by the sensor is ≥ 38.3% and the servo motor will rotate 90˚ (tap off) if the soil moisture value is ≤30.1%. This servo motor is connected directly to the faucet and the faucet is connected directly to the main pipe as a water channel from the tube to the emitter. The faucet will open (on) if the servo motor moves 0˚ and the faucet will be closed (off) if the servo motor moves 90˚.

3.5. Soil Texture

Based on the results of laboratory tests, the data obtained on the physical properties of the soil at the research site are as shown in Table 1:

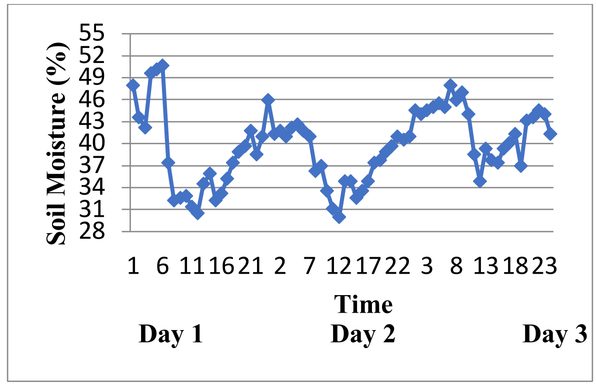

Figure 1 Soil moisture

Figure 1 shows a graph of soil moisture at the study site. From the graph, it can be seen that soil moisture is influenced by environmental conditions such as ambient temperature and plant activity. Plants need water to carry out life activities such as photosynthesis. Temperatures that tend to be high during the day cause higher evapotranspiration activity, causing the soil water content to decrease during the day. On the other hand, in the afternoon and evening, the humidity tends to increase and the air temperature is lower so that the soil moisture in the afternoon and evening is higher than during the day.

Table 1. Soil Texture

Fraction			Texture Class	Soil Properties
Clay	Dust	Sand		
33.80%	38.20%	28.00%	clayey clay (CL)	slightly rough, forming a ball that is somewhat firm (moist), forming rolls but crumbling easily, and a bit sticky

Source: Observation Results

Based on the results of laboratory tests, it was shown that the soil in the study area was classified as loamy soil with a composition of 33.80% clay, 38.20% silt, and 28.00% sand. The texture of clayey clay is characterized by a slightly rough taste, forming a rather firm (dry) ball, forming rolls but easily crushed, and moderately attached [8]. Clay and dust textured soils have a small size with a very large surface so that they are able to hold large amounts of water and the evaporation that occurs is low.

3.6. Soil Moisture

Soil moisture is also known as the water content (moisture) contained in the soil pores which is usually expressed in units of weight percent or volume percent. Soil moisture is influenced by several factors such as climate, organic matter content, irrigation water supply system, soil clay fraction, topography, and the presence of both organic and inorganic ground cover materials [9]. The soil moisture sensor is plugged into the soil at a distance of 7 cm from the plant and the emitter.

3.7. Soil Temperature

Similar to the soil moisture sensor, the soil temperature sensor (DS18B20) is placed at a distance of 7 cm from the plant and the emitter at a depth of 8 cm.

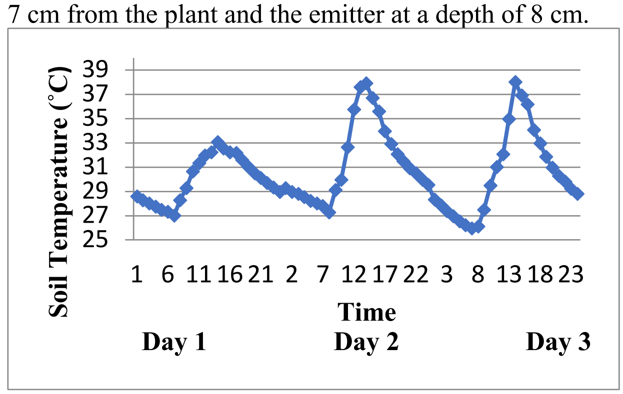

Figure 2 Soil temperature chart

Based on Figure 2, it can be seen that the soil temperature fluctuated, where the soil temperature during the day was higher than in the morning and at night. Soil temperature is influenced by the temperature of the surrounding environment, where the higher the ambient temperature, the higher the soil temperature, and vice versa, the lower the ambient temperature, the lower the soil temperature. The maximum heat absorption that occurs during the day causes high environmental temperatures, thus causing the soil temperature to also increase.

Table 2. Emitter uniformity value

Emitter	Value for each test (ml)					Average
	1	2	3	4	5	
A1	16	17	18	14.8	15	16.16
A2	15	15.5	17	18	16	16.3
A3	13.5	14	16.5	18	16	15.6
A4	16	16	16	16	17.5	16.3
A5	15.5	14	15.5	15	16.5	15.3
A6	17	16	18	15	17	16.6
B1	18	17.5	18	20	19	18.5
B2	19	18.5	18	18.5	17	18.2
B3	11.5	12	13.5	14	16	13.4
B4	14	13.5	15	14	16	14.5
B5	18	17	15	16.5	17	16.7
B6	15	14	14.5	15.3	16	14.96
qn (liter/s)						14.29
qa (liter/s)						16.04
EU (%)						89.05

3.8. Air Humidity

Air humidity is the amount of water vapor contained in the air or atmosphere [10]. Air humidity is one of the factors that affect soil moisture. When the air humidity is high, the water in the steam can be absorbed by the soil so that at night the soil experiences an increase in soil moisture. Changes in air humidity can be seen in Figure 3.

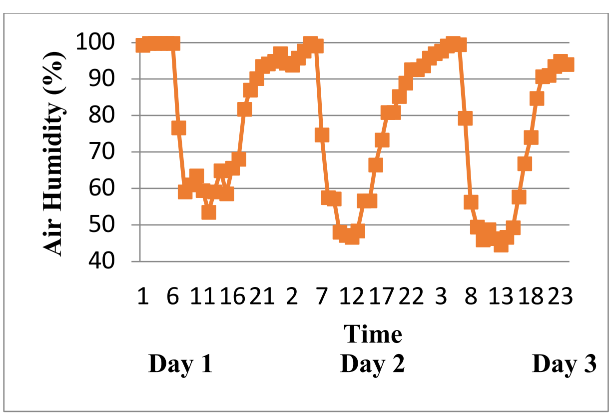

Figure 3 Humidity chart

Based on Graph 3, it can be seen that the humidity during the study fluctuated, the maximum humidity occurred at night and the minimum humidity occurred during the day. Temperature conditions greatly affect the humidity of the air, where the higher the air temperature, the lower the humidity and vice versa, the lower the temperature, the higher the humidity.

3.9. Emitter uniform

The emitter uniformity of the instrument used in this study is 89.05%, which means that this tool is included in the good criteria used, referring to the criteria according to ASAE that the emitter uniformity value which ranges from 85-90% is in the good category. The higher the emitter uniformity value of an irrigation device, the better the tool.

3.10. Plant height

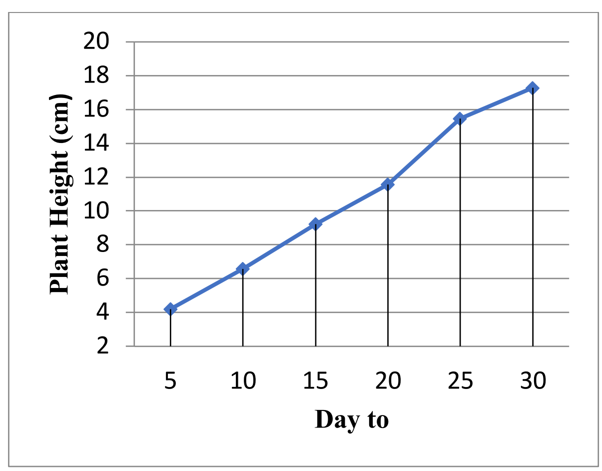

Figure 4 Plant height growth chart

Based on Figure 4, it can be seen that the plants with automatic irrigation until the 30th day had an increase, reaching a plant height of 17.29 cm. The increase in plant height was caused by the supply of water to the plants. This indicates that this drip irrigation device is successful and feasible to use. Provision of water with a drip irrigation system can increase the use value of water, water given in small amounts but consistent or in accordance with plant water needs per day can avoid percolation and the humidity of the growing media can be maintained optimally. If the planting medium becomes dry with the water content below the depletion limit, the plant will absorb less water so that it wilts and eventually will die. And vice versa, in planting media that contains a lot of water will cause poor soil aeration and unfavorable for root growth, as a result plant growth will be thin and stunted. With the use of a drip irrigation system, soil moisture can be maintained so that plant growth can be maximized [11].

3.11. leaf area

Measurement of total leaf area was carried out using the Easy Leaf Area Free android application. The results of observations of the total leaf area of the pakcoy plant in this study can be seen in Figure 5.

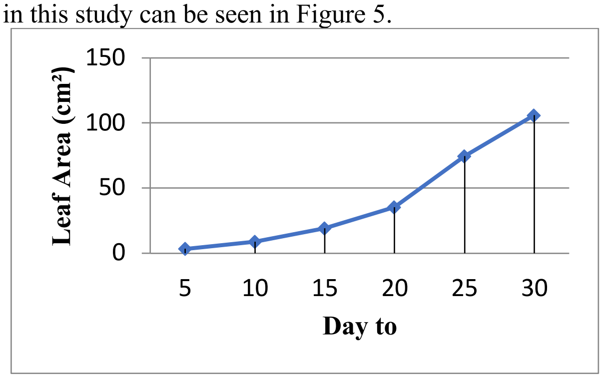

Figure 5 Total leaf area data

Based on Figure 5, it can be seen that the total leaf area increased with increasing planting age. The total leaf area until the data collection on the 30th day reached 106.14 cm². This shows that in terms of the total leaf area of the pakcoy plant, it can be seen that the use of microcontroller-based drip irrigation can be used to support plant growth, especially to ensure the availability of sufficient water for plants.

4. CONCLUSION

The microcontroller-based drip irrigation system that has been created can be used on dry clay types with a good emitter uniformity value of 89.05% with a good pakcoy plant growth response which includes an average plant height and leaf area for 30 days. i.e., 17.29 cm and 106.14 cm², respectively.

AUTHORS' CONTRIBUTIONS

Conceptualization: Joko Sumarsono., and M Daniawan.; Methodology: Ida Ayu Widhiantari., Joko Sumarsono., and M. Daniawan.; Validation: Ida Ayu Widhiantari., and Joko Sumarsono.; Formal analysis: Ida Ayu Widhiantari., Joko Sumarsono., and M. Daniawan.; Preparation of the original draft: Ida Ayu Widhiantari., and M Daniawan.; Writing-review and editing: Ida Ayu Widhiantari., and Joko Sumarsono

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