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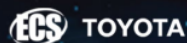
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Time based automatic system of drip and sprinkler irrigation for horticulture cultivation on coastal area

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Abstract. This paper presents a compact and simple automated irrigation based on supplying time to use the energy and water optimally according to the needs of plants in coastal-sandy land. Namely RTC-DS1302, Arduino Mega-2560, and AC or DC pumps as timing sensor, control processing unit, and irrigation actuator respectively, were employed in this study. The system also works for automated water filling inside the reservoir. Automated irrigation of drip and sprinkler were applied, powered by solar system for onion (*Allium cepa* L.) and cabbage flower (*Brassica oleracea* var. *botrytis* L.) cultivation at coastal area of Banjarsari Village, Cilacap, Central Java, Indonesia. As the result, applied system was able to supply water continuously to the plants on adjusted time (07:00, 11:00, and 17:00, for 15 minutes respectively).

1. Introduction

The utilization of marginal land in coastal areas, sandy land, for horticulture cultivations has strategic potential in overcoming the problem of shrinking agricultural land. Around Jenderal Sudirman University, there are still many marginal areas in the form of sand land that has not been optimally utilized in the southern coastal areas, such as at Ketapang Banjarsari Village, Nusawungu District, Cilacap Regency, Central Java, Indonesia.

The land area in Banjarsari village consists of 55% rice field land, 40% of residential and yard lands, and 5% of coastal land [1]. The yard and coastal areas are not yet utilized optimally since the insufficient knowledge and technology skilled by farmers which support horticulture cultivation in sand fields. Farmers are faced with heavy operation, labor availability, and high operational costs to cultivate on sand land of coastal area due to unfriendly environment and hard soil properties. Land in coastal areas is greatly affected by climate and weather.

One costly activity in coastal agriculture is irrigation, providing sufficient water to crops. Irrigation in agriculture is one of the main tasks. It is highly essential to water the crops as per their need. Very less watering or too much watering can damage the crops. In present irrigation system, a farmer cannot check the moisture level of soil. Conventional irrigation system employs manpower and consume much fuel, and given in unequal time and amount. Hence often it may happen that the watering is more than the need of the crop and sometimes water doesn't reach up to the roots of the plants. This



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will waste the water and efforts. If water doesn't reach up to the plants roots then it will directly affect the plant growth and profit. It is necessary to avoid the unnecessary (excess) or less supplying of water in the field so as to make cultivation more profitable. Automated irrigation aims to manage usage of water efficiently and effectively in order to grow the plant optimally [2].

Land in coastal areas is greatly affected by climate and weather, like at Banjarsari, Nusawungu, Cilacap Regency, Central Java, Indonesia. Uncertain and rapid change of climate often occur there. The intensity of rainfall is around 47.3 mm/day and the intensity of sun is around 109.960 lux[3]. In certain months (known as transition period) the air temperature and soil temperature are very high (respectively 39°C and 44°C) and low air humidity 36%[3]. In addition, the physical properties of sand that have very high percolation of 209 mm/day and low water holding capacity require farmers in the coastal area to maintain water availability on the land through very intensive watering of plants, i.e. at least 3 times a day so that plants can grow well. In addition, farmers also need to frequently monitor and do more intensive watering than usual the condition of soil moisture. It causes watering dominates the cost of horticulture cultivation in coastal sand.

The conventional method of giving water using a watering can is very ineffective and inefficient for a large area of land. It greatly limits the ability of a farmer to manage a wider area of land. While the use of water pumps directly (without reservoirs) makes the pump, engine turn on-off frequently which may cause high costs and damage to the pump. The amount and pressure of water that will be given is also difficult to measure, which if too large can cause damage to the plant. So that the water reservoir in the reservoir is needed to make more efficient use of water. The application of water supply automation technology is expected to increase farmer's business capacity as well as water utilization efficiency.

The lack of knowledge on irrigation technologies together with the properties of water dynamics of the sandy soils which has low water holding capacity, makes optimization of irrigation scheduling criteria become critical issue for improve production efficiency (i.e. time set-points for triggering irrigation and optimal duration of irrigation pulses). Based on this, the main objectives of the work were to design time-based irrigation scheduling criteria adjusted for sandy soils, and to assess the automatic irrigation system performance.

2. Design of time-based automatic system of drip and sprinkler irrigation

The application of drip and sprinkler irrigations are carried out on the cultivation of onions and flower cabbage on sandy land in the coastal area. We tested two kinds of pumps that depend on the type of irrigation, namely the Alternating Current (AC) pump for high pressure sprinklers and Direct Current (DC) pumps for small pressure sprinkler and drip irrigation.

Figure 1 shows a diagram of an automatic watering system on plants based on the supplying time for drip and sprinkler irrigations. The main part of the automatic system is Real Time Clock (RTC) DS-1302 and Arduino minimum system, which integrated with other supported components such as LCD viewer and indicator, actuator unit, and AC pump and DC pump. We add sensor of water level for water reservoir which is simple, low-cost, self-made water detection sensor. The Arduino Uno minimum system is compact enough to be used as a control center.

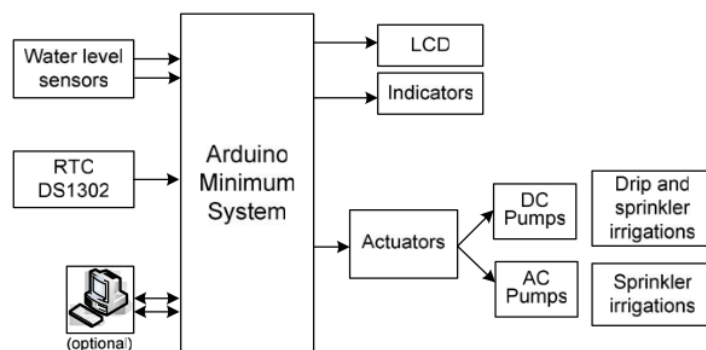


Figure 1. Diagram of automatic system of drip and sprinkler irrigation based on time of supplying to plant.

The implementation of drip and sprinkler irrigation is on the cultivation of onions and flower cabbage. The watering is scheduled to supply plants automatically on three periods, namely at on 07:00, 11:00, and 17:00, for 15 minutes respectively. The automatic system and pumps of irrigation are powered and actuated by 800 watt solar-wind system, comprises of 400 Watt solar and 400 Watt wind system. Figure 2 shows the application diagram of watering system for cultivation of onion and cabbage on sandy soil at coastal area using sprinkler and drip irrigation technique.

Experimental was done in sandy soil, located in Banjarsari village, Nusawungu, Cilacap Regency, Central Java Indonesia. The study was conducted during 6 months, from June to September 2018. The land used is around 1200 m² which is only 100 meters from the side of beach. Cultivation of onions and cabbage is carried out by applying optimum nutrient management for each plant. It is implemented optimum parameters of cultivation that can be applied to demonstration plots include [3–5]:

- Size of land plots of onions is (1x2) m².
- Size of land plots of flower cabbage is (2x4) m².
- Utilization of manure soil enhancers and utisol soil to overcome percolation of sand soil and suppress run-off.
- Use of straw mulch.
- Treatment of nitrogen fertilizer and POC fertilizer.
- Dosage of manure is 20 tons / ha.

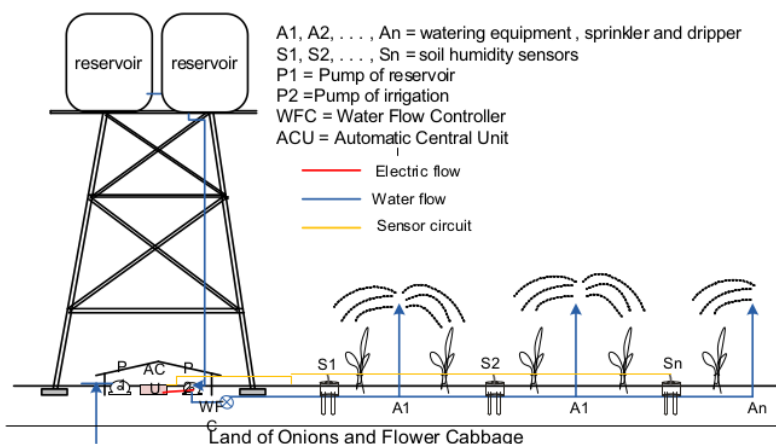


Figure 2. Application of Automatic watering system for cultivation of onion and cabbage on sandy soil at coastal area.

3. Results and discussions

We utilized and configured minimum system of Arduino-Uno optimally, by using almost all available pins for automatic application of watering based on scheduling time to trigger the irrigation equipment at desired time and optimum duration for onions and cabbage cultivation. We built the automatic time-based watering system together with soil humidity-based watering system. The picture of built system and the algorithm of the system put into the minimum system are shown in Figure 3 and Figure 4 respectively.

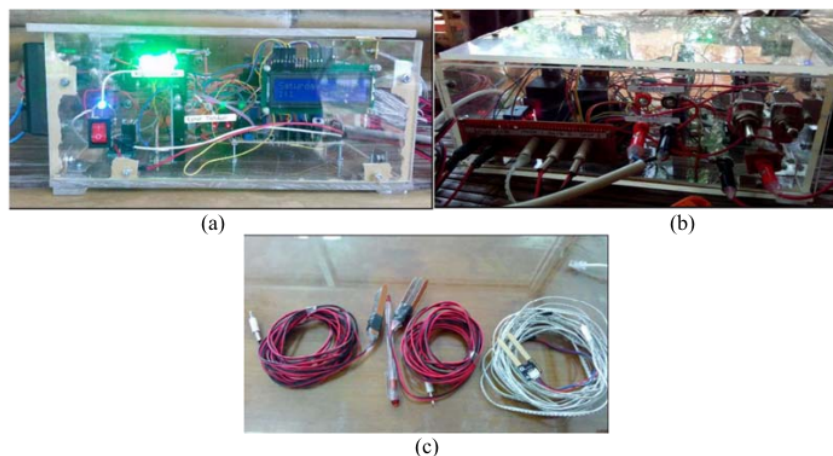


Figure 3. The hardware of watering control system: (a) front view, (b) back view, and (c) the sensors.

The flowchart of system is depicted in Figure 4 and the principle works of the system is as follow:

- The system takes actual day, date and hour data from the RTC-DS1302 and displays it on the LCD screen. Actual HOURS AND MINUTES data stored.
- The system reads the soil conditions of the three soil moisture sensors and stores their values.
- The system compares the actual hours with the hour SET used when giving water. In this study the time of giving water is every 07:00, 11:00 and 17:00.
- When the actual hour shows the value 07:00 or 11:00 and 17:00 there will be two conditions, namely:
 - If the three soil moisture sensors show digital value above 800 (meaning the ground is dry), the irrigation pump LED indicator will light up and the LCD displays "Watering Time" and "Dry Soil". Time pump will be switch ON for 15 minutes.
 - If all three soil moisture sensors show digital value below 400 (meaning that the soil is very wet, such as after rain), the irrigation pump LED indicator does not light up and the LCD displays "Watering Time" and "Wet Soil". This condition may occur when or after raining.
- Besides 07:00, 11:00 and 17:00, the system keeps reading the data on the condition of soil moisture.

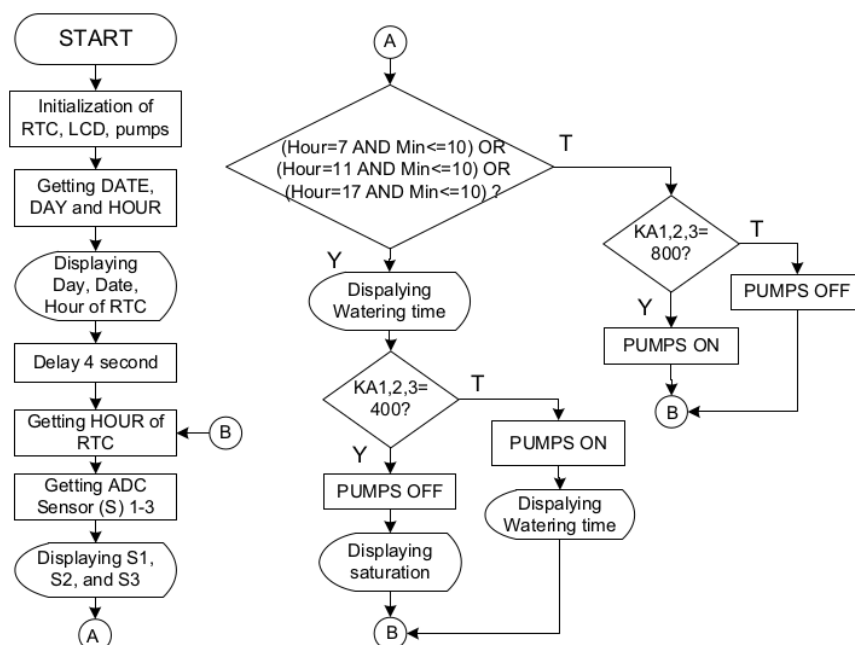


Figure 4. Flowchart of automatic watering control system.

Agriculture is an intensive use of water, because crop production requires a lot of water. Therefore, it creates need of a system that on one hand saves water and on the other is suitable to produce high yield simultaneously. An automatic watering system requires all the components that control continuously the available water in reservoir and then deliver to the plants at particular time and

amount without human intervention and failure. The watering system should perform the following functions: (a) monitor continuously the amount of soil water available to plants, (b) determine if watering is required for the plants based on the information obtained from monitoring the soil moisture, (c) supply exact (or approximate) amount of water required for the plants, (d) discontinue the water supply when the required amount has been given to the plants. Those features are important as the amount of water available for the irrigation system is not infinite, therefore water controlling is essential[6].

The response of the output of soil moisture sensors to soil conditions is shown in Figure 5 and Table 1. It can be seen that in dry conditions the sensor will give a large output, while in wet conditions it will give a small response. In other words, the sensor output value is inversely proportional to the condition of soil moisture. This shows that the sensor has a behavior following the principle of resistance. The tests of watering system were carried out at The Laboratory of Agricultural Machinery and Equipment, Jenderal Soedirman University. Table 2 shows that the test is carried out by observing the condition of the irrigation pump at set times. During testing, the automatic system can work properly.

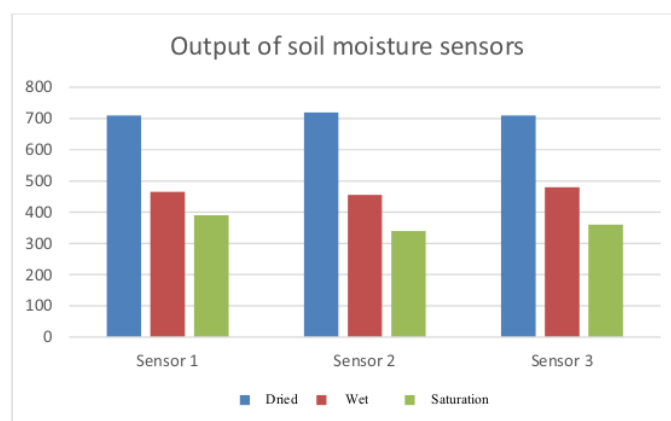


Figure 5. Response of soil moisture sensors to three conditions.

Automatic irrigation system built is a simple system, using Arduino to automate the irrigation and watering of crops. This system does the control of soil moisture in which when particular time and dry soil, it will activate the irrigation system pumping water for watering plants. A 16×4 LCD displays all actions that are taking place and a real time clock. This system uses a water level sensor and a moisture sensor to detect the moisture level. A pump is also connected which will get on when moisture level falls down and will automatically turn off when moisture level will become sufficient. LCD is connected to the Arduino, which displays current date and time, setting of watering time, and upper and lower moisture levels, current moisture level of soil, and status of pump and watering.

Table 1. Average output of soil moisture sensors.

Sandy soil condition	Sensor 1*	Sensor 2*	Sensor 3*
Dried	510	720	710
Wet	465	435	480
Saturation	390	340	360

*Output Range: 0 – 1023.

The most advantages of applied automatic sprinkler or drip irrigation system is the labor and time efficiency, and cost savings. Once installed, the system can be set to a timer to water at specific time intervals a day during cultivation. It means that farmer or user is no need to worry about missing to water the plants. Another advantage is that the sprinklers and drippers can be positioned and pointed so that water is more effectively targeted where it is needed.

Table 2. Test of watering system performance.

Time	Sensor 1	Sensor 2	Sensor 3	State Irrigation	Note
06:50	463	433	445	OFF	Watering time
07:01	465	430	450	ON	
07:15	390	340	360	ON	
07:35	375	365	370	OFF	
10:07	370	340	364	OFF	Watering time, but land is still wet.
10:30	371	345	367	OFF	
10:45	370	340	365	OFF	
11:05	750	704	715	ON	Watering time, the land is dry
14:00	580	572	597	OFF	Watering time, the soil is conditioned to dry.
17:03	710	705	714	ON	

Some works reported success applications of automatic watering system based on microcontroller. Prakash *et al.* [7] built a microcontroller based closed loop to water plants in greenhouse. The real time values of soil moisture are wirelessly transmitted from field to system which drives the state of the motor and irrigation equipment according to the desired moisture levels. Then Jagdeep *et al.* [8] reported that the advantages most felt by farmers are employee efficiency and time, and the savings provided by automatic sprinklers or drip irrigation systems. Once installed, the system can be set to a timer to water at certain time intervals a day during cultivation. This means there is no need to worry about forgetting to water the plants. Another advantage is that sprinklers and water droplets can be positioned and directed so that water is targeted more effectively if needed.

4. Conclusion

The automatic watering system based on the supplying schedule using Arduino minimum system has been successfully built from desired time of scheduling irrigation effectively. The system also controls the water level in the reservoir and measures the condition of soil moisture. The test results show the system can work in accordance with the program flowchart designed. This system provides flexibility and accuracy in respect of time set for the operation of a sprinkler and drip irrigation. In present work the automatic sprinkler and drip irrigations drove with solenoid AC pumps and DC pumps. The system is able to supply water continuously for the plants on particular time (on 07:00, 11:00, and 17:00) for 15 minutes for onions and cabbage flower cultivation on costal area.

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