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# Comparison between Manual Irrigation System and Automatic Irrigation System Based-on Soil Moisture

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***Abstract***— *Food productivity is one of the vital factors of human's need. Nowadays, food productivity rate is unsustainable with the food demand. The crop's quality and quantity tend to get lower as the climate starts getting extremely erratic. The degradation of quality and quantity are also depended on the decreasing number of the farmer. This condition is also worsened by the water scarcity. To prevent the deterioration, we need to take a deeper look on what matters on the crop's growth which is soil moisture. Soil moisture can dissolve the minerals in soil to help crops meet their nutritional needs. The research alternative way of maintaining the soil moisture is to have an automatic irrigation system using microcontroller and soil moisture sensors. This technology can increase the effectiveness of water usage on irrigation system. From this experiment, we have observed that the automatic irrigation system can provide a sustainable water resources to keep the soil moisture stable.*

***Keywords***— *Agricultural, irigation, agricultural technology.*

## I. INTRODUCTION

Water is a component of the earth that has a fundamental role in the life of an organism (Deng, Wang, Li, Zhao, & Shangguan, 2016). Water availability is a primary living condition that constraint plant communities in such terrestrial, unexceptionally in Indonesia. The plant characteristics differentiate based on each area's condition. Besides, the previous study shows that decreasing soil moisture causes a decrease in the majority of yield (Mulyaningsih, 2014).

Lack of moisture in the soil causes the plant to grow slower. However, land productivities of plant yields increase under the wetter area (Alves, Pinheiro, Jong, Lier, & Jirka, 2019). The wetter area can provide a better habitat for other organisms such a bacteria and fungi to help the plant fulfil their nutrition needs. In terms of plant growth itself, the moisture helps to keep the soil precipitation resistance so the root can ramify and absorbs more nutrition rather than only grow into deeper soil layer to obtain water(Colombi, Chagas, Walter, & Keller, 2018).

Water shortage is a major factor that negatively affects agricultural (Darré, Cadenazzi, Mazzilli, Rosas, & Picasso, 2019). Groundwater drilling, unpredictable climate change, and deforestation play a role as the causes of the speed-up water shortage rate. According to FAO, climate change takes a role in threatens food security. Greenhouse gas (GHG) emissions from human activity and livestock are a significant driver of climate change, trapping heat in the earth's atmosphere and triggering global warming. The drought rate was increased for the past time years causing water shortage. As a result, the upper layer of the soil was lack of moisture and cannot be used as a plant habitat

To prevent deterioration, the irrigation system is needed to maintain the food productivity rate. Irrigation has a significant effect on soil pH values and increases in pH can attribute to a chemical reaction of soluble salts presents in soil and groundwater (Nawaz et al., 2019). To achieve the ought result, a sustainable irrigation system is required. This paper would like to introduce the automatic irrigation system that provides flexible settings to achieve the better condition for the plants to grow using the soil moisture sensor and microcontroller and expound the comparison between manual and automatic irrigation system.

## II. MATERIAL AND METHODS

### A. Average Climate

Since Indonesia is located on the equator, Indonesia has tropical climate. Region on the coastal plains have average temperature of 28$^{o}$C, while the inland and mountains areas have average temperature of 26$^{o}$C. Moreover, higher areas have average temperature of 23$^{o}$C. The main variable that affects climate change in Indonesia is rainfall. On the other side, variations of rainfall in Indonesia itself is affected by monsoons. Hence, because of that reason, Indonesia has two seasons. Those are dry seasons and rainy seasons.

Monsoons clouds moves to north and westward of Indonesia region and cause Western Sumatra, Java, Bali, the interiors of Kalimantan, Sulawesi, and Irian Jaya tend to be damp region. Monsoons clouds can increase the humidity of those regions because when they have reached those distance, they are going to be heavily moisturized.

### B. In Situ Soil Measurements

Two different irrigation system was inserted in two different areas. The first area used the automatic irrigation system and the other used the manual irrigation system. The main component of the automatic irrigation system was the microcontroller. This component controlled the amount of resistance that was needed for certain soil moisture levels. The manual irrigation system consisted of installed 58m- long pipe

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with 4 sprinklers and only turned on at 07.00 A.M. and 03.00 P.M. To compare both of the systems, the starting soil moisture level is the same, which was at level 7 and measured using water volume meter. During the experiment time, the soil moisture level would be measured to see the soil moisture level fluctuation from each system.

The soil meter was inserted in each irrigation system with the same depth as the soil moisture sensors, which was 25cm below the soil surface. The soil meter measured the pH level and soil moisture fluctuation every 3 hours from 07.00 A.M. until 07.00 P.M. for 3 days straight.

### C. Automatic Soil Irrigation System

Water irrigation is needed to prevent deterioration on water supply and soil moisture stability. Soil moisture fluctuation can be stabilized efficiently by using automatic irrigation system which use sensor as inputs and produce 12V output to make solenoid change its condition become normally opened and let the pumped water stream through the sprinkler. The voltage can only supply the solenoid when the sensor in its area get a high resistance input. The wetter the soil, the sensor resistance is going to be lower and so is the other way around. Since the automatic irrigation system is capable to stabilize soil moisture, that means water that is used to keep the soil moisture stability will be more efficient. So the water usage for the crop will be suitable for the soil needs. Hence, the benefits by using automatic irrigation system are water efficiency and stability of soil moisture fluctuation.

The soil moisture is divided into 10 levels, which is in every level marked with range of resistance that is the input by the sensor. First level of the soil moisture symbolizes the driest condition of the soil. The sensor shows resistance of 1024 ohm. In the other side, while soil is in the wettest condition, the sensor shows resistance of 0 ohm. Moreover, every range level of the soil moisture contain around 100 ohm.

## III. Result and Discussion

TABLE I. Soil Moisture Measurement Using Manual Methods

| Time \ Date | 30th June | 1st July | 2nd July |
|---|---|---|---|
| 7:00 AM | 7 | 8 | 7 |
| 10:00 AM | 5 | 7 | 4 |
| 1:00 PM | 3 | 3 | 3 |
| 4:00 AM | 6 | 5 | 4 |
| 7:00 PM | 7 | 7 | 7 |

Table I and II shows soil moisture data that is measured by the soil meter at a depth of 25 cm from the ground. The crop was watered at 7:00 A.M. and 3:00 P.M.. While using manual methods of irrigation, the highest soil moisture is at 7:00 A.M., after that the soil moisture of the crop will decrease continuously. On June 30th, 2019, at 7:00 A.M. the soil moisture was on the seventh level, at 10:00 A.M. and 1:00 P.M. the soil moisture of the crop was on the fifth and third level. The soil moisture increased at 4:00 P.M. and 7:00 P.M., with the soil moisture level of 6 and 7. This condition also happened in the next few days. On July 1st, at 7:00 A.M. it's on the eighth level, at 10:00 A.M. it's on the seventh level, at 1:00 P.M. it's on the third level, at 4:00 P.M. it's on the fifth level, and at 7:00 P.M. it's on the seventh level. This pattern of soil moisture fluctuation did happen as well on July 2nd as the data shown in Table I.

TABLE II. Soil Moisture Measurement Using Automatic Irrigation System

| Time\Date | 30th June | 1st July | 2nd July |
|---|---|---|---|
| 7:00 AM | 7 | 8 | 7 |
| 10:00 AM | 7 | 7 | 7 |
| 1:00 PM | 7 | 7 | 6 |
| 4:00 AM | 7 | 7 | 7 |
| 7:00 PM | 7 | 7 | 7 |

Table II On the automatic irrigation system, the soil moisture level was quite stable. On 30th June 2019, the soil moisture level resulted in level 7. In 1st of July 2019 at 07.00 A.M., soil moisture level was at level 8 and was found stable at level 7 afterward. On the 2nd of July 2019, soil moisture level was measured stable in level 7. It shows that automatic irrigation provides soil moisture stability for 3 days straight.

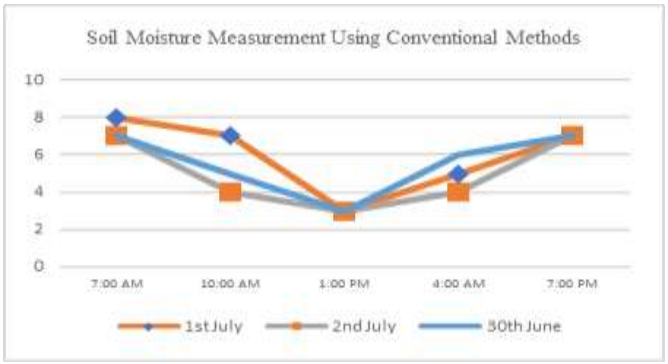


Fig. 1. Soil Moisture Using Manual Methods

However, the manual irrigation system only provides enough soil moisture levels. In the same 3 days as the automatic one, the manual irrigation system is relatively decreased in soil moisture level over time. The land with the manual irrigation system only can be moistened when watered or exposed by rain. Soil moisture level in the manual irrigation system was inconsistent due to the decreased soil moisture level during the experiment shown in Fig. 1. There was a fluctuation of soil moisture level caused by changes in temperature. The temperature triggered water evaporation caused the loss of soil moisture. As seen in Fig. 2. which shows the average temperature in Semarang City, the maximum temperature during the day was around 11.00 A.M. until 01.00 P.M.

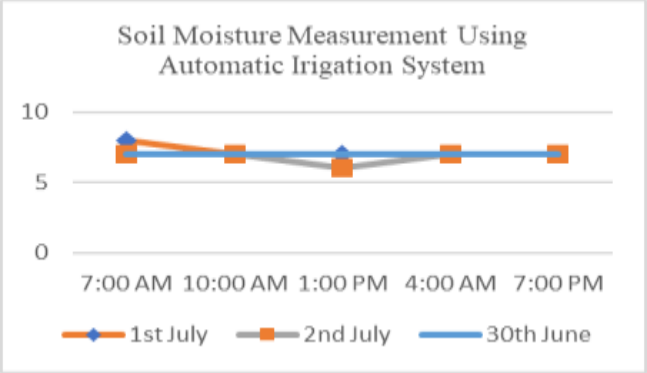


Fig. 2. Soil Moisture Using Automatic Irrigation System

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The difference between these two irrigation system is the ability to maintain the soil moisture level. The automatic irrigation system consistently maintaining the soil moisture level to be in level 7. The sensor will triggered the system to waters the soil when the soil moisture level becoming too low. As an outcome, the soil moisture can be maintained in the stable state. In this case, the soil moisture data mode was at level 7. Nevertheless, there is two aberration was found in soil moisture level which is in 1st of July 2019 at 07.00 A.M. with soil moisture level is 8 and 2nd July 2019 with soil moisture level is 6. This aberration was caused by the air humidity in the morning that affected the soil moisture level. Condensed vapor in the morning that was trapped in the soil can increase the soil moisture level significantly. Other than that, the aberration occurred in 2nd July 2019 was caused by the soil moisture variable that has not reaching the resistance level of the soil moisture sensors. As a result, there was no watering activity.

TABLE III. PH Measurement Using Automatic Irrigation System

| **PH Measurement Using Automatic Irigation System** | | |
|---|---|---|
| 30th June | 7:00 AM | 7,9 |
| | 10:00 AM | 7,89 |
| | 1:00 PM | 7,89 |
| | 4:00 AM | 7,87 |
| | 7:00 PM | 7,87 |
| 1st July | 7:00 AM | 7,86 |
| | 10:00 AM | 7,86 |
| | 1:00 PM | 7,86 |
| | 4:00 AM | 7,85 |
| | 7:00 PM | 7,85 |
| 2nd July | 7:00 AM | 7,85 |
| | 10:00 AM | 7,85 |
| | 1:00 PM | 7,84 |
| | 4:00 AM | 7,84 |
| | 7:00 PM | 7,83 |

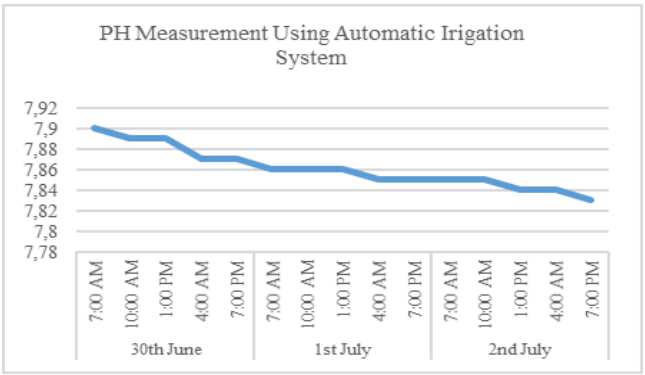


Fig. 3. PH Measurement Using Automatic Irrigation System

Fig. 3. show the pH level of the soil in each area. Decreases of pH level happened both on the automatic irrigation system and manual irrigation system. The starting pH level in automatic irrigation system as well as the manual irrigation system was 7,90. During the sunlight, the pH level on the automatic irrigation system decreased into 7,89 (10.00 A.M.) and 7,87 ( 04.00 P.M.) on the first day. The second day, first pH level at 07.00 A.M. was 7,86. The pH level was relatively decreased into 7,85 (04.00 P.M.). On the third day, the starting pH level was 7,83 and also it was decreased over time.

TABLE IV. PH Measurement Using Automatic Irrigation System

| **PH Measurement Using Conventional Methods** | | |
|---|---|---|
| 30th June | 7:00 AM | 7,9 |
| | 10:00 AM | 7,9 |
| | 1:00 PM | 7,9 |
| | 4:00 AM | 7,9 |
| | 7:00 PM | 7,9 |
| 1st July | 7:00 AM | 7,89 |
| | 10:00 AM | 7,89 |
| | 1:00 PM | 7,89 |
| | 4:00 AM | 7,89 |
| | 7:00 PM | 7,89 |
| 2nd July | 7:00 AM | 7,88 |
| | 10:00 AM | 7,88 |
| | 1:00 PM | 7,88 |
| | 4:00 AM | 7,87 |
| | 7:00 PM | 7,87 |

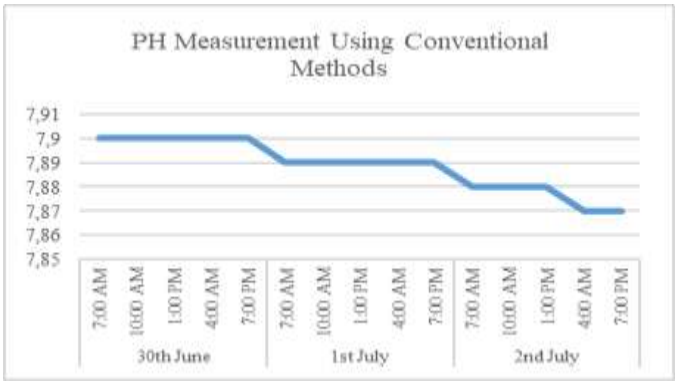


Fig. 4. pH Measurement Using Manual Methods

On the manual irrigation system, the pH level was relatively decreased each day. The starting pH level was 7, 90. On the second day, it was decreased into pH level 7,89 at 07.00 A.M. on the third day, the pH level was also decreased into 7,87.

The suitable pH level for most of the crops is approximately 5,5-6,5. The pH level in the soil affects directly to the growth of the crops because pH value can attribute the chemical reaction of soluble salts presents in soil (Nawaz et al., 2019). Also the suitable pH level provides good environment for many microorganisms which contribute many

chemical decomposition (Wijanarko, 2004). Based on the data, both of land has the same soil pH level which was 7,9. Moderate watering system is capable to maintain the soil pH level. As shown in the Fig. 4., the lowering pH level was more significant in the automatic irrigation system rather than in the manual irrigation system. In the stable situation, this would affect the growth of the crop so that the crop grows optimally.

## IV. CONCLUSION

An application of automatic irrigation should be considerated more as an option to achieve sustainable agriculture in Indonesia, because by using sensor as control irrigation, water usage for the irrigation can be used efficiently and the soil moisture fluctuation is also stabilized constantly.

## REFERENCES

[1] Alves, E., Pinheiro, R., Jong, Q. De, Lier, V., & Jirka, Š. (2019). The role of soil hydraulic properties in crop water use e ffi ciency : A process- based analysis for some Brazilian scenarios, *173*(December 2018), 364–377. https://doi.org/10.1016/j.agsy.2019.03.019

[2] Colombi, T., Chagas, L., Walter, A., & Keller, T. (2018). Science of the Total Environment Feedbacks between soil penetration resistance , root architecture and water uptake limit water accessibility and crop growth – A vicious circle. *Science of the Total Environment*, *626*, 1026–1035. https://doi.org/10.1016/j.scitotenv.2018.01.129

[3] Darré, E., Cadenazzi, M., Mazzilli, S. R., Rosas, J. F., & Picasso, V. D. (2019). Environmental impacts on water resources from summer crops in rainfed and irrigated systems. *Journal of Environmental Management*, *232*(October 2018), 514–522. https://doi.org/10.1016/j.jenvman.2018.11.090

[4] Deng, L., Wang, K., Li, J., Zhao, G., & Shangguan, Z. (2016). Effect of soil moisture and atmospheric humidity on both plant productivity and diversity of native grasslands across the Loess. *Ecological Engineering*, *94*, 525–531. https://doi.org/10.1016/j.ecoleng.2016.06.048

[5] Mulyaningsih, S. (2014). ( Nicotiana tabacum L ; Solanaceae ) TEMANGGUNG PADA TIGA JENIS TANAH * [ Soil Moisture Effects on Agronomic Characters , Yield and Nicotine Content of Temanggung Tobacco ( Nicotiana tabacum L ; Solanaceae ) at Three Types of Soil ], 1–11.

[6] Nawaz, A., Uris, M., Kumar, R., Ahmed, I., Hussain, M., & Ahmed, S. (2019). Acta Ecologica Sinica Effects of irrigation frequencies on soil salinity and crop water productivity of fodder maize. *Acta Ecologica Sinica*. https://doi.org/10.1016/j.chnaes.2019.05.013