



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 1, January 2023

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 8.118**

9940 572 462

6381 907 438

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# Microcontroller Based Control System of Greenhouse Using Drip Irrigation for Pak Choi Plant

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**ABSTRACT:** In traditional pakchoi (= bok choy) plantation, the process of fertilizing and watering is often unpunctual and improper dosing. Besides, soil moisture and environmental temperature are not controlled. It makes pakchoi plant to grow not optimal. The purpose of the research is to solve the problem by designing the automatic control system of greenhouse using drip irrigation technique for pakchoi plant.

By design, microcontroller reads soil moisture through the YL-69 sensor when a watering schedule arrives. If the soil moisture is less than the setting value, then microcontroller will provide the soil with drop by drop of water until the soil moisture reaches the required. Similarly, if a fertilizing schedule arrives, microcontroller will activate the fertilizer pump. In addition, if microcontroller using DS18B20 temperature sensor detects that temperature inside of greenhouse is more than the setting value, then microcontroller activates exhaust fan to decrease it. This system also uses the ultrasonic sensor HC-SR04 to monitor water level inside of the storage tank. If the water level is less than the setting value, then microcontroller will activate water pump to fill the tank. Moreover, by using smartphone via internet, pakchoi farmer can manage schedule of watering and fertilizing, and also control soil moisture and air temperature inside of the greenhouse by real time. This is possible because the system uses the blynk application software.

The test result shows that the automatic control system can provide the proper fertilizing and watering with drip irrigation technique based on either the preset time schedule or direct control by smartphone via internet. Besides, the user can monitor and set the land's parameters by using smartphone via internet.

**KEYWORDS:** *Bok choy, blynk application, drip irrigation, microcontroller, pakchoi*

## I. INTRODUCTION

Pak choy is a short-lived plant and contains good nutrition for the human body. The content of beta-carotene in pakchoy can prevent cataracts. Besides containing high beta-carotene, pakchoi also contains many nutrients including protein, vegetable fat, carbohydrates, fiber, Ca, Mg, Fe, sodium, vitamin A, vitamin B, vitamin B2, vitamin B6, vitamin C, fiber, phosphorus, copper, and proteins [1]. Pak-choi plant lives ideally at environment temperatures of 19-30 °C [2].



Fig. 1: Pak Choi Plant

However, traditional pakchoi farmers are often unpunctual and improper dosing to water and fertilize. It causes the plants to grow not optimal. Besides, the farmers are also unable to protect their plants against rising environmental temperature that will disturb the plant growth. Moreover, if the farmer's land area is large, the fertilizing and watering activities cause the farmer tired. On the other side, pakchoi planting needs a system to control plant's parameter, such as soil moisture, environment temperature by real time. Moreover, modern farming always uses efficient and proper watering and fertilizing [3]



Fig. 2: Common Greenhouse of Pak Choi Plant

Figure 2 shows one of the existing common greenhouses of pakchoi plant. However, the greenhouse does not have automatic control system for land parameters. Besides, the farmer is unable to control and monitor remotely via internet.

## II. RELATED WORK

K.Prathyusha, and M. Chaitanya Suman[4] proposed microcontroller based drip irrigation. Irrigation system controls valves by using automated controller to turn ON & OFF. This allows the farmer to apply the right amount of water at the right time. This reduces runoff over watering saturated soils avoid irrigating at the wrong time of the day. It improves crop performances and help in time saving in all the aspects.

IpinPrasojo, AndinoMaselena, Omar Tanane, and NishithShahu[5] proposed microcontroller system to control watering automatically based on soil moisture detected using a soil moisture sensor. This system detected whether the soil was dry or not. So, the farmers did not need to do watering manually.

ChoirulUmam, Sandra MalinSutan, and Yusuf Hendrawan[2] proposed the Tsukamoto fuzzy control system to get the ideal environment temperature and humidity in factory plant for Pak Choi hydroponics. The research results that by using fuzzy inference system, the value of PWM (Pulse Width Modulation) provided to the control system is 628.8515 to reach the 28°C of temperature setpoint and the 75% of humidity setpoint.

Nandan N, and Dr. K. Thippeswamy[6] proposed the automated drip irrigation. The system completed by PIR sensor to alert the farmer and give warning to intruders like animals (came for destroying the crop) and humans (to steal to device). PIR sensor will invoke the camera to take picture of the intruder and sends to the farmer. The camera is also to take pictures to monitor the crop growth. According to the soil moisture sensor data, the farmer can control drip using the mobile application provide with internet connectivity. Besides, the system utilized solar power supply.

Sumeet Sarode [7] proposed the automatic controlling an irrigation system. In the system, Arduino as a slave controller senses environment temperature and soil moisture. Then, the data is sent to Raspberry Pi computer which operates by using machine learning algorithm K-NN. The data set pertaining to moisture and temperature are checked in this algorithm and accordingly the prediction is made. This predicted is given to Arduino which is in charge of the water pumping action. The state of the field and the status of the irrigation system is stored in cloud web page where the farmer can access it from any place.

## III. METHODOLOGY

To achieve the purpose of research, step of research is arranged to consist of system design, implementation, and testing. Moreover, troubleshooting and improvement are conducted if improper function of the system occurs.

The following Figure 3 shows the proposed system design of greenhouse using drip irrigation. It shows that the system devices include greenhouse, controller, smartphone, soil moisture sensors, temperature sensor, water pumps, fertilizer pump, storage tanks, and exhaust fan. Meanwhile, block diagram of the proposed control system of greenhouse using drip irrigation for pakchoi plant is shown in Figure 4.

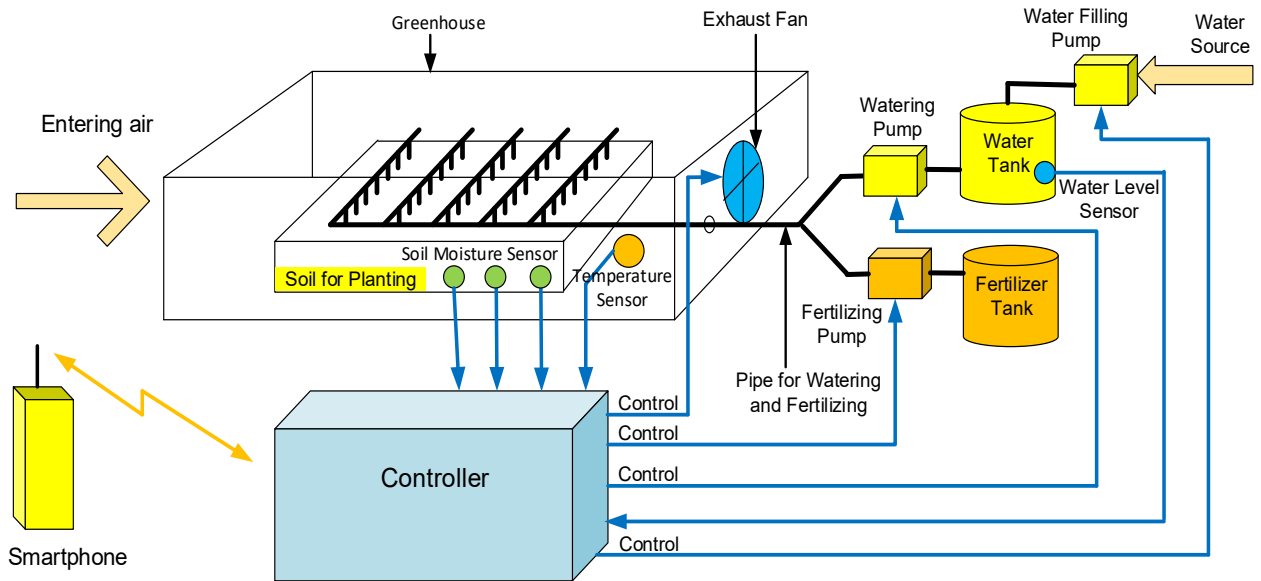


Fig. 3: The Proposed System Design of Greenhouse Using Drip Irrigation

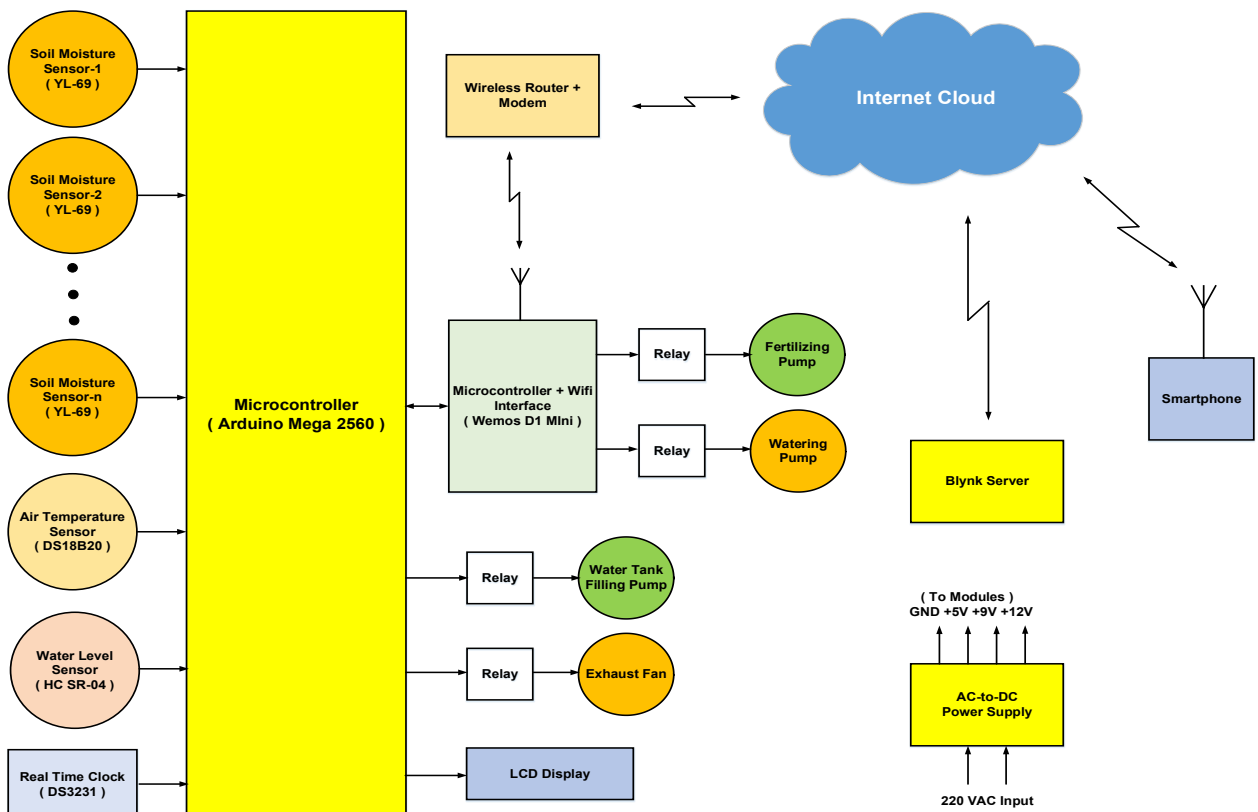


Fig. 4: Block Diagram of the Proposed Control System of Greenhouse Using Drip Irrigation for Pak Choi Plant

By design, Arduino board reads the soil moisture first through the YL-69 sensor when a watering schedule arrives. If the soil moisture is less than the setting value, then microcontroller will provide the soil with drop by drop of water until its soil moisture reaches the required. Similarly, if a fertilizing schedule arrives, microcontroller will activate the fertilizerpump. In addition, if microcontroller using DS18B20 temperature sensor detects that temperature inside of greenhouse is more than the setting value, then microcontroller activates exhaust fan to decreaseit. This system also uses the ultrasonic sensor HC-SR04 to monitor water level inside of the storage tank. If the water level is less than the setting value, then microcontroller will activate water pump to fill the storage tank. Moreover, by using smartphone via internet, pak choi farmer can manage the schedule of watering and fertilizing, and also control soil moisture and air temperature inside of the greenhouse by real time.This is possible because the system uses the blynk application software.

The following Figure 5 shows schematic diagram of the proposed control system for greenhouse.

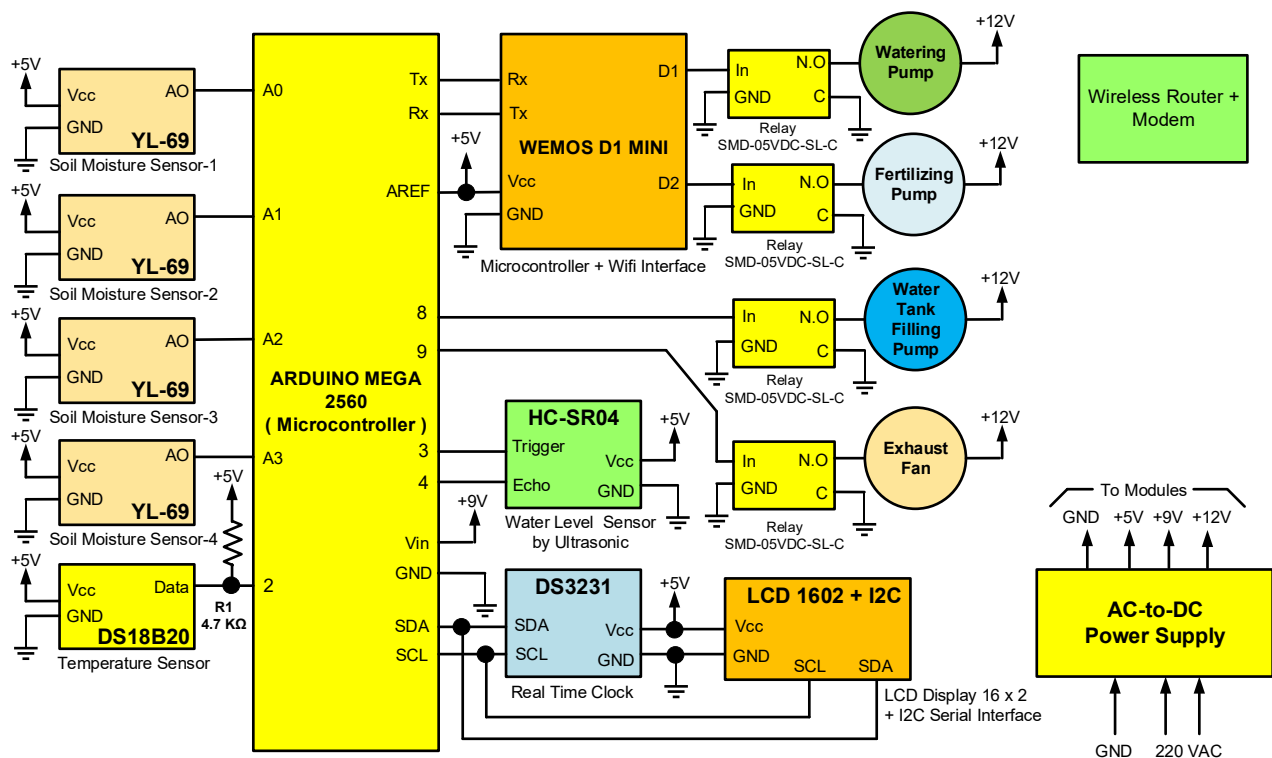


Fig. 5: Schematic Diagram of the Proposed Control System of Greenhouse Using Drip Irrigation for Pak Choi Plant

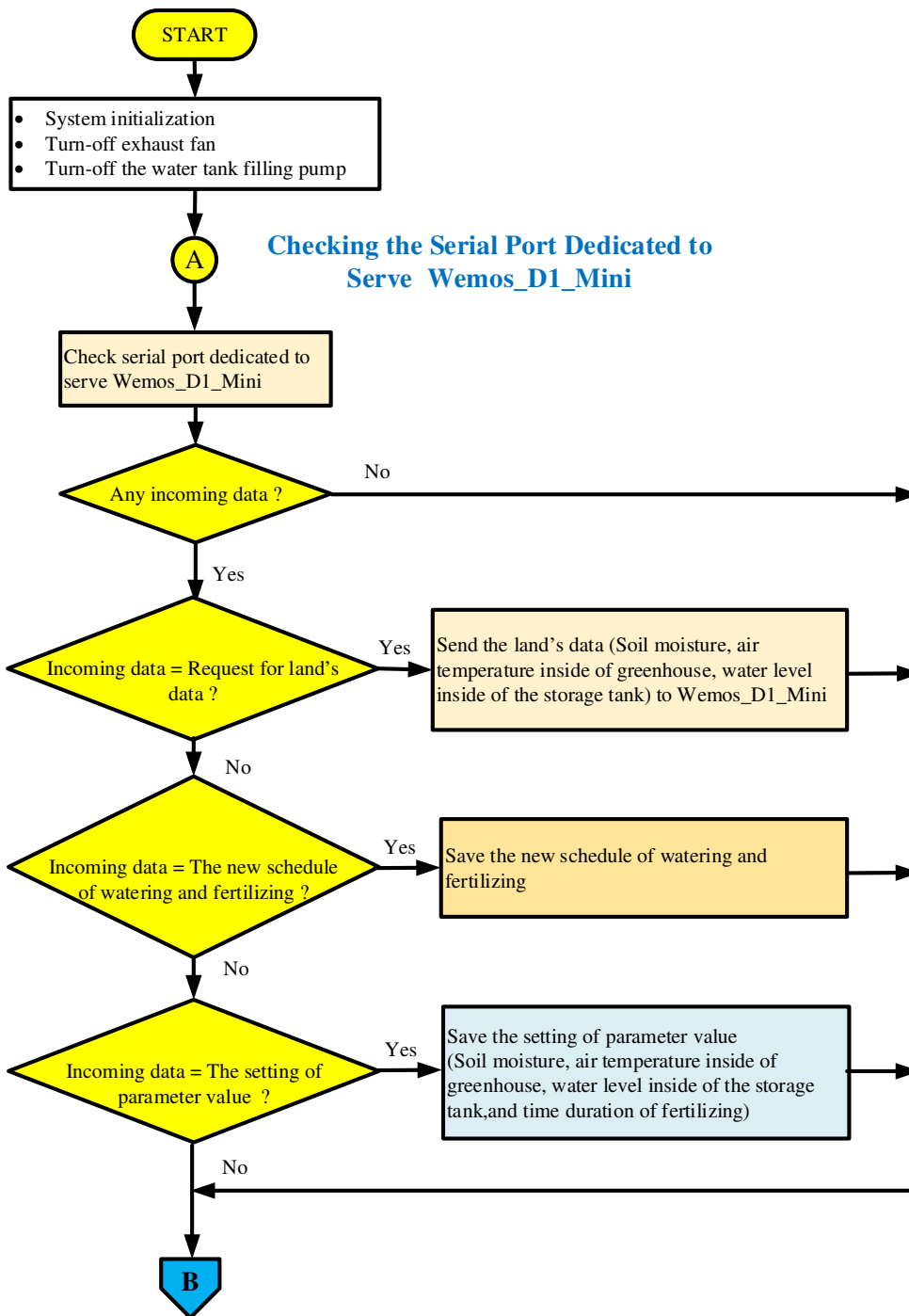
It shows that the system has Arduino Mega 2560 board and also Wemos D1 Mini board as controllers. The Arduino board monitors the soil humidity and also controls water tank filling pump and exhaust fan. Meanwhile, Wemos D1 Mini board has function as interface to communicate with smartphone via internet and also executes the process of fertilizing and watering. To connect to internet, the system is also completed with wireless router and modem unit.

By design, if the soil humidity is less than the setting value, then Arduino board commands the Wemos D1 Mini to provide the soil with drop by drop of water until its soil humidity reaches the required. Besides monitoring soil humidity, Arduino board also monitors the air temperature inside of greenhouse and water level inside of the storage tank.

Due to output of soil moisture sensors (YL-69) are analog signal, so each of them is connected to analog input pin of Arduino Mega 2560 (pin A0, A1, A2, A3). Meanwhile, the output of air temperature sensor DS18B20 is digital data. So, it is connected to digital input pin (pin 2) of Arduino board. Moreover, to measure water level inside of the storage tank, Arduino board provides two pins for connecting to pin-Trigger and pin-Echo of ultrasonic module HC-SR04. Besides, by using LCD module completed with I2C interface, the system displays land's parameters, such as soil humidity, air temperature inside of the greenhouse, and water level inside of the storage tank.

Arduino board utilizes Real Time Clock (DS3231) output as time reference of schedule execution. On its operation, the DS3231 utilizes pin-SDA and pin-SCL to transfer data to Arduino board. Then, Arduino board checks the schedule of watering and fertilizing. If the time arrives, Arduino board sends Wemos D1 Mini the command for either watering or fertilizing.

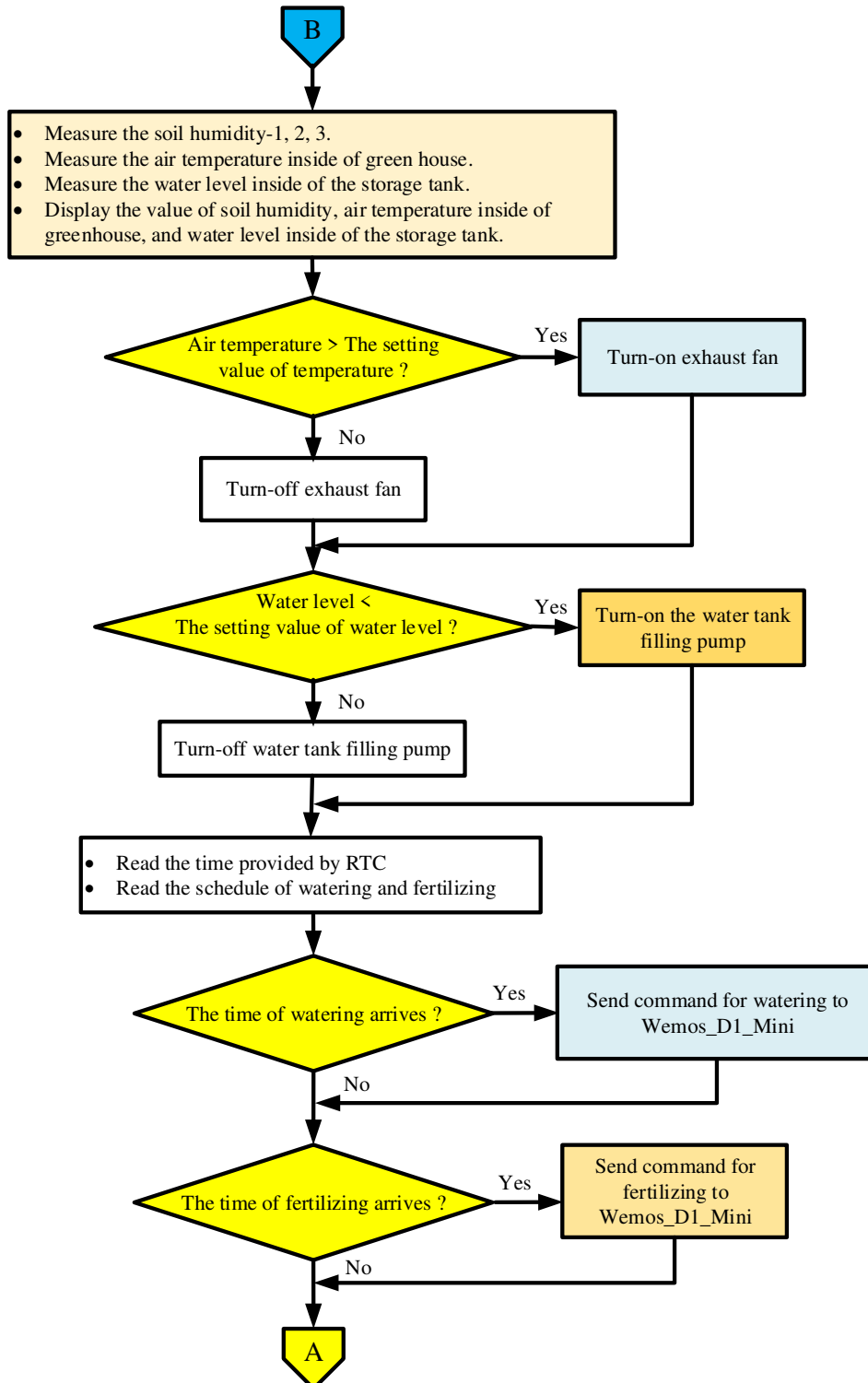
As described before, this system utilizes microcontrollers inside of Arduino Mega 2560 board and Wemos D1 Mini board. Therefore, each microcontroller has own respective software. The following Figure 6a, 6b, 7a, 7b show the flowchart design of which the software using Arduino programming language refers.



Go to Read Land's Parameter

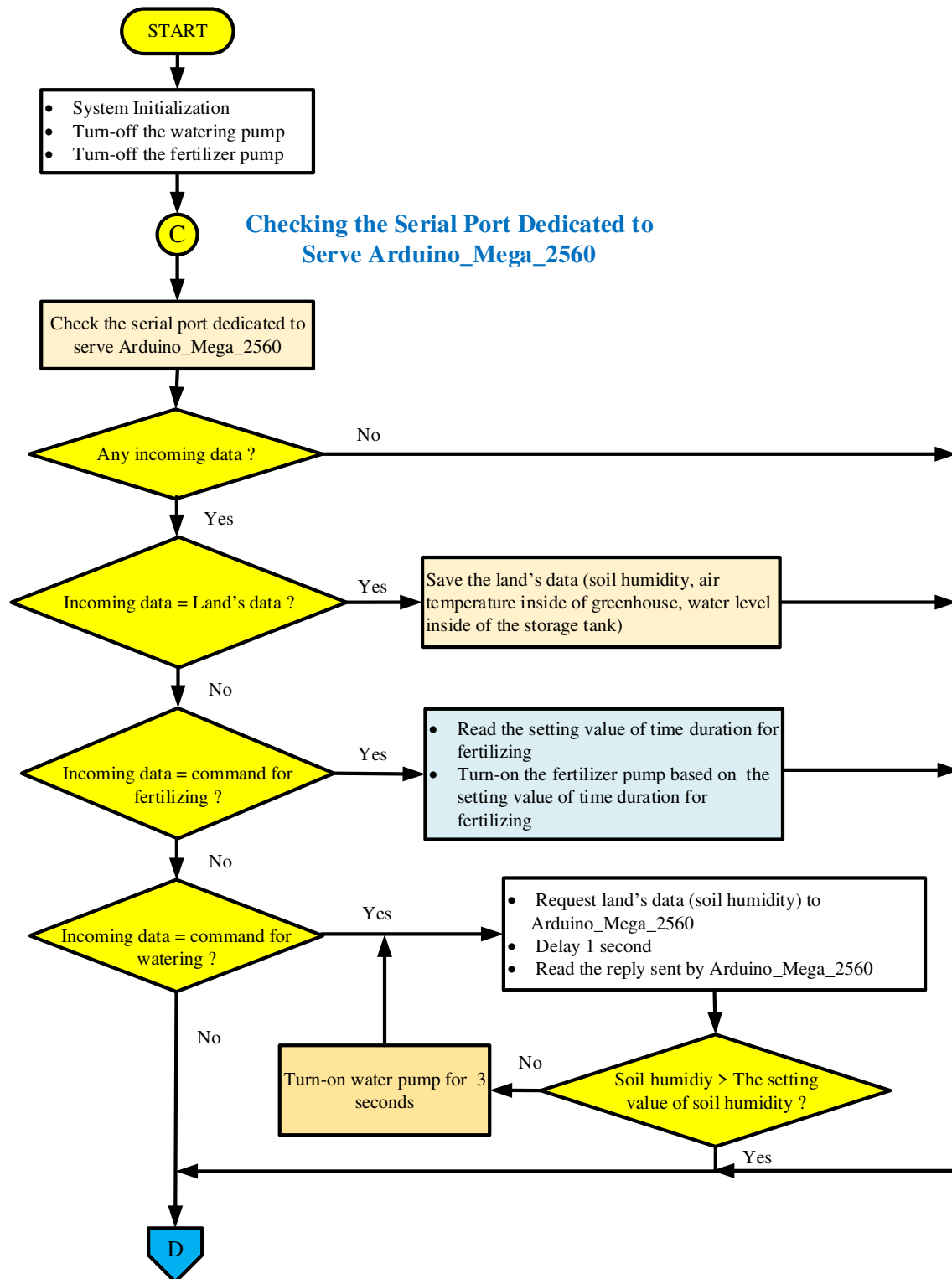
Fig. 6a: Software Flowchart of Arduino\_Mega\_2560 (Part 1 of 2)

**The Reading of Land's Parameter**



**Back to Check the Serial Port Dedicated to Serve Wemos\_D1\_Mini**

Fig. 6b: Software Flowchart of Arduino\_Mega\_2560 (Part 2 of 2)

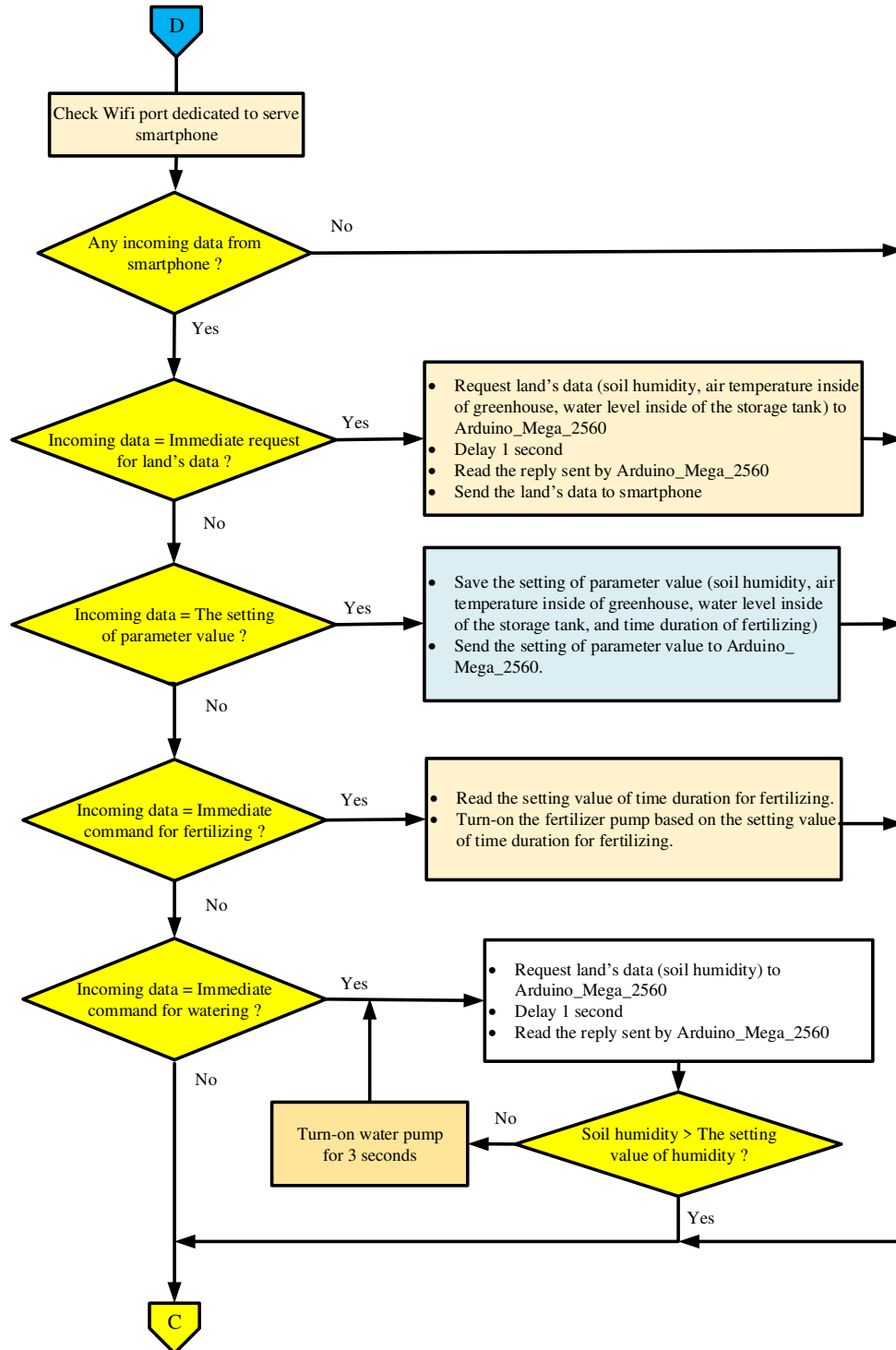


Go to Check the Wifi Port Dedicated to Serve Smartphone

Fig. 7a: Software Flowchart of Wemos\_D1\_Mini (Part 1 of 2)



Checking the Wifi Port Dedicated to Serve Smartphone



Back to Check the Serial Port Dedicated to Serve Arduino\_Mega\_2560

Fig. 7b: Software Flowchart of Wemos\_D1\_Mini (Part 2 of 2)

IV. EXPERIMENTAL RESULTS

The following Figure 8 shows design implementation of the microcontroller based control system of greenhouse using drip irrigation for pak choi plant. Meanwhile, the miniature of greenhouse using drip irrigation is shown in Figure 9.

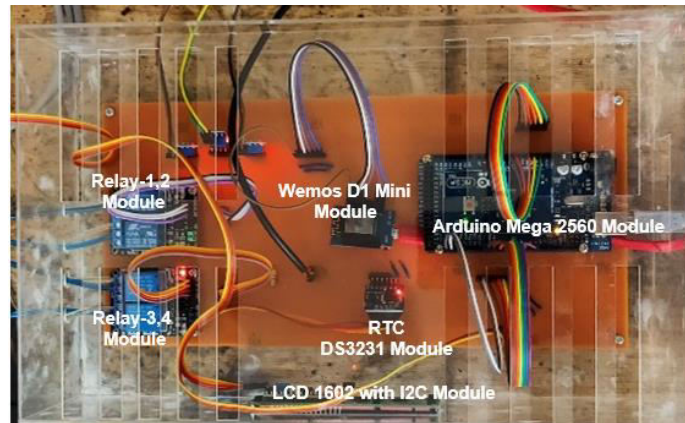


Fig. 8: Controller of Greenhouse Using Drip Irrigation

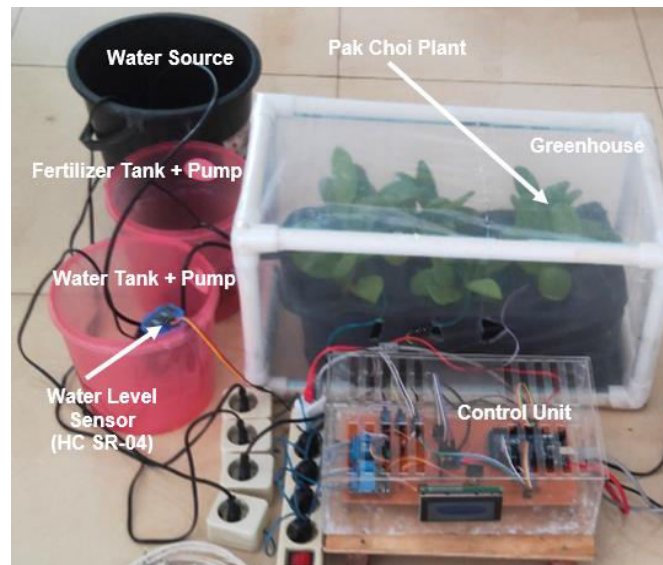


Fig. 9: Miniature of Greenhouse Using Drip Irrigation for Pak Choi Plant

The following Table 1 shows the test result of actual system response due to either any change of land’s parameters, the arriving schedule of watering and fertilizing, or direct control by smartphone via internet.

Table 1: Test Result of System Response

No.	Test Input	Observation Result on the Actual System Response	Justification
1	The time of watering arrives as scheduled.	<ul style="list-style-type: none"> <li>Water pump turns-on many times until the soil humidity reach the setting value of humidity.</li> <li>LCD Display shows the land’s parameters (soil humidity, air temperature inside of greenhouse, water level inside of the storage tank).</li> </ul>	<ul style="list-style-type: none"> <li>The actual system response complies as designed.</li> </ul>



No.	Test Input	Observation Result on the Actual System Response	Justification
2	The time of fertilizing arrives as scheduled.	<ul style="list-style-type: none"> <li>Fertilizer pump turns-on according to the setting value of time duration for fertilizing.</li> <li>LCD shows the land's parameters (soil humidity, air temperature inside of greenhouse, water level inside of the storage tank).</li> </ul>	<ul style="list-style-type: none"> <li>The actual system response complies as designed.</li> </ul>
3	Immediate command for watering comes from smartphone via internet.	<ul style="list-style-type: none"> <li>Water pump turns-on many times until the soil humidity reaches the setting value of humidity.</li> <li>LCD shows the land's parameters (soil humidity, air temperature inside of greenhouse, water level inside of the storage tank).</li> </ul>	<ul style="list-style-type: none"> <li>The actual system response complies as designed.</li> </ul>
4	Immediate command for fertilizing comes from smartphone via internet.	<ul style="list-style-type: none"> <li>Fertilizer pump turns-on according to the setting value of time duration for fertilizing.</li> <li>LCD shows the land's parameters (soil humidity, air temperature inside of greenhouse, water level inside of the storage tank).</li> </ul>	<ul style="list-style-type: none"> <li>The actual system response complies as designed.</li> </ul>
5	Water level inside of the storage tank is less than the setting value of water level by smartphone.	<ul style="list-style-type: none"> <li>Water tank filling pump turns-on until the water level inside of the storage tank reaches the setting value of water level.</li> <li>LCD shows the land's parameters (soil humidity, air temperature inside of greenhouse, water level inside of the storage tank).</li> </ul>	<ul style="list-style-type: none"> <li>The actual system response complies as designed.</li> </ul>
6	Soil humidity is either less or greater than the setting value of soil humidity by smartphone.	<ul style="list-style-type: none"> <li>If the soil humidity is less than the setting value, then the water pump turns-on many times until the soil humidity reaches the setting value.</li> <li>If the soil humidity is greater than the setting value, then the water pump turns-off.</li> <li>LCD shows the land's parameters (soil humidity, air temperature inside of greenhouse, water level inside of the storage tank).</li> </ul>	<ul style="list-style-type: none"> <li>The actual system response complies as designed.</li> </ul>
7	Air temperature inside of greenhouse is either less or greater than the setting value by smartphone.	<ul style="list-style-type: none"> <li>If the air temperature inside of greenhouse is greater than the setting value, then exhaust fan turns-on until the air temperature decrease to the setting temperature.</li> <li>If the air temperature inside of greenhouse is less than the setting value, then exhaust fan turns-off.</li> <li>LCD shows the land's parameters (soil humidity, air temperature inside of greenhouse, water level inside of the storage tank).</li> </ul>	<ul style="list-style-type: none"> <li>The actual system response complies as designed.</li> </ul>



No.	Test Input	Observation Result on the Actual System Response	Justification
8	Immediate request of land's data comes from smartphone.	<ul style="list-style-type: none"> <li>• Smartphone displays land's data (soil humidity, air temperature inside of greenhouse, water level inside of the storage tank).</li> <li>• LCD shows the land's data (soil humidity, air temperature inside of greenhouse, water level inside of the storage tank).</li> <li>• LCD and smartphone display the same land's data.</li> </ul>	<ul style="list-style-type: none"> <li>• The actual system response complies as designed.</li> </ul>

V. CONCLUSION

The control system of greenhouse results proper fertilizing and watering with drip irrigation technique based on either the preset time schedule or direct control by smartphone via internet. Besides, the user can monitor and set the land's parameters by smartphone.

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