

Research Article

a Prototype Design of Smart Quranic Garden System using ATmega328 and ESP8266 Microcontrollers

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ABSTRACT

Medicinal plants are a significant agricultural commodity cultivated by farmers in Parongpong District, West Bandung Regency, with the bidara plant (*Ziziphus mauritiana*) being a primary focus of the Quran Garden Foundation. In addition to its health benefits, bidara cultivation aligns with Islamic teachings, making it a valuable resource for wellness and religious practice. This study aims to develop and test a Smart Quranic Garden System prototype based on greenhouse automation technology and Internet of Things (IoT) security using ATmega328 and ESP8266 microcontrollers to optimize bidara plant growth. The research employed an experimental design to create and test systems for automated watering, weather control, and security. The prototype integrates sensors and actuators to automate these processes and enhance cultivation efficiency. Testing revealed that the watering system activates the pump when the soil moisture sensor detects an ADC value of 700 or higher. For the weather control system, the heater activates when the DHT11 sensor detects temperatures below 25°C, and the blower operates when temperatures exceed 30°C. The security system responds effectively, with the solenoid lock opening only when the correct password is entered and the virtual button on the Blynk application is pressed. This prototype demonstrates the potential for implementation in optimizing the growth of bidara plants in Parongpong District by improving cultivation efficiency and security, contributing to sustainable agricultural practices and supporting the Quran Garden Foundation's vision.

1. INTRODUCTION

During this era of new drug designing, medicinal plants had become a very interesting object of further research (Yanuar et al. 2011). There are about 31 types of medicinal plants in Indonesia which are used as raw materials for the traditional medicine (herbal) industry, non-herbal and spice industries, as well as for export needs (Pribadi, 2015). Some medicinal plants with high nutritional value are mentioned in the *Al-Qur'an* (Dalil, 2017; Kahrizi et al. 2012) such as bidara (Haeria et al. 2016; Qamariah, 2019)), olives, figs, dates, grapes, bananas, and so on (Farhangi et al. 2014; Malichah, 2016). This has also become a treatise or *sunnah* carried by Muslims (Idris et al. 2020; Rochanah, 2019), including the example of the Prophet Muhammad SAW, namely being medicine, *ruqyah* (Triantoro et al. 2019; Yusof et al. 2017), bathing corpses (Idris et al. 2020; Siregar, 2019), bathing converts (Hassan et al. 2020), and others.

The cultivation of these plants is very important to be optimized in view of their abundant properties with chemical content such as alkaloids, phenols, flavonoids, saponins, quercetin, and terpenoids (Karim et al. 2011). One of the efforts that have been made is to cultivate these plants in a green house as was done in Parongpong District, West Bandung Regency (Ayesha, 2017) by the Quran Garden Foundation which focuses on Bidara plant commodities. Bidara plants ideally grow in hot and dry climates with average temperatures ranging from 25-30 °C (Rahayu et al. 2016), altitude 15-300 masl, climate types D, E and F, with annual rainfall of 428 - 1622 mm/year, and 3-5 wet months on average (Setiawan et al. 2012). Meanwhile, Parongpong is a highland with cool and fertile air with an average daily temperature of 17-24 °C, rainfall of 2500-5000 mm/year, and is located at an altitude of 800 meters above sea level (Putra, 2013; William et al. 2018). The use of the green house itself is not optimal due to the fluctuating temperature



and humidity values (Sultan, 2016). Green house safety also needs to be optimized because the benefits of the bidara plant make it relatively expensive (Alqarni, 2015; Wahyuni, 2021). Figure 1 is the condition of bidara plant cultivation at the Parongpong Quran Garden Foundation.

The author tries to adopt several studies that have been made in an effort to optimize the cultivation of bidara plants in a green house. Some of these studies only focus on conditioning physical parameters (Teslyuk et al. 2015; Sultan, 2016) without considering the safety of the green house, then there is no green house technology that optimizes the cultivation of bidara plants. Based on these conditions, a technology is needed that can optimize the physical parameters of the green house in the form of temperature and soil moisture in the cultivation of bidara plants, and there is a good security system.



Figure 1. Cultivation of bidara plants at the Quran Garden Foundation

Therefore, the author tries to use the ATmega328 and ESP8266 microcontrollers (Abidin, 2018; Tan, 2019)) as a physical quantity controller in the green house and as a green house security supervisor through IoT (Internet of Things) technology integrated on the owner's smartphone. The schematic diagram of the greenhouse system is shown in Figure 2.

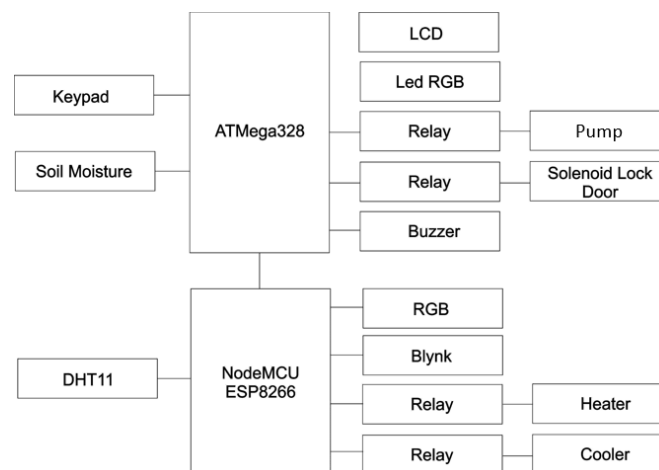


Figure 2. Schematic diagram of the system

Physical quantities in the form of temperature and soil moisture will be controlled through a watering and weather system. Meanwhile, the security system is controlled through a locking system that is integrated into the keypad and virtual buttons on the green house owner's smartphone. On this occasion the author aims to design a prototype green house system called the Smart Quranic Garden System to support the cultivation of Bidara plants at the Qur'an Garden Foundation, Parongpong, West Bandung Regency. The discussion is only limited to the design of the green house system that functions as a watering, weather and security system as well as the test results.

The objectives of this study are to obtain: (a) the performance of the ATmega328 and ESP8266 microcontroller-based control systems in Smart Quranic Garden and (b) the performance of the IoT-based security systems integrated on smartphones.

2. RESEARCH METHODS

In this study, experimental methods were used which included design and testing (Jaedun, 2011; Sevim et al. 2012)). The design that is done first is the hardware design by detailing the input, process, and output components. Hardware materials are installed on the experimental board as a medium for research (Barera et al. 2014; Muchlas et al. 2021) which is equipped with a control system based on ATmega328 and ESP8266 microcontrollers, as well as a number of support systems, and an IoT-based communication system. After designing the hardware, then a program is made

according to the planned system using the Arduino IDE software. Figure 3 shows the research methodology of this prototype system design.

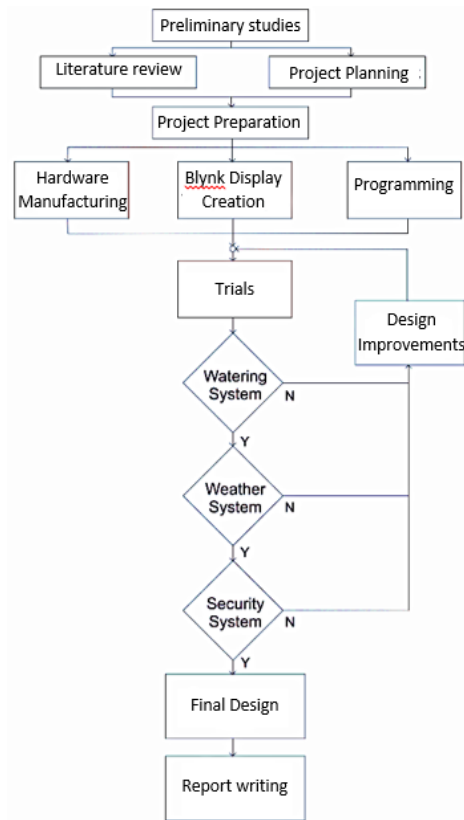


Figure 3. Research Methodology

In this design, the ATmega328 microcontroller gets input from the keypad which is integrated into the relay (Abbas, 2018; Saleh, 2020) for the Solenoid Lock Door, RGB (Red, Green and Blue) LEDs, and Liquid Crystal Display (LCD) as a security system. This microcontroller also gets input in the form of soil moisture from the YL-69 Soil Moisture sensor which is integrated with a water pump as a watering system (Ismail et al. 2019; Jariyayothin et al. 2018; Kamelia et al. 2018; Mardika et al. 2019). The ESP8266 microcontroller gets input in the form of temperature and humidity values through DHT11 (Saha et al. 2017) with integrated temperature values on RGB LEDs and relays for heaters and blower fans (Reshika et al. 2020) as a weather system. The ESP8266 microcontroller is also integrated with the IoT system by sending security system notifications via indicators on Blynk (Hutabarat et al. 2018).

Program design is carried out after the hardware design is completed. So that the program is made following the components that are assembled. This stage is carried out by making a program flow beforehand for each system, both watering, weather and security systems as shown in Figure 4.

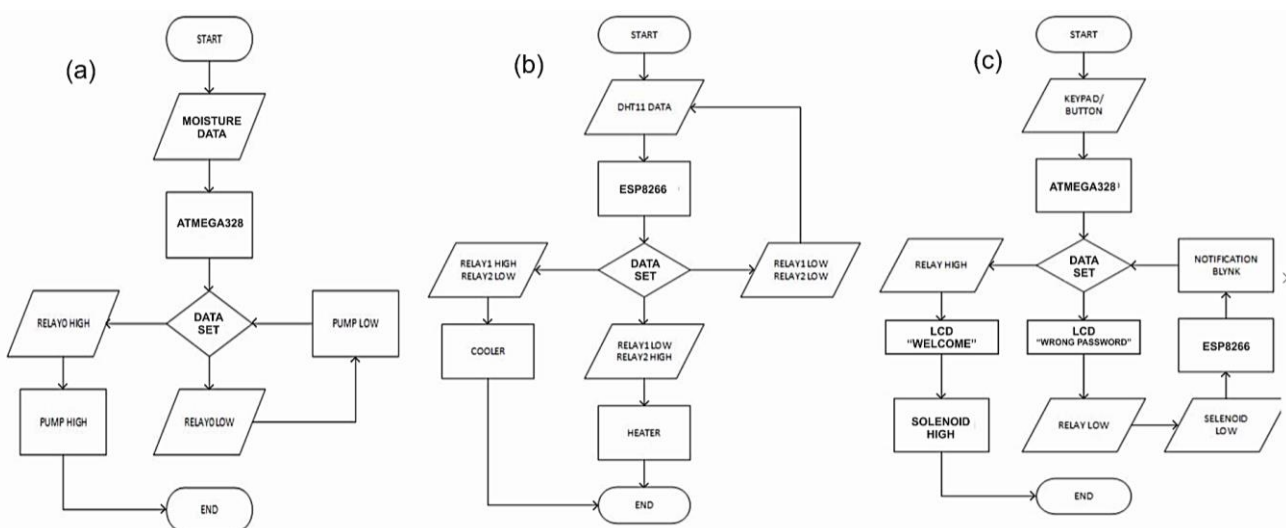


Figure 4. Flowchart (a) watering system, (b) weather system, and (c) security system

The watering system gets input from the YL-69 soil moisture sensor to read the ADC value of soil moisture. The water pump will work through the relay when the soil moisture is less than the data set. The need for soil moisture for the bidara plant itself is 68-78% (Setiawan et al. 2012) so the water pump is programmed to be active when the YL-69 soil moisture sensor detects a moisture value above or at the ADC value of 700.

The weather system gets input from the DHT11 sensor in the form of water temperature and humidity. The actuator will work through a relay in the form of a heater and a blower when the temperature is at the minimum and maximum values of the data set. Bidara plants ideally grow at an average temperature ranging from 25-30 °C (Rahayu et al. 2016)], when DHT11 reads temperatures below 25 °C it will activate the relay for the heater. Likewise, when DHT11 reads temperatures above 30°C it will activate the relay for the blower.

The security system in Smart Quranic Garden works by getting input in the form of a password that is entered via the keypad. When the password input is correct, the program on the ESP8266 microcontroller will provide a notification via Blynk (Durani et al. 2018; Raju et al. 2019; Singh et al. 2019; Sasmoko, 2020) to the owner that someone has opened a greenhouse. The program on the ATmega328 microcontroller will display on the LCD and execute the relay for the Solenoid lock door. However, when the password is entered on the keypad incorrectly, the ATmega328 microcontroller will give a command to the ESP8266 microcontroller to send a notification to the owner's smartphone that someone is trying to open the greenhouse using Serial communication. The program on the ATmega328 microcontroller will display on the LCD that the password entered is incorrect (Adriano et al. 2018).

After the hardware is integrated with the program that has been created and Blynk is already connected to the hardware, then the tool is tested. This stage includes testing the suitability of hardware performance on each system and program that has been made. It is hoped that the system in this prototype can be implemented in a greenhouse in the Parompong sub-district, West Bandung Regency, especially at the Quran Garden Foundation. The author designs the hardware layout plan and system installation in the greenhouse which is shown in Figure 5.



Figure 5. Design of hardware installation layout plan in green greenhouse

The controller box is installed near the door, including part of the security system, while the sensors and actuators are placed in the middle of the greenhouse as shown in Figure 5. The design plan is made to be used as a reference when this system is implemented.

3. RESULTS AND DISCUSSIONS

In this section, the results of the prototype design will be discussed including hardware, Blynk display and programming as well as the results of system testing.

3.1 Design Results

3.1.1 Hardware Manufacturing

Hardware manufacture is carried out following the circuit scheme shown in Figure 6.

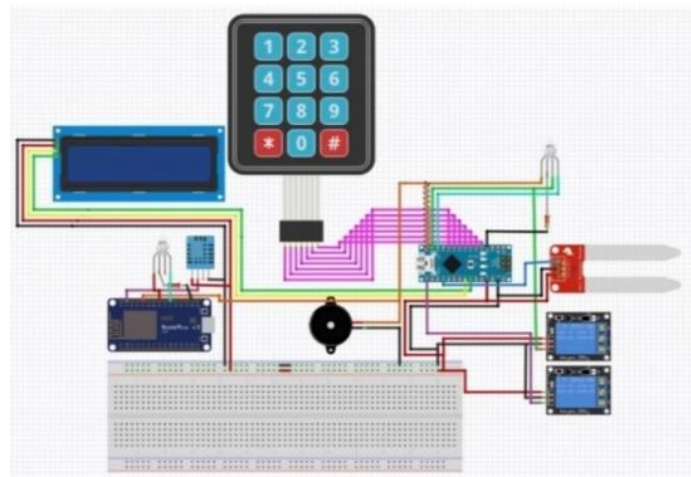


Figure 6. Schematic of the hardware circuit

In this study, hardware design was carried out for research needs on the cultivation of bidara plants. Each component was tested using an experimental board following the scheme in Figure 6. The actuators in this system in the form of pumps, solenoid lock doors, blowers and heaters were replaced with relays and information on RGB LEDs. Meanwhile, for the supply it uses is a 5V 2A adapter to meet the power needs of this circuit. Figure 7 shows the manufacture of hardware on a test board for research needs.

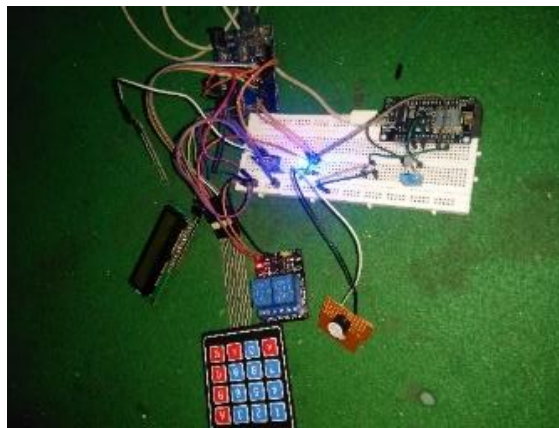


Figure 7. Making hardware

3.1.2 Programming

This program is made according to the flowchart planned in Figure 4 and is supported by the library of each component using the Arduino IDE software (Badamasi, 2014). Figure 9 shows a partial view of the program to be uploaded to the Arduino Nano Board and NodeMCU.

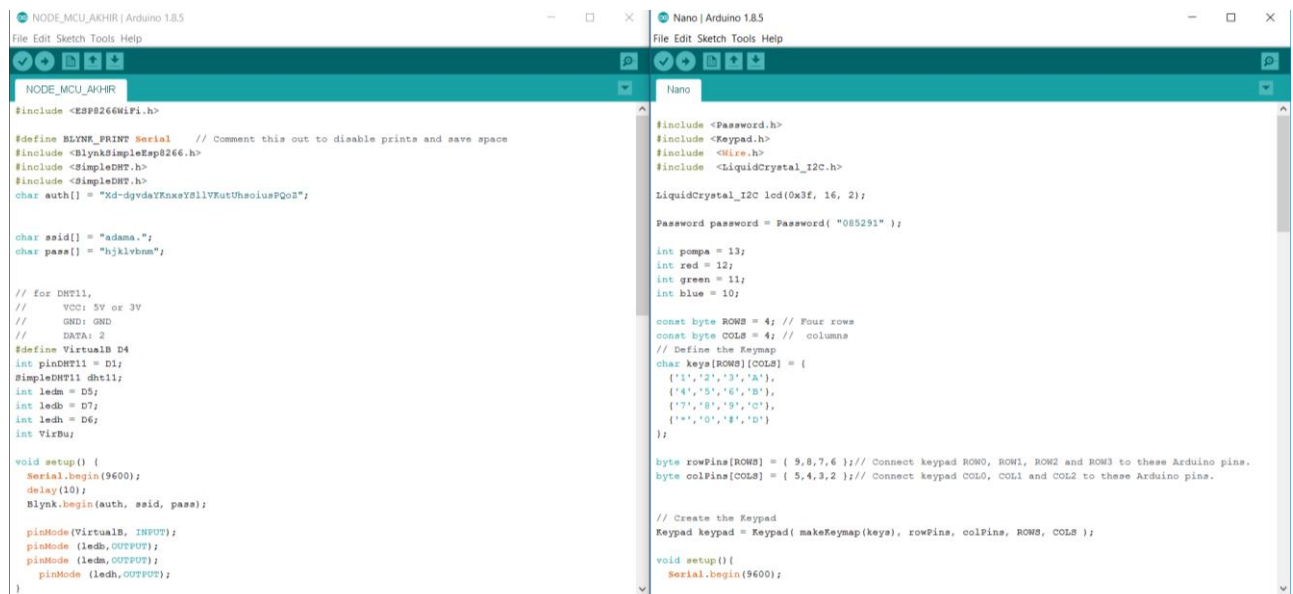


Figure 8. Program Line (a) NodeMCU and (b) Arduino Nano on Arduino IDE software

3.1.3 Blynk Display View

In this study, Blynk is used as input in the form of a virtual button to access the security system, as well as an indicator for remote notification when someone else tries to access the greenhouse by entering a password on the keypad. Figure 8 shows the display on Blynk.

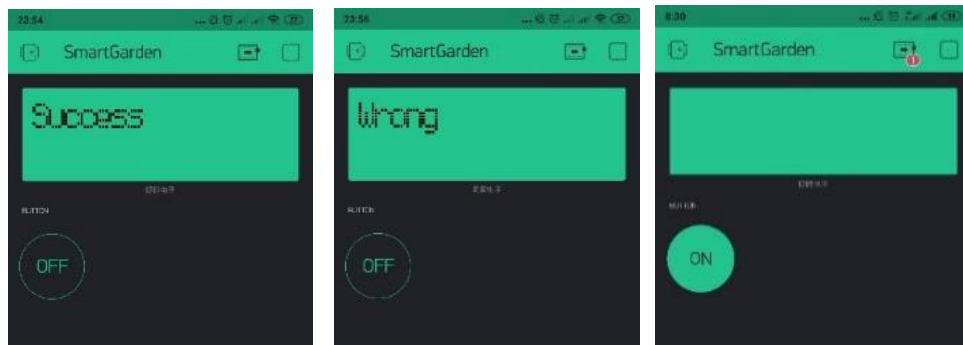


Figure 9. The display on Blynk is a virtual button and LCD when conditions (a) enter the password correctly, (b) enter the password incorrectly, and (c) the virtual button is pressed

3.2 Trial Results

3.2.1 Testing Watering System

The test was carried out through 5 experiments, as shown in Table 1.

Table 1. Watering system test results

No	Trial	ADC value of soil moisture	Pump Relay Condition
1	Dry land is not given water	946	ON
2	The soil is given 20 ml of water	766	ON
3	The soil is given 40 ml of water	422	OFF
4	The soil is given 60 ml of water	278	OFF
5	Water	60	OFF

Based on the test results, the system works well, namely the relay for the pump will turn on when the ADC value is more than or equal to 700. We can see the ADC value through the serial monitor on the Arduino IDE software with the ADC used is 10 bits. On and off the relay for the pump considers the values on the sensor both output voltage, current, and resistance. Table 2 shows the measurement results of the soil moisture sensor.

Table 2. Measurement results of soil moisture sensor

No.	ADC Value	V _{out} sensor (V)	Current (A)	Resistance (Ohm)
1	946	4,85	0,00047	10319
2	766	3,7	0,00047	7282
3	422	2,05	0,0103	199
4	278	1,35	0,0104	129
5	60	0,4	0,073	26

3.2.2 Weather System Test

The test was carried out with several experimental conditions as an assumption of temperature in the field. The results of this trial are shown in Table 3. The temperature data set required by the bidara plant in this prototype is 25-30°C (Rahayu et al. 2016). While the air humidity data is ignored.

Table 3. Weather system test results

No.	Experiment (Time Assumption)	Temperature (°C)	Humidity (%)	RGB	Heater	Blower
1	06.00	15	85	Red	ON	OFF
2	09.00	19	68	Red	ON	OFF
3	12.00	31	42	Green	OFF	ON
4	16.00	27	54	Blue	OFF	OFF

Based on the test results, the system works well, namely the relay for the heater and the red LED on the RGB LED lights up when the temperature is below 25°C, it is assumed that the temperature is in the morning. The relay for the boiler and the green LED on the RGB LED light up when the temperature is above 30°C, it is assumed that the temperature is during the day. While the weather system is in standby condition, namely when the temperature is between 25-30°C according to the dataset so that the heater and boiler do not turn on, this condition is indicated by the blue LED on the RGB LED lights up.

3.2.3 Security System Test

The test is carried out with several input conditions from the keypad and virtual buttons on Blynk. The input in the test is a password that has been set in the program and a virtual button on the Blynk application on the greenhouse owner's smartphone. The test results of this stage are shown in Table 4.

Table 4. Security system test results

No	Input	LCD Display	RGB	LCD Blynk	Buzzer	Solenoid Lock Door
1	Correct Password	"Welcome back sir"	Green	"Success"	-	Open
2	Wrong Password	"Wrong"	Red	"Wrong"	ON	OFF
3	Standby	"The Password:"	Blue	-	-	OFF
4	Virtual Button	"Welcome back sir"	Green	-	-	Open

Based on the test results, the solenoid lock door will open when the password entered on the keypad is correct or the virtual button on Blynk is pressed. This condition is indicated by the "Welcome back sir" display on the LCD the green LED lights up, and the Blynk LCD shows "Success". The solenoid lock door will not open when the wrong password is entered, it is indicated by the display "Wrong" on the LCD, the red LED lights up, the buzzer sounds, and the LCD Blynk shows "Wrong". Another condition is when standby is marked with a blue LED that lights up.

4. CONCLUSION

The design of the greenhouse system for the cultivation of Bidara plants using the ATmega328 and ESP8266 microcontrollers was successfully carried out with each system running well. In the testing process with several experimental conditions, the relay for the pump on the watering system works when the soil moisture sensor detects soil moisture at an ADC value of more than or equal to 700. While in the weather system, the relay for the heater will work when DHT11 detects a temperature below 25°C and the relay for the blower will work when the temperature is detected above 30°C. The security system also responds according to the program that is set, namely the relay for the solenoid lock door will open only when the password is correct and the virtual button on Blynk is pressed. It is hoped that the design of this prototype can be a reference for optimizing the cultivation of bidara plants in West Bandung Regency as a medicine and also the implementation of the *sunnah* in Islam.

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