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Temperature and Soil Control Design with Fuzzy Method in Greenhouse for Cabe Seeding

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***Abstract*— The ideal soil temperature and humidity in red chili pepper seedling are very important in the growth of the plant. The cultivation of red chili plants in greenhouses is very good because the environment in greenhouses can be manipulated according to the needs of that plants. The ideal temperature for red chili breeding is 25oC to 27oC, for soil moisture drainage and temperature must be maintained during growth. Red pepper plants can grow well in moisture 50% to 70%, irregular soil moisture can cause rooting disease and root decay in plants. Cultivation of plants in greenhouses can maintain the nursery process because the plants can be cultivated in accordance with the Operational Procedure Standards (SOP). Generally, the farmers in the breeding of red pepper are done in a traditional way. In the process of temperature control and soil moisture through a fuzzy method, it makes the system can work automatically. Thus, it can facilitate the work of farmers in seeding plants from uncertain outside environmental conditions. In the measurements that have been done can be taken conclusion which is percentage error mean temperature from set-point which has been set at the time in the morning equal to 2,48%, at noon around 9,79% and at night we got 1,93%. Then each addition of 1-second watering, soil humidity rise up to 0.067%.**

***Keywords*— greenhouse, temperature, soil humidity, fuzzy.**

I. Introduction

The environment is an important factor of growth of a plant, unstable environmental conditions can lead to disruption of plant growth. To avoid uncertain environmental factors, crops can be cultivated in greenhouses. The greenhouse is a building made of glass or plastic that allows sunlight into it. In general, the seeding of a plant is done manually by the farmers. The design of this tool is made in the form of a greenhouse prototype where the temperature and soil moisture will be controlled in accordance with conditions of temperature and soil moisture ideal for plant growth. Setting the temperature and soil moisture is an important factor in plant growth [13]. If a plant has been cultivated in accordance with its operational standard procedure then plant growth will run well [14].

I. Methodology

2.1. Research on Efforts to Increase Agricultural Products

The main problem that farmers gain in seeding a plant is the effect of unstable external environment conditions. Unstable environmental conditions cause disturbed plant growth and susceptible to disease [1],[2].

Cultivation of plants in greenhouses has an advantage for farmers [9]. there are some benefits of cultivating plants in greenhouses which are plants can produce continuously, the use of fertilizers and pesticides more efficient, reducing the risk of disease attachment. In chili plant breeding the ideal growth, the temperature is between 25oC and 27oC . Then the appropriate moisture level of the soil from 50% to 70% (moist).

Chili plants require adequate irrigation if the water is given excessive it will be able to cause high humidity in the area of roots, as a result, stimulate the growth of fungal and bacterial disease to death. If water shortages, pepper plants can be thin and dwarf wilt and die, the waters can use irrigation, groundwater, and rainwater.[3],[5] [9].

2.2. Green House

Greenhouses have a form resembling a closed and transparent house that can be penetrated by sunlight. Then sunlight is used to plant the plant so that the plant grows optimally without being affected by the external climate. For this purpose, greenhouses should have high light transmission, low heat consumption, adequate and efficient ventilation, strong structures, construction, and low-cost, high-quality operational costs [12],[18] 2.3. *Fuzzy* Controls

Fuzzy Logic Controller is an easy alternative to modern control systems because it does not need to look for mathematical models of a system, but it is still effective because it has a stable system response. The designed Fuzzy logic has 2 inputs (Err & DErr) and 1 output (D output). Here are the steps of the fuzzy algorithm.[8],[16].

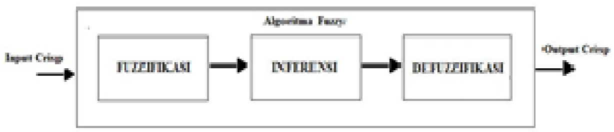

Fig 1. Fuzzy Algorithm Steps

a. Fuzzification is to determine the input crisp and crisp output
b. The inference is the rule basis in problem-solving with fuzzy logic
c. The process to get crisp output

II. SYSTEM PLANNING

3.1 System planning

System design includes things related to block diagram, hardware design, software design and design of printed circuit board (PCB). In the circuit design should be taken into account the economic value of the use of components. Before making the circuit and system, firstly planned block diagram which will have one purpose for the circuit that is made to lead to the desired destination.

The block diagram illustrates in general how the whole circuit works

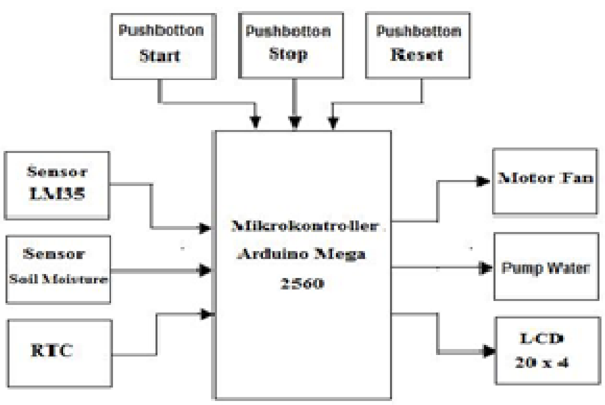

Fig 2. Temperature and humidity control system design of a greenhouse

3.2 Fuzzy Method

In the design method, the fuzzy used as the input of the sensor is the temperature reading, where the readable temperature will be used as a benchmark for setting the motor fan speed, which later input will be processed and processed by Arduino microcontroller using a fuzzy algorithm. Setting point temperature at this design is 27oC. The input of fuzzy itself is an error (e) and delta error (de). The error is the difference of the setpoint value of the temperature read on the sensor. The delta error is the difference between the current error and the previous error. For the output decision of both fuzzy input is PWM fan motor. The value of PWM that will be output on the motor is the defuzzification of the process[11],[15].

While the error is:

e (t) = SP - C

Where

e (t) = Error
SP = Set Point (RPM desired)
C = RPM value read

The delta error is the difference between the previous RPM value and the current RPM value. de (t) = e (t) - e (t-1)

Where

de (t) = delta error
e (t) = current error
e (t-1) = Error One previous sampling

The membership function for the error position (e) is

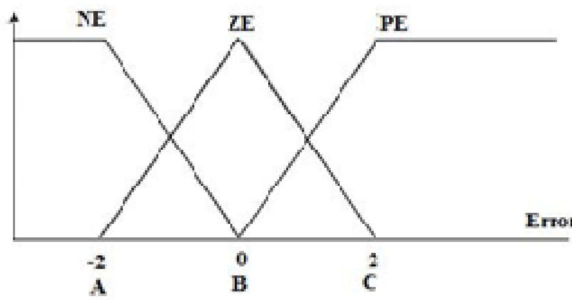

Fig 3. Error function as fuzzy input

Description of Membership Function error
NB: Negative Error
ZE: Same Error With Zero
PE: Positive Error
As for the union function delta error (de)

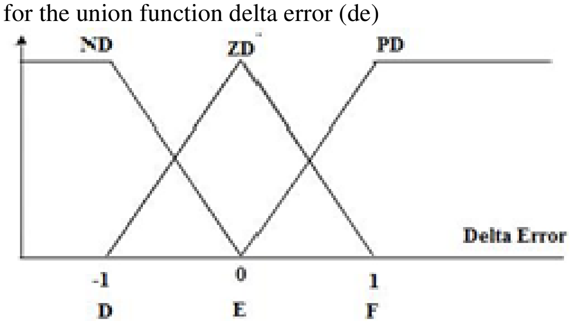

Fig 4. Delta error function as fuzzy input

Description of Function delta error (de)
ND: Negative Delta Error
ZE: Delta Error Equals Zero
PD: Positive Delta Error
While the decision function PWM took is

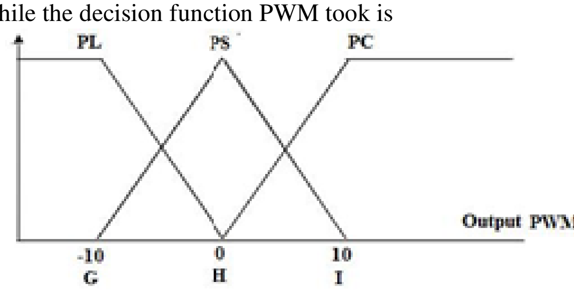

Fig 5. Union function for PWM motor

Output Union Function Description
PL: PWM Slow
PS: PWM Zero
PC: Fast PWM

TABLE I
RULE BASE

Deer	ND	ZD	PD
NE	**PC**	**PC**	**PS**
ZE	**PC**	**PS**	**PS**
PE	**PS**	**PS**	**PL**

III. TESTING AND ANALYSIS TOOLS

4.1 Temperature Control Using Fuzzy Algorithm

The following is a temperature control system test using a fuzzy algorithm inside the greenhouse. Testing is done when all systems are in active state.

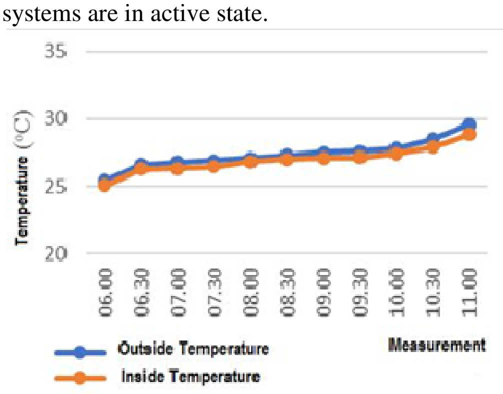

Fig 6. Temperature Measurement graph in the morning

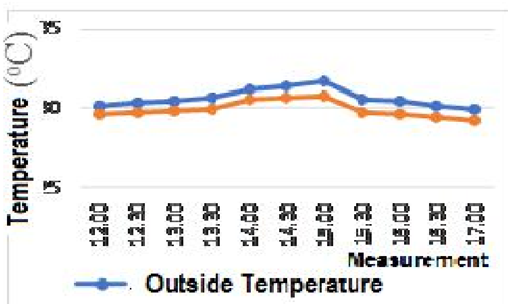

Fig 7. Temperature Measurement graph at noon

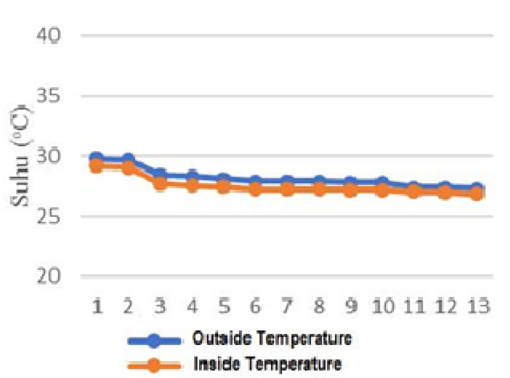

Fig 8. Temperature Measurement graph at night

The above tables and graphs show the measurements of the conditions in the greenhouse in the morning, afternoon and at night. On the measurement is seen that the system on the tool can work well, seen from changes in the speed of the fan motor when the condition of the temperature began to increase and the temperature decreased. The speed condition of the fan motor will be adjusted automatically using the fuzzy algorithm until the temperature inside the greenhouse is stabilized again. In the morning conditions, the system can achieve the ideal temperature for the chili plants. The system can achieve the desired setpoint due to the condition of the outside environment is stable enough so that the fan motor can stabilize the temperature as desired. The percentage of the average error value obtained when compared with the results of the set point is 2.48%.

In daytime conditions, the system can not reach the ideal temperature for chili plants. Temperatures obtained in daytime conditions ranged from 28oC to 30oC, it is due to environmental conditions that are a very influential large greenhouse, at daytime conditions the rotation speed of the fan motor is in maximum condition because the setpoint on the system is 27oC. Another factor that causes the temperature inside the greenhouse can not reach the setpoint is the fan motor is unable to lower the temperature inside the greenhouse because the greenhouse prototype uses only 12-volt dc fan motor to lower the temperature. The percentage of average error obtained if the measurement results compared with the setpoint is 9.79%.

At night conditions the system can run well with the system able to achieve the ideal temperature for the plants, at night temperature 27oC has been recovered, it is also influenced from outside environmental conditions that have returned in normal circumstances. To change the speed of the fan motor can also be seen when the temperature returns stable, where the fan motor speed decreases when the temperature has reached the setpoint. The average percentage error obtained when the measurement results compared with the set point was 1.93%.

4.2 Humidity Changes Against Watering Period

Changes in soil moisture are strongly affected for long periods of watering. Soils that are too wet or too dry can cause disturbed plant growth. The following data changes the soil moisture based on the duration of the given watering time.

TABLE II
HUMIDITY CHANGES BASED ON THE WATERING TIME

No	Plantation Pot	Time	Humidity Change	Level of Change (%)
			Humidity (%)	
1	Pot 1	0	51,04	0,39
		10 s	51,43	
2	Pot 2	0	50,32	0,53
		15 s	50,85	
3	Pot 3	0	47,74	1,07
		20 s	48,81	
4	Pot 4	0	48,03	1,36
		25 s	49,39	
5	Pot 5	0	49,29	1,75

		30 s	51,04	
6	Pot 6	0	47,04	1,92
		35 s	48,96	
7	Pot 7	0	47,64	3,3
		40 s	50,94	
8	Pot 8	0	48,71	3,78
		45 s	52,49	
9	Pot 9	0	47,74	5,05
		50 s	52,79	
10	Pot 10	0	49,2	5,14
		55 s	54,34	
11	Pot 11	0	50,65	6,11
		60 s	56,76	

4.3 Comparison of Temperature and Soil Humidity

The following is a test of temperature and soil moisture in greenhouses. Soil moisture is very influential to the growth of a plant the higher the temperature obtained by a plant so the soil moisture must be maintained so that the growth conditions of the plant keeps growing well.

TABLE III
HUMIDITY MEASUREMENT IN THE MORNING

No	Time	Greenhouse Temperature (°C)	Soil Humidity (%)	Water Pump
1	6:00	25,4	50,43	Off
2	6:30	26,6	50,23	Off
3	7:00	26,8	49,21	On
4	7:30	26,9	51,32	Off
5	8:00	27,1	51,15	Off
6	8:30	27,3	50,80	Off
7	9:00	27,5	50,42	Off
8	9:30	27,6	50,10	Off
9	10:00	27,8	49,21	On
10	10:30	28,5	51,32	Off
11	11:00	29,6	51,22	Off
Average Humididty			50,61	

TABLE IV
HUMIDITY MEASUREMENT AT NOON

No	Time	Greenhouse temperature (oC)	Soil Humidity (%)	Water pump
1	12:00	29,58	50,31	Off
2	12:30	29,72	49,40	On
3	13:00	29,85	51,40	Off
4	13:30	29,96	51,23	Off
5	14:00	30,54	50,10	Off
6	14:30	30,67	49,54	On
7	15:00	30,75	51,17	Off
8	15:30	29,73	50,24	Off
9	16:00	29,62	49,43	On
10	16:30	29,41	51,26	Off
11	17:00	29,24	50,64	On
Average Humidity			50,62	

TABLE V
HUMIDITY MEASUREMENT **AT NIGHT**

No	Time	Greenhouse temperature (oC)	Soil Humidity (%)	Water pump
1	18:00	29,17	50,78	Off
2	18:30	29,02	50,29	Off
3	19:00	27,68	49,88	On
4	19:30	27,56	51,65	Off
5	20:00	27,43	51,87	Off
6	20:30	27,25	51,68	Off
7	21:00	27,22	51,65	Off
8	21:30	27,21	50,24	Off
9	22:00	27,2	50,07	Off
10	22:30	27,18	49,55	On
11	23:00	27,02	51,31	Off
12	23:30	27	51,68	Off
13	24:00	26,82	51,28	Off
Average Humididty			50,91	

Based on soil moisture testing table above it is found that the system has been able to control the soil moisture with ideal humidity. RTCs are used to routine plant routines. Water is given to the plant in the morning at 07:00 p.m and in the afternoon at 17:00. In a soil moisture setting, the ideal soil moisture for chili planting is 50% - 70%. The temperature factor of the environment also affects the change of soil moisture, because the hot temperature causes the soil moisture to rapidly change from moist soil to dry. Soil moisture plays an important role in the growth of plants, plants that have soil that is dry or too wet can cause the growth of a plant. Basically, the growth of red chili plants is strongly influenced by temperature and soil moisture.

IV. CONCLUSION

Based on data and measurements on the prototype of temperature control and soil moisture in the greenhouse, the following conclusions are obtained.

1. The temperature sensor in this system has an overall average error to the thermometer as a comparison is equal to 2.66%.
2. The soil moisture sensor in this system has an overall average error of soil tester as a comparison is equal to3.07%
3. The percentage of error obtained to achieve setpoint value in the morning is 2.48%, during the day is 9,79%, and at night equal to 1,93%.
4. The inability of its tool to get the value of setpoint temperature during the day due to cooling that only uses 12-volt dc motor fan.
5. Soil moisture keeps increasing every 5 seconds add watering.
6. From the average obtained, each addition of 1 second of plant watering, the soil moisture rose by 0.067%.

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