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# Irrigation Water Supply Patterns in Several Land Uses with Automated Application of Soil Moisture Monitoring Based on Dielectric Technology

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## ABSTRACT

*Indonesia is a necessary to develop an increase in the soil productivity. The decline in soil productivity for agriculture can be caused by several factors, namely land conversion to a decrease in the quantity of ground water. The actual pattern of providing irrigation water with the application of dielectric sensor technology is carried out in soil cultivation in order to create efficiency in providing irrigation water. This research was conducted using a single factor experimental method with repeated measurements on three types of land use, such as land without vegetation, soil with tomato cultivation, and soil with grass. Measurements were carried out using an automated application of soil moisture monitoring based on dielectric technology with two measuring periods. Each measuring period consists of two weeks or fourteen days. Soil sample analysis was carried out at the Bengkulu University soil laboratory. The results of the observations were analyzed using variance (ANOVA) on the 5% F test table, the LSD test was carried out at the 5% level on data that had a significant effect. The results showed that the daily irrigation water for vegetated land was lower than for tomato cultivation and without vegetation in each measurement period. The frequency of irrigation water application in the two observation periods also showed that the land without vegetation had a higher amount and frequency of water application compared to the other two types of land use.*

*Keywords :* *dielectric, irrigation water, land use, tomato*

## INTRODUCTION

Indonesia's development towards advanced and resilient agriculture cannot be separated from agriculture that has been developed thousands of years ago. After assuming the status of an agrarian country with people's livelihoods and the country's needs being fully supported by the agricultural sector, Indonesia needs to re-develop agriculture from various aspects, one of which is irrigation on agricultural land. Although what is often questioned is the conversion of agricultural land, a more serious threat to future food supply is the reduced water supply (Rosegrant & Hazell, 2000). Irrigation is something that needs to be considered in the development of the agricultural sector because in accordance with the needs of the commodity being cultivated will be one of the determining factors for the success of agricultural production.

Irrigation is the addition of artificial water shortages, namely by providing water systematically to the cultivated land. In general, irrigation aims to increase the lack of water from the rainwater supply for plant growth, provide protection during temporary droughts and make the plant growth environment more conducive through lowering soil temperature (Arsyad, 2010[2]). Bulk irrigation or overhead irrigation is a method of providing irrigation water to the soil surface through high pressure pipes and pouring it into the air in the form of small water droplets that resemble rain. The bulk irrigation system consists of several units of constituent components, such as irrigation water sources, water pumps and their propulsion, piping networks, and sprinklers.

Land cover can affect the availability of ground water due to changes in the value of the infiltration rate that enters the soil. The amount of vegetation factors that affect infiltration is seen from the amount of water that reaches the soil surface that has experienced stem flow and water escapes. In forested areas the runoff coefficient is 19.88% and in open land 49.20% (Arsyad, 2010[1]). So that indirectly vegetation is included in the factors that affect infiltration. Factors that affect infiltration in general are soil texture, type of vegetation, biological activity, groundwater depth, soil moisture, and soil permeability (Utaya, 2008).

Vegetated land generally absorbs more water because surface litter reduces the impact of raindrops, as well as organic matter, microorganisms and plant roots which tend to increase porosity and stabilize soil structure. Vegetation also depletes groundwater to deeper layers, increases the soil's water-holding capacity, and causes higher infiltration rates. This effect is more significant in forest cover where roots will penetrate deeper and the rate of evapotranspiration is greater. Covering litter and undergrowth will also create a soil microclimate for plant growth. Vegetated land has a high relative humidity when compared to dry, sandy, and the like conditions which tend to cause high temperatures and low humidity. This is due to dry soil conditions that will directly receive sunlight without shade and the reflection of sunlight from the vegetation above it, while for vegetated land it will have an effect on the creation of a cooling effect around by lowering the air temperature and increasing the relative humidity value (Shahidan *et al.,* 2012).

Different land uses will also have an impact on different soil characteristics, so in this case the infiltration rate will also affect. Infiltration is a very related component in the field of land conservation, because infiltration is a regulator of the relationship between rainfall intensity and infiltration capacity, as well as surface runoff. Surface flow can be regulated by increasing the ability of the soil to store water, in this case infiltration is the ability of the soil to accommodate water that enters the soil in unit time. In addition, the infiltration rate will decrease with the influence of the increase in water content or moisture from the soil (Asdak, 2004).

Soil moisture control is not easy to do manually to get the appropriate dose for each type of plant. Therefore, a technique that is able to provide convenience in controlling soil moisture is needed through irrigation automation. In addition to system operations that can simplify and also provide validation of plant requirements, this technique can minimize work in irrigation monitoring and can also be a solution in an optimal irrigation system in real time. The application of dielectric sensors in controlling the mechanical work of irrigation systems has been widely applied in various countries. For example, using seven basic components in an automatic irrigation system, consisting of a structured data type, a DC pump motor, a battery charger, a water storage tank, a soil moisture sensor, a water flow control valve, and an Arduino system on an electronic control unit (Senpinar, 2019). In China, the automation of irrigation systems like this is used to carry out conservation actions in grassland areas to determine the geospatial distribution according to the applied technology (Campana *et al.,* 2017).

## MATERIALS AND METHODS

This research was conducted from October 2021 to January 2022 at the Soil Science Laboratory Park, Faculty of Agriculture, Bengkulu University. The materials used in the study were water, tomato plant seeds, fertilizer, and secondary data as support. The tools used are dielectrometer, pipe/paralon, water tank, sprinkler, soil moisture sensor cable, water flow regulator pole, dc water pump, PDAM water meter, wifi repeater/router/ap, socket, adapter, spc power supply..

This study used a single factor experimental method with repeated measurements. The factors tested were land cover with three levels, namely land without vegetation cover and soil with grass and tomato plants. Measurements were carried out every day, the measurement results were grouped into two periods where each period consisted of two weeks or 14 days at the same time functioning as a test.

A plot of land measuring 5 x 15 $m^2$ is divided into three, each without and with cover vegetation (grass and tomato plants). Three pairs of sensors 20 cm long were inserted into the soil in each plot, so the sensors would monitor and control soil moisture at a depth of 0-20 cm. The sensor probe is connected to a dielectrometer capable of monitoring soil moisture. Water tanks/tubes are prepared as a source of irrigation water. The tank/tube is connected to a faucet that can work automatically according to commands from the sensor on the dielectrometer. The dielectrometer sensor will send a signal to open the faucet when the soil moisture content drops to 0.20 g $g^{-1}$ or about 50% of the available water content. The faucet is connected by a hose/pipe to the sprinkler in each plot. The dielectrometer sensor will send a signal to close the tap when the soil moisture content has reached field capacity conditions.

Land preparation was carried out by dividing a plot of 5 x 15 $m^2$ grass vegetated land into three plots measuring 5 x 5 $m^2$ each, spraying two plots with herbicide, after the grass died one plot was planted with tomatoes. Tomato seedlings were planted after 1 week of spraying herbicides on the plots and after tillage.

A pair of sensor cables with the bottom stripped 20 cm long will be inserted into the soil profile in each plot to monitor and control soil moisture at a depth of 0-20 cm. The dielektometer is set to send a signal to open the tap when the soil moisture content drops to 0.20 g $g^{-1}$, so that the device is also set to close the tap when the soil moisture content approaches field capacity.

Water tanks/tubes are prepared as a source of irrigation. The water tank/tube is connected to a faucet that can work automatically according to the sensor commands on the dielectrometer. The pipe/hose is installed first with the water meter so that it can monitor the amount of water that comes out and then a sprinkler is installed that can emit irrigation water when the water tap is open.

The dielectric sensor is able to monitor soil moisture at certain intervals. The amount of water that comes out of the tank will be accumulated per day by looking at the numbers on the PDAM water meter to later be used as 1 irrigation cycle for 2 weekly periods or for 28 days. Observations and measurements will be continued regarding the supporting variables observed in this study. For example, in each cycle there is rainfall and also air temperature that needs to be measured at a certain time.

## RESULTS AND DISCUSSION

*Research Overview*

This study used two types of land cover, namely on land vegetated with grass and tomato plants, and on land without vegetation cover (Figure 1). This research is a single factor experimental study that will analyze the frequency of irrigation water supply and irrigation water requirements automatically through controlling soil moisture using a dielectric sensor. This experiment was carried out at the Bengkulu University Soil Science Laboratory. The experiment was carried out by observing the control of instantaneous soil moisture which was detected through the Dielectrometer tool every day at the time of measurement, and the results of daily irrigation water needs at each measurement time were carried out through automatic observation of the water meter. Measurements and observations of this study were carried out for 28 days at the research location and then divided into 2 observation periods as a form of replication in the analysis of diversity. Before starting the research stage, an initial analysis was carried out to determine the uniformity of field conditions as a supporting variable, at the Soil Science Laboratory, Bengkulu University.


Figure 1. Two types of land cover, namely on vegetated land (grass land and tomato plants), and on land without vegetation

*Momentary* Humidity

The results of the analysis of instantaneous soil moisture diversity (water content) at 5% level showed that in the second period it had a significant effect (Table 1). The real effect was influenced by the very significant difference in the value of water content on the 3 lands observed, namely on grass and tomato plant vegetation and on fallow land in the 2nd period compared to the previous period. There are factors that affect the real difference in the 2 periods, especially on the results of observations of humidity in the field (Table 2). In addition, climate is one of the factors that affect soil moisture. Rainfall conditions affect the humidity value obtained during field observations. Land cover will affect the rate of infiltration in the soil so that later it will affect soil moisture. Plants will protect the soil from direct rain by preventing its fall to the ground through the canopy, twigs, or stems of the plant. Litter found on a land will form humus so that later it is useful to increase the infiltration capacity of the soil.

Grass-vegetated land has a fairly large number of roots and has a high enough transpiration rate so that it can deplete the water content in the soil to the deep soil layers. Soil moisture on land vegetated with grass will be higher, compared to land without vegetation cover and land vegetated with tomato

Table 1. The results of the analysis of the variation of the effect of instantaneous soil moisture

| Water content (instantaneous soil moisture) | F Count | F Table ( 5%) |
|---|---|---|
| First periode | 0.374 ns | 3.238 |
| Second periode | 4.231* | 3.238 |

* = Significantly different, ns = Not Significantly different

Table 2. Measurement of instantaneous soil moisture on observation days 1 to 14 firt periods and second periods

| Observation | Momentary humidity (g/g) | | | | | |
|---|---|---|---|---|---|---|
| | First periods | | | Second periods | | |
| | Grass water content | Tomato water content | Without vegetation water content | Grass water content | Tomato water content | Without vegetation water content |
| 1 | 0.4 | 0.37 | 0.34 | 0.38 | 0.37 | 0.37 |
| 2 | 0.31 | 0.3 | 0.29 | 0.29 | 0.28 | 0.28 |
| 3 | 0.29 | 0.28 | 0.28 | 0.33 | 0.28 | 0.28 |
| 4 | 0.28 | 0.27 | 0.27 | 0.36 | 0.33 | 0.31 |
| 5 | 0.29 | 0.27 | 0.26 | 0.38 | 0.34 | 0.33 |
| 6 | 0.26 | 0.26 | 0.25 | 0.38 | 0.31 | 0.31 |
| 7 | 0.38 | 0.36 | 0.36 | 0.33 | 0.32 | 0.32 |
| 8 | 0.3 | 0.3 | 0.29 | 0.33 | 0.33 | 0.33 |
| 9 | 0.4 | 0.39 | 0.39 | 0.29 | 0.28 | 0.28 |
| 10 | 0.33 | 0.32 | 0.32 | 0.33 | 0.32 | 0.32 |
| 11 | 0.38 | 0.38 | 0.38 | 0.38 | 0.33 | 0.33 |
| 12 | 0.3 | 0.3 | 0.3 | 0.33 | 0.32 | 0.27 |
| 13 | 0.33 | 0.33 | 0.32 | 0.33 | 0.31 | 0.32 |
| 14 | 0.39 | 0.37 | 0.37 | 0.31 | 0.31 | 0.3 |

The results from the analysis of the Least Significant Difference (LSD) on instantaneous soil moisture in the second period showed that land without cover vegetation and land with grass vegetation had significantly different humidity positions compared to other treatments (Table 3). This indicates that land cover is very influential on soil moisture. The water content in the soil is naturally influenced by air temperature, rainwater infiltration, vegetation cover, topography, evaporation and soil type (Sofyan *et al.,* 2017), so that land that does not have sufficient vegetation cover or fallow will accelerate the evaporation process. This causes soil grains to release water more quickly into the atmosphere in the form of water vapor (Penman, 2004). In addition, especially in soils that contain a high clay texture, the amount of water content in the soil measured <20% at a depth of 40 cm can be said to be in the dry category while 40% at a depth of 20 cm can be said to be in the wet category (Kirham, 2005).

Table 3. LSD results level 5% in the 2nd period instantaneous soil moisture

| Treatment | Average |
|---|---|
| Land without vegetation cover | 0.315 a |
| Tomato plant vegetated land | 0.321 ab |
| Grass vegetated land | 0.344 b |

The numbers followed by the same letter in the same column mean that they are not significantly different in the LSD test 5% level.

***Daily Irrigation Water***

The average results of field measurements show that the amount of daily irrigation water on vegetated land is less than on land without vegetation (Table 4). This is due to the different soil moisture values in each land treatment. Setting the value of soil moisture obtained in each measurement will affect the amount of irrigation water given to the land treatment plot. In addition, unstable climatic conditions during the measurement period provide a low humidity value so that the water supply will be in accordance with the needs of each land treatment in each treatment plot. The need for irrigation water on a land is the most important stage needed in managing an irrigation system on a land. Plant needs for water at a certain period are needed by plants to grow and produce normally. The need for water in a land will also affect the process of water loss in the soil or evapotranspiration so that it will affect the next irrigation water supply.

Table 4. The results of the average daily irrigation measurements on days 1 to 14 in periods 1 and 2

| Treatment | Amount of daily irrigation water given during the study/period (liters) | |
|---|---|---|
| | First periods | Second periods |
| Grass land | 2.6 | 0 |
| Tomato plant vegetated | 5.5 | 1.7 |
| Land without vegetation cover | 7.7 | 5.1 |

Based on statistical tests on the three treatments given, the amount of daily irrigation water in the 1st period and 2nd period was not significantly different (Table 5). This occurs because the efficiency of water utilization by plants is achieved through a water supply mechanism when the availability of water in the soil is really close to a critical point or permanent wilting point condition (Putra *et al.*, 2019). Water supply will stop automatically when soil moisture has reached field capacity conditions or when the soil's ability to store water has reached its maximum, thus the amount of daily irrigation water flowing in each land will be different. The difference in the amount of water needed is not significant because the measurement period is also influenced by many external factors such as rainfall, errors in humidity measuring devices, and errors in water meter measurements.

Table 5. The results of the analysis of the diversity of the effect of the amount of daily irrigation water

| Amount of daily irrigation water given during the study | F count | F table ( 5%) |
|---|---|---|
| First period | $1.893^{ns}$ | 3.19 |
| Second period | $2.011^{ns}$ | 3.19 |

* = Significantly different, ns = Not Significantly different

## CONCLUSION

Based on the results of the research "Irrigation Water Supply Patterns in Several Land Uses with Automated Application of Soil Moisture Monitoring based on Dielectric Technology" the following conclusions can be drawn:

The average daily irrigation water results from field measurements show that the amount of daily irrigation water on vegetated land is less than on land without vegetation

The frequency of irrigation water administration as a result of the frequency of irrigation water on the $1^{st}$ to the $14^{th}$ day in the 2 observation periods showed that on the Fallow land the frequency of adding water was more frequent.

Provision of irrigation water will stop automatically when the dielectrometer shows the condition of field capacity, so that the frequency of giving water to each land will be different.

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