Linearity of Soil Moisture in Residential Plants Using Soil moisture sensor YL-69

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***Abstract*— Planting media for plants is very important because various kinds of ornamental plants used in housing can grow well according to the needs of their respective conditions. Soil moisture is generally defined as the water contained on the unsaturated soil surface of the Earth. Soil moisture has an influence on the level of moisture needed by plants. The use of soil moisture sensor YL-69s is very popular, especially in the last 2 - 3 decades, where these sensors can review soil moisture and soil conditions in percentage form. However, how can the value of the soil moisture sensor YL-69 itself represent actual conditions? For this reason, a design was carried out with the aim of seeing the linearity value of the sensor. In the overall test the average error value produced has reached less than 3%. In this study, "Nor" conditioning needs to be developed again to further specify whether the plant's moisture needs require a separate percentage to reduce the margin gap that appears at the transition between dry and wet conditions. In this study, using the YL-69 soil moisture sensor produced an error value up to 6.16%, especially in the "Nor" condition with a conditioning difference of 13%.**

Keywords—Soil moisture sensor YL-69, NodeMCUESP8266, Linearity

I. INTRODUCTION

The fertile expanse of Indonesian soil, coupled with its tropical climate, has established the nation as an agrarian society, with agriculture serving as a defining aspect of Indonesia's identity. In essence, agriculture encompasses activities related to the field of cultivation, emerging as a primary economic source requiring effective management for the majority of the Indonesian population [1, 2]. Planting media for plants, especially ornamental plants, is very important because various kinds of ornamental plants used in housing can grow well according to the needs of their respective conditions [3, 4]. In Indonesia itself, ornamental plants are popular in residential areas. Apart from beautifying the aesthetics of the house, the benefit of ornamental plants is that they also provide oxygen (O2) which humans need for breathing [5, 6].

Soil moisture is generally defined as the water contained on the unsaturated soil surface of the Earth, which originates from rainfall, from snowmelt or by the capillary attraction of the soil. Soil water content is an important component of climate, hydrology, and ecological systems. The classical estimate of global soil moisture is about 70 x 103 km3 (0.005% of the earth's total volume), with an extension time of 280 days [7-9]. The role of soil moisture (SM) is the main factor in the development of vegetation on earth. Coupled with the high demand for water in the atmosphere, this leads to vapor pressure deficit (VPD) [10, 11]. Soil moisture has an influence on the level of moisture needed by plants. For this reason, the use of soil moisture sensor YL-69 is very popular, especially in the last 2 - 3 decades, where these sensors can review soil moisture and soil conditions [12, 13]. In addition, with the presence of soil moisture sensors, many farmers and flower sellers can create automatic watering systems that can water based on the needs of the plants [14-16].

However, how can the value of the soil moisture sensor YL-69 itself represent actual soil moisture conditions? For this reason, a design was carried out with the aim of seeing the linearity value of the sensor which was carried out. Even though climate change in Indonesia itself is not too fluctuating, it is necessary to test the linearity of the soil moisture sensor YL-69 to be able to carry out automatic monitoring and controlling functions accurately.

II. METHODS

To gain reliable data, several steps are carried out start from requirements analysis stage, design stage, and testing stage as can be seen in Fig. 1.

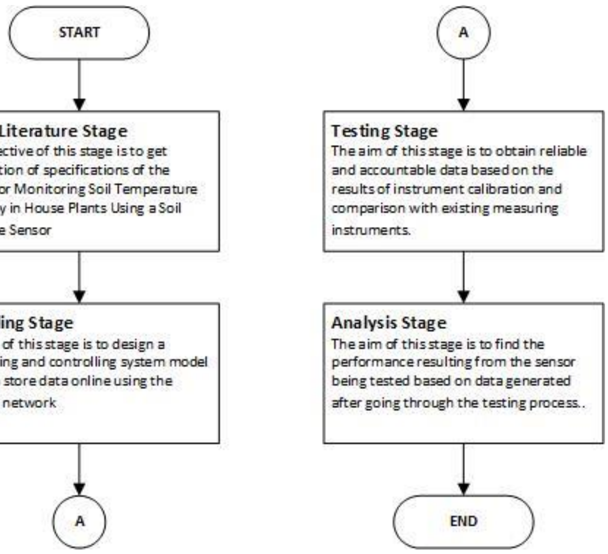

Fig. 1. Research flow diagram

A. *Monitoring and controlling system*

In this section, researcher designing the system chart block diagram before implement it on ornamental plants. To be able to obtain soil moisture, a soil moisture sensor YL-69 is used which can measure the percentage of moisture in the soil structure based on the resulting resistance value by looking at

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ISSN 0216-8685 (print); 2528-6889 (online)

two conditions where more water in the soil means better conductivity which will result in lower resistance and vice versa. Then, in order to carry out monitoring and control functions, the NodeMCU ESP8266 is used which can forward information via the Wi-Fi network to transmit data that has been read to the sensor. Next, the data from the sensors will be forwarded and stored on the Thingspeak website as can be seen in Fig. 2.

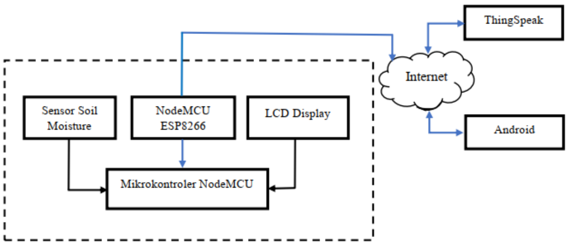

Fig. 2. Diagram Block System

Based on the monitoring and control system requirements, create a hardware design with wiring between components which can be seen in Fig. 3.

Fig 3. Hardware Design

B. *Calibration Process (Drying Method)*

To get accurate results, the sensor requires a calibration process before testing. In the calibration process, the technique of adding water discharge periodically from normal conditions is used with an addition rate of 10 ml in each calibration process up to 100 ml of water. In each calibration process, the amount of water added will be mixed first into the planting medium before measurements are carried out with the aim of ensuring that the moisture conditions in the soil are evenly distributed. It should also be noted that in this test a planting medium was used in the form of burnt husks as can be seen in Fig. 4.

Fig. 4. Calibration process on roasted husk planting media

The calibration process is initiated by using a soil sample that is heated to ensure that the soil sample to be used is dry soil before adding water discharge. The weight of the soil sample will be weighed. Water is then added to the soil with an additional figure of 10 ml, then mixed to ensure the soil has even moisture, then weighed again so that it meets the following formula:

$$Soil\ Moisture\ Content\ (\%) = \frac{W}{M} x\ 100 \quad (1)$$

M is the weight of soil before drying, W is the weight of soil moisture, that is, the difference between M and the weight of soil after drying M'

C. *Comparison Process*

The comparison process is carried out by using two types of similar sensors that are calibrated and treated the same. Then the results from the two sensors will be compared with the readings produced from the measuring instrument. The process of reading data from the soil moisture sensor YL-69 is greatly influenced by the weight of the soil or planting media used. Therefore, in this comparison process there is no addition or reduction in the volume of planting media to be able to see the linearity of the measurements that occur. For the reading process, the comparison process itself can be seen in Fig. 5.

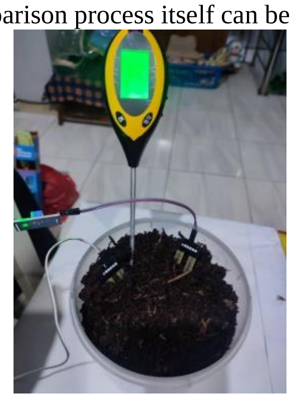

Fig 5. Comparison process

III. Results and Discussion

Based on the design that has been made, a monitoring and control system has been produced that is connected to Thingspeak and can carry out automatic watering based on the soil moisture values that are read. However, the focus of this research is to see the level of linearity of the soil moisture sensor YL-69 by comparing the reading data produced with the same calibration process. The system that has been formed can be seen in Fig 5. and Fig. 6.

Fig. 5. System implementation on ornamental plant

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Fig. 6. Finished hardware

A. *Calibration Result*

Based on the results of the calibration carried out, it was found that there was a difference between the measurements of soil moisture presentation values where in this study using burnt husks the results were obtained as shown in Table 1

TABLE 1. CALLIBRATION TEST RESULT

Water addition (ml)	Data Result (%)	Calculation Result (%)	Error (%)	Condition
0	1.13	1.14	0.88	Dry+
10	7.32	7.47	2.01	Dry
20	13.31	13.61	2.20	Nor
30	15.69	16.1	2.55	Nor
40	17.43	18.08	3.60	Nor
50	21.32	21.73	1.89	Wet
60	27.53	28.44	3.20	Wet
70	29.42	29.64	0.74	Wet
80	31.17	31.67	1.58	Wet+
90	39.23	40.78	3.80	Wet+
100	44.82	45.97	2.50	Wet+
Average of Error			2.27	

In the sensor calibration test results, it was found that there was a fluctuating difference between the calculation results and the output results from the sensor with an average value of 2.27 %. This can occur during the process of mixing and weighing soil which is less than proportional. Fluctuations in error values can occur in all conditions including Dry+, Dry, Nor, Wet, and Wet+. However, we can observe that even though there are error values, in Fig. 6, the response graph of the output data produced by the moisture sensor shows values that are linear with the calculation results.

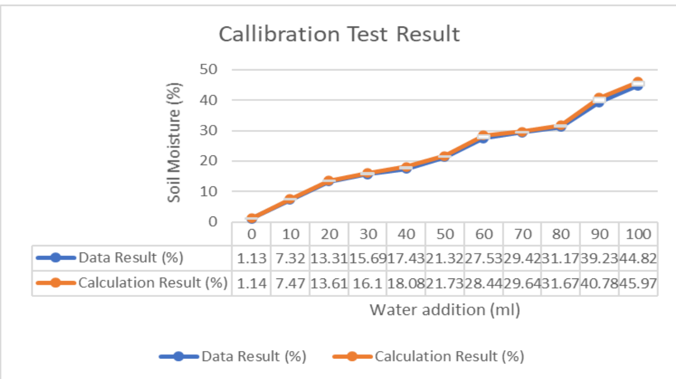

Fig. 7. Output data of calibration test result

B. *Comparison Result*

After get calibration test result, to ensure reliability of soil moisture YL-69 sensor, comparison has been done by testing two sensor soil moisture that has been calibrated before and soil meter as measurement instrument. Sensor measurements by comparing similar sensors and measuring instruments are carried out to see whether the data produced is linear based on changes in conditions that occur. In this test, data resulting from adding 10 ml of water. However, in this test the ornamental plants used were placed under conditions which is the growth ornamental plants is not concern of this research. Based on the result of calibration test, to ensure monitoring and control process, external results testing is carried out by determining the soil moisture condition category which is determined with the limits of each value as shown in table 2 to trigger the water pump to provide water to the plants.

TABLE 2. SOIL MOISTURE CATEGORY SETS VALUE

Soil Moisture (%)	Condition
$0 \leq 5$	Dry+
$5 \leq 7$	Dry
$7 \leq 20$	Nor
$20 \leq 25$	Wet
$25 \leq 30$	Wet+

After taking comparative data on the calibrated YL-69 sensor and the soil meter, the results were obtained showing the margin average of error less than 3% of the response to changes in soil moisture values as can be seen in table 3.

TABLE 3. COMPARISON TEST RESULT

No.	Penambahan air (ml)	Sensor Soil Moisture I	Sensor Soil Moisture II	Soil Meter	Soil Moisture Condition
1	0	2.54	2.05	2.3	Dry+
2	10	9.84	8.31	8.8	Dry
3	20	13	13.88	13.98	Nor
4	30	17.5	14.27	17.5	Nor
5	40	19.55	16.52	19.06	Nor
6	50	25.81	20.43	24.04	Wet
7	60	28.64	27.76	28.93	Wet
8	70	29.81	29.42	29.49	Wet
9	80	30.99	30.4	31.26	Wet+
10	90	39.69	39.1	39.05	Wet+
11	100	43.7	46.82	45.75	Wet+

Refer on the comparison test result, the lowest value of the error rate that appears in the experiment is 0.22% which is found in dry conditions. If we look at the comparison results, the error value found has the largest margin of error between dry and wet conditions (Nor) when water is added in quantities of 20, 30 and 40 ml, where on average an error of 6.16% occurs. Meanwhile, for more specific conditions such as Dry+, Dry, Wet and Wet+ with respective percentage error values of 0.22%, 3.12%, 2.26% and 1.25%. To clarify the linearity relationship in this research, it can be seen in Fig. 7. In this case, limits on soil moisture conditions are also included based on the percentages from Table 2.

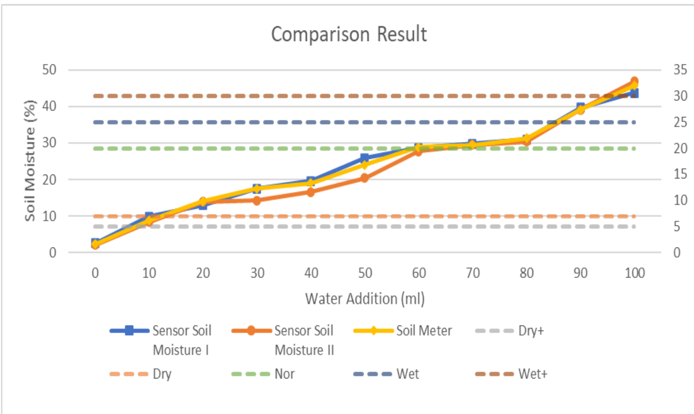

Fig. 7. Output data of calibration test result

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ISSN 0216-8685 (print); 2528-6889 (online)

IV. Conclusion

The hardware and software are well connected so that they can display graphs according to the actual temperature that has been measured. The program will respond if the plant soil moisture is too dry by provisions that have been programmed/set. Even though in the overall test the average error value produced has reached less than 3%, there is a need for further depth in determining the condition of the plant, which is neither dry nor wet. Currently, triggering is only carried out under certain conditions, namely if the soil moisture has reached the dry or wet category. If necessary, "Nor" conditioning needs to be developed again to further specify whether the plant's moisture needs require a separate percentage to reduce the margin gap that appears at the transition between dry and wet conditions. In this study, using the YL-69 soil moisture sensor produced an error value of up to 6.16%, especially in the "Nor" condition with a conditioning difference of 13%.

In this research, the monitoring and controlling function is only an indicator that shows the design can function based on changes in soil moisture values. Further discussion is needed which focuses on the quality of the data produced along with the influence of the plants themselves if the design is applied in an open environment with changing weather conditions.

Acknowledgment

This publication research was supported by grants from Research Management Centre of Jakarta Global University.

References

[1] N. D. Rahayu, B. Sasmito, and N. Bashit, "Analisis pengaruh fenomena Indian Ocean Dipole (IOD) terhadap curah hujan di pulau Jawa," *Jurnal Geodesi Undip,* vol. 7, no. 1, pp. 57-67, 2018.

[2] A. Savelli *et al.*, "Climate-Smart Agriculture in Indonesia," *CSA Country Profiles for Asia Series,* 2021.

[3] T. Nuraya, "Pelatihan Pembuatan Media Tanam Untuk Tanaman Hias dan Tanaman Toga," *Prosiding Penelitian Pendidikan dan Pengabdian 2021,* vol. 1, no. 1, pp. 677-682, 2021.

[4] T. Batool *et al.*, "Plant growth promoting rhizobacteria alleviates drought stress in potato in response to suppressive oxidative stress and antioxidant enzymes activities," *Scientific Reports,* vol. 10, no. 1, p. 16975, 2020.

[5] H. Hamidah, "BUDIDAYA TANAMAN HIAS SKALA RUMAH TANGGA," *Jurnal Pengabdian Kreativitas Pendidikan Mahakam (JPKPM),* vol. 3, no. 2, pp. 140-144, 2023.

[6] C. S. Rocha, D. C. Rocha, L. Y. Kochi, D. N. M. Carneiro, M. V. Dos Reis, and M. P. Gomes, "Phytoremediation by ornamental plants: a beautiful and ecological alternative," *Environmental Science and Pollution Research,* pp. 1-19, 2022.

[7] Y. Deng *et al.*, "Variation trend of global soil moisture and its cause analysis," *Ecological Indicators,* vol. 110, p. 105939, 2020.

[8] W. Dorigo *et al.*, "The International Soil Moisture Network: serving Earth system science for over a decade," *Hydrology and earth system sciences,* vol. 25, no. 11, pp. 5749-5804, 2021.

[9] Y. Liu and Y. Yang, "Advances in the Quality of Global Soil Moisture Products: A Review," *Remote Sensing,* vol. 14, no. 15, p. 3741, 2022.

[10] D. L. Hoover, A. A. Pfennigwerth, and M. C. Duniway, "Drought resistance and resilience: The role of soil moisture–plant interactions and legacies in a dryland ecosystem," *Journal of Ecology,* vol. 109, no. 9, pp. 3280-3294, 2021.

[11] F. Zhao, G. Wang, S. Li, D. F. T. Hagan, and W. Ullah, "The combined effects of VPD and soil moisture on historical maize yield and prediction in China," *Frontiers in Environmental Science,* vol. 11, p. 1117184, 2023.

[12] L. Yu *et al.*, "Review of research progress on soil moisture sensor technology," 2021.

[13] H. Husdi, "monitoring kelembaban tanah pertanian menggunakan soil moisture sensor fc-28 dan arduino uno," *ILKOM Jurnal Ilmiah,* vol. 10, no. 2, pp. 237-243, 2018.

[14] D. B. Anggoro, A. P. Sari, V. Sharaswati, O. P. Sari, and A. Muamar, "Penyiram Tanaman Otomatis Menggunakan Soil Moisture Berbasis Arduino Uno," in *SEMINAR NASIONAL TEKNOLOGI INFORMASI & KOMUNIKASI,* 2021, vol. 1, no. 1, pp. 183-190.

[15] D. D. Yoridho, S. H. Adi, and R. Siskandar, "Rancang Bangun Sistem Navigasi Kekeringan dan Meluapnya Air pada Lahan Berbasis web di BALITKLIMAT," *Jurnal Sains Indonesia,* vol. 1, no. 3, pp. 144-151, 2020.

[16] M. Jefri, "Implementasi IoT Penyiraman Tanaman Sawi Menggunakan esp2866 dan Construct 2," *Jurnal Portal Data,* vol. 2, no. 4, 2022.

ISSN 0216-8685 (print); 2528-6889 (online)