Precision agriculture: automated irrigation system in tandem with solar panels for melon farming cultivation

I S Nasution1, A A Munawar1*, Devianti1, P Satriyo1,2, H G Gunawan1, Y Yunus1,2

1Agricultural Engineering Department, Universitas Syiah Kuala, Jalan Tgk. Hasan Krueng Kalee 3, Darussalam-Banda Aceh 23111, Indonesia
2Agricultural Mechanization Research Center, Universitas Syiah Kuala, Indonesia

*Email: aamunawar@unsyiah.ac.id

Abstract. This present study aimed to design and apply an automated irrigation system powered by solar panels for melon farming cultivation. It related to precision agriculture practices from which benefited as an environmental friendly approach. This study was performed by designing irrigation systems, constructing solar panels as a power source for generating pump used to irrigate melon orchard. The results showed that those combinations setup were benefited to reduce manual irrigation system which is normally conducted by human efforts. Further, it also acted as an environmental friendly practice since the system is attempted to utilize solar energy as main power source for irrigation pump. Based on obtained results, it may conclude that abundance energy in our earth can be used for precision agriculture practices with the aim to reduce environmental pollution and waste.

1. Introduction
Irrigation is an important factor for increasing crop productivity for farmer. The production of agricultural products will decrease if the crop is under water stress. Irrigation becomes a necessity due to lack of supplying water to land. Siebert and Döll [1] estimate the average yield of grain crops with an irrigation system is 4.4 tonnes ha\(^{-1}\), whereas with a rainfed system it is 2.7 tonnes ha\(^{-1}\). A number of 42% of grain crops generally comes from irrigated land. Moreover, the number of production will decrease by 20% without an irrigation system.

Recently, irrigation water management which is equipped with an automatic control system has been developed. This system will improve plant growth, land productivity and water productivity, as well as an income for farmer groups. Bennis et al [2] proposed water irrigation by using wireless sensor network. Bolu et al [3] reported solar powered microcontroller-based for irrigation system with moisture sensor. Some of studies reported design, construction and installation of sprinkle irrigation in greenhouse [4], automatic sprinklers in prototyping greenhouse using smartphone based android [5], and a microcontroller is utilized for monitoring real time multiple sensors in greenhouse [6].

Utilization of solar power has been widely used by the wider community both for agricultural and non-agricultural purposes. Various trials and studies of solar powered automatic irrigation have been carried out with computer simulations to operate irrigation pumps based on soil moisture as control reference. Some studies have been use the simulation model which is implemented on a laboratory scale. Development of a solar powered irrigation system has been discussed by using automated SCADA controlled system [7]. Solar panel, submersible pumps, PV cells are used in producing energy, in which the moisture sensor and the pH level sensor are powered wirelessly [8]. Rahmawati
et al [9] studied a simulation of solar farm planning in Weh island Aceh, the highest energy output is 792.4 MWh which was produced in January, whereas the lowest energy output is 603.3 MWh which was produced in September. The aim of this study is to design and apply an automated irrigation system powered by solar panels for melon farming cultivation.

2. Materials and methods

2.1. Materials

Some of materials used in this study were Arduino Uno ATmega328P microcontroller, pump, 12 Volt DC batteries, inverter, relay, solar panel and solar charge controller, barrier terminal, soil moisture sensor, Real Time Clock (RTC) module, and micro SD.

2.2. Methods

The study was implemented in Ruyung village, Aceh Besar-Indonesia. The automatic control system is determined based on the set point value of the ground water content in the melons field. According to preliminary study in the field, the soil moisture was set 13.58% as the lower set point and 28.29% was set as upper set point. The microcontroller will give a signal to activate the relay to turn on the pump when the soil moisture condition is below 13.58%. On the other hand, the microcontroller will give a signal to activate the relay and move the pump is off, when the soil humidity is above 28.29%.

In the microcontroller block, RTC and micro SD modules were also installed so that they can record the data from the sensor reading along with the measurement time. The RTC and micro SD modules were installed on the 3 volt port, ground port, digital port 10, digital port 11, digital port 12, and digital port 13 found on the microcontroller.

Other circuits including an inverter as a DC to AC current converter used to operate an electric pump, a relay as an automatic switch to turn on or turn off the system, a barrier terminal, solar panels and a solar charge controller as a support system of solar power. A 12 batteries Volt is as a source of electric voltage that will be flowed through a relay to drive an electric pump motor which functions as an open and close the water flow that will flow to the irrigation. Solar panels work by converting heat energy from sunlight into electrical energy which is then stored in a battery.

2.3. Design of drip irrigation

Design of drip irrigation is shown in figure 1 below. The drip irrigation plan with the length of pipe is about 50 m. Each pipe will divided into 20 beds with the length of 22 m.

![Figure 1. Design of drip irrigation system](image-url)
3. Results and discussion
Installing the watering system automatically requires power from electrical energy to drive the pump in the water distribution. The temperature in the location is in the range of 32-34°C between 11:00 to 16:00 o'clock. Therefore, the location has the potential to absorb electrical energy through introduction of automatic watering technology with solar panel energy.

![Figure 2. Installation of solar panel in melon farming](image)

This design aims to obtain watering efficiency in economic point of view. The watering efficiency is calculated based on the major and minor head losses according to smaller values, obtained by simulation. Head loss is influenced by the height of the reservoir, and the number of elbow which depends on the number of joints. Drip irrigation design also depends on the main pipe and main line.

In addition to the height of the water reservoir, the quality of water will also affect the performance of drip irrigation. If the water is cloudy, it will be blockages in the main line pipe, so that a filter is needed, as shown in Figure 3.

![Figure 3. Installation of filter pipe](image)

The height of the water reservoir is 3 meters. The watering system was calculated efficiently in order to reach each bed uniformly without using a pump. Based on this, it is necessary to make groups with the aim that when the water level in the reservoir decreases. It is necessary to distribute of water uniformly for each plant in the beds. There are five groups, where each group has four beds or four drip lines as shown in Figure 4.
Figure 4. Installation of drip lines for melon farming

Figure 4 shows drip irrigation consisting of manifold pipes (main) of PVC material, where the manifold pipe is divided into five groups, where in one group there are main line pipes (drip line), so that there are twenty planting beds or drip lines. The uniform distribution of water to the plants is very important for the growth of melon plants. In order to avoid uneven water distribution, then a pump with a higher power is installed in the installation section. The pump that has been installed in the irrigation installation can be seen in Figure 5. Installation of the pump is intended if there is a decrease in the reservoir tube. The solar cell used as a power of the pump during water distribution.

Figure 5. Water pump installation

Installation of the entire series of drip irrigation has been carried out, and it has been tested by turning on the pump and the entire main line installed on each raised bed, meaning that the water performance has been running according to the design plan. The last thing after testing is the installation of the main line pipe on each bed. The main line pipe has water droplets with a distance of 20 cm.

After the main line pipe is exposed to each bed, it is followed by testing water discharge. The test results showed that the uniformity of droplets in each bed was 98%. The time required for watering 20 beds is 15 minutes. Before using this system, the farmers (1 worker) need 2 hours for watering the 20 beds, however, by using our system it takes only 15 minutes without a worker.
4. Conclusions
The automated irrigation is powered by solar panel is successful installled in the Ruyung village, Aceh Besar-Indonesia. The advantage of this system is able to watering the plant for 15 minutes without a worker in the area of 50 m x 22 m. The solar panel is able to support energy for pumping the water to the field area.

Acknowledgments
The authors gratefully acknowledge the Institute of Research and Community Services (LPPM) Syiah Kuala University-Indonesia for financial support in the year of 2020.

References
[1] Siebert S and Döll P 2010 Quantifying blue and green virtual water contents in global crop production as well as potential production losses without irrigation J. Hydrol. 384 198–217
[2] Bennis I, Foucal H, Zytoune O and Aboutajdine D 2015 Drip irrigation system using wireless sensor networks Proc. 2015 Fed. Conf. Comput. Sci. Inf. Syst. FedCSIS 2015 1297–302
[3] Bolu C A, Azeta J, Alele F, Daranijo E O, Onyeubani P and Abioye A A 2019 Solar Powered Microcontroller-based Automated Irrigation System with Moisture Sensors Journal of Physics: Conference Series vol 1378 (Institute of Physics Publishing) p 032003
[4] Zakari M D, Tadda M A, Maina M M, Abubakar M S and Lawan I 2013 Design, Construction and Installation of Localized Drip Irrigation System African J. Eng. Reseach Dev. 6 39–47
[5] Nasution I S, Iskandar M R and Jayanti D S 2020 Internet of things: automatic sprinklers in prototyping greenhouse using smartphone based android IOP Conf. Ser. Earth Environ. Sci. 425 012069
[6] Ichwana, Nasution I S, Sundari S and Rifky N 2020 Data Acquisition of Multiple Sensors in Greenhouse Using Arduino Platform IOP Conf. Ser. Earth Environ. Sci. 515
[7] Abdelkerim A I, Eusuf M M R S, Salami M J E, Aibinu A and Eusuf M A 2013 Development of solar powered irrigation system IOP Conf. Ser. Mater. Sci. Eng. 53
[8] Durai C R B, Vipulan B, Khan T A and Prakash T S R 2018 Solar powered automatic irrigation system Proceedings of the International Conference on Power, Energy, Control and Transmission Systems, ICPECTS 2018 (Institute of Electrical and Electronics Engineers Inc.) pp 139–42
[9] Rahmawati S, Iqbal M and Sara I D 2019 Energy analysis of solar farm planning in weh island, aceh, indonesia IOP Conf. Ser. Mater. Sci. Eng. 539