International Journal of Scientific Engineering and Science
Volume 5, Issue 10, pp. 30-33, 2021. ISSN (Online): 2456-7361

Utilization of Information and Communication Technology with the Internet of Things on Regosol Soil Characteristics

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Abstract— *Information and communication technology with the internet of tings can be used to monitor soil moisture and soil fertility, water use will be more efficient, especially on Regosol soils which have low levels of soil fertility and water availability. This study aims to determine the role of the Internet of Things on soil moisture, pH and NPK of Regosol soil, to determine capillary irrigation and liquid organic fertilizer on soil characteristics. The method used in this study was a completely randomized design (CRD) with two factors. namely the type of fertilizer, consisting of 4 levels, P0: No liquid organic fertilizer, P1: 5 liters/ha of household waste liquid organic fertilizer, P2: 5 liters/ha Liquid organic fertilizer of biduri leaves, P3: 300 kg/ha NPK fertilizer. The second factor is the number of wick of capillary irrigation, consisting of 3 levels: I0 : No capillary irrigation, I1 : 1 wick of capillary irrigation, I2 : 2 wicks of capillary irrigation. The results showed that the soil moisture was 16.59-23.48%, the more capillary wick, the higher the soil moisture. Mustard plants began to wilt and lack of water in soil moisture at the permanent wilting point of 6.47%. Liquid organic fertilizer and capillary irrigation had no significant effect on soil moisture. Capillary irrigation has a significant effect on water volume, liquid organic fertilizer has a significant effect on soil pH, soil organic C and soil NPK levels.*

Keywords— *Internet of Things, capillary irrigation, liquid organic fertilizer, soil characteristics.*

I. INTRODUCTION

Water is important in agriculture, especially in the needs of the body, the process of photosynthesis, in the dissolution of nutrients/nutrients, etc., one of which is that the quality and quantity of water in the soil is monitored and managed effectively and efficiently, it is necessary to use an IoT-based wireless sensor network [1]. Utilization of information and communication technology innovations in agriculture is the use of the internet of things (IoT) to monitor soil moisture, pH and soil NPK levels which are plant media, especially for horticultural crops. The implementation of the Internet of Things (IoT) plays an important role in the manufacturing industry in the future [2]. From the results of [3], that soil moisture monitoring system can be used to monitor agricultural land with wet, moist and dry soil conditions. Sensors can monitor the environment and soil [4]. Sensor networks are used to continuously record soil and environmental properties [5].

The problem of Regosol soil is the level of soil fertility and low water availability, to overcome these problems it is necessary to have an effective and efficient water utilization technology, namely capillary irrigation, while to increase physical, chemical and biological fertility it is necessary to add organic matter. The addition of liquid organic fertilizer is expected to improve single grains into a crumb structure, so as to increase the availability of water/soil moisture, increase the availability of C, N, P and K nutrients. Carbon elements as an energy source for soil microorganisms. The results showed that the characteristics of Regosol soil were low nitrogen content (0.15%), very low available N content (0.01%), low CEC (13.57 me%), low C-organic (0.99%), neutral pH (6.75) and sandy texture with sand content (44.96 %) [6].

Limited water available to plants, can be done by regulating the amount of water needed by plants through capillary irrigation by adding limited water shortages to the soil by using a tube as a water reservoir accompanied by a hole with a wick/capillary underneath. Capillary irrigation is useful for saving plant water use, reducing rapid water loss due to evaporation and infiltration, helping to meet plant water needs at the beginning of planting so that it will also increase the utilization of soil nutrients by plants [7]. Watering plants every day can be done with the internet of things information system [8].

Household waste as raw material for organic fertilizer is very abundant, the average per household is 1.46 liters/person/day or 0.38 kg/person/day equivalent to the category of SNI 19-3964-1994[9], to deal with the problem of fertilizer scarcity at the beginning of the growing season, the quality of liquid organic fertilizer fermented from household waste meets the quality standards of the Minister of Agriculture Regulation No. 70/Permentan/SR.140/10/2011 [10]. Household waste is a potential raw material for organic fertilizer, and will continue to grow in line with the increasing welfare and lifestyle of the community. The highest composition of organic waste is water content which reaches 60 percent to 80 percent. The content of water and nutrients in organic waste has the potential as a liquid organic fertilizer to increase crop production. In order to improve the quality of liquid organic fertilizer from household waste, the Biduri plant has potential as a raw material for liquid organic fertilizer. Biduri plants contain high carbon, nitrogen, phosphorus and potassium nutrients, indicated by thick, green leaves and grow well in marginal soils in the dry season.

Based on statistical data, the demand for vegetable commodities in Indonesia continues to increase in line with the

International Journal of Scientific Engineering and Science
Volume 5, Issue 10, pp. 30-33, 2021. ISSN (Online): 2456-7361

increase in Indonesia's population, in 2018 it increased by 420,998 tons or 19.1% from the previous year period [11]. Mustard (Brassica rapa L) is a vegetable plant that is easy to grow in any climatic conditions

The purpose of this research is to apply an Internet of Things (IoT) information system to monitor soil moisture in capillary irrigation and liquid organic fertilizer on Regosol soil, study the capillary irrigation system and liquid organic fertilizer on soil characteristics.

II. Research Methodology

The research was carried out in a greenhouse and soil analysis was carried out at the Laboratory of Soil Biology and the Environment of the Soil Science Study Program, Faculty of Agriculture, UPN Veteran Yogyakarta.

Experiment with completely randomized design (CRD) experimental method with two factors, namely Factor 1 type of liquid organic fertilizer, consisting of 4 levels: P0: No liquid organic fertilizer; P1 : Liquid organic fertilizer from household waste 5 liters/ha P2 : Liquid organic fertilizer from Biduri leaves 5 liters/ha, P3 : NPK fertilizer 300 kg/ha. Factor 2 Number of wick of Capillary Irrigation, consisting of 3 levels: I0 : No capillary irrigation I1 : Capillary irrigation with 1 wick, I2 : Capillary irrigation with 2 wicks.

Soil analysis before treatment included: soil texture, pH H_2O, soil CEC, total N, P available, K available, C-organic, Soil analysis after experiment included: pH H_2O, NPK, C-organic soil, available P, available K, CEC and soil NPK levels. Data analysis of observations and laboratory analysis was carried out using variance (ANOVA) at a 5% confidence level, to determine differences between treatments used Duncan's multiple distance test (DMRT) with significant levels. 5% [12]

III. Results and Discussion

Characteristics of the soil used in this study is soil that has a low level of soil fertility. The results of the analysis of the characteristics of the Regosol soil and liquid organic fertilizer used in the study are listed in table I.

TABLE I. Some characteristics of Regosol soil and liquid organic fertilizers used in research

Characteristics	Soil	Household waste liquid organic fertilizer	Biduri leaf liquid organic fertilizer
Texture Sand (%);Silt (%);Clay (%)	),97; 3,83; 5,20		
Class Texstur	Sand		
pH (H_2O)	7,0 (neutral)	6,9 (neutral)	7,4 (neutral)
C- organic (%)	1,78 (low)	20,45 (high)	10,71 (high)
N- total (%)	0,42 (low)	1,56 (low)	1,28 (low)
P_2O5 (ppm)	9,53 (low)	84,77 (low)	12,64 (low)
K_2O (me %)	0,39 (low)	32,28 (low)	19,32 (low)
CEC (Cmol(+) Kg-1)	3,46 (low)	-	-

The characteristics of Regosol soil have a neutral pH, low organic matter content, causing this soil to have low elemental and water binding capacity. In addition, the rough texture of the soil also causes the soil to be poor in nutrients, especially nitrogen, phosphorus, potassium and very low cation exchange capacity, this is due to the leaching process. This is in accordance with the results of research by [6], the characteristics of Regosol soil are low nitrogen content (0.15%), very low available N content (0.01%), low CEC (13.57 me%), low C-organic (0.99 %), neutral pH (6.75) and sandy texture with sand content (44.96 %),

Liquid organic fertilizer has a neutral pH. C-organic content is more than the SNI quality standard (6 %), total nitrogen nutrient content, available phosphorus, available potassium are below the SNI quality standard (3-6 %), this is because the anaerobic fermentation process takes longer, so the availability of elements of the waste have not been completely decomposed, and the source of compost from household waste is dominated by vegetable waste. Research results [13], show that the characteristics of liquid organic fertilizer from household waste include high organic C content (23.94%), high organic matter (41.17%), high total nitrogen content (1.61%), the ratio C/N is low (14.87), available phosphorus (P_2O_5) is high (14.66%). (Ministry of Agriculture No: 70/SR.140/10/2011).

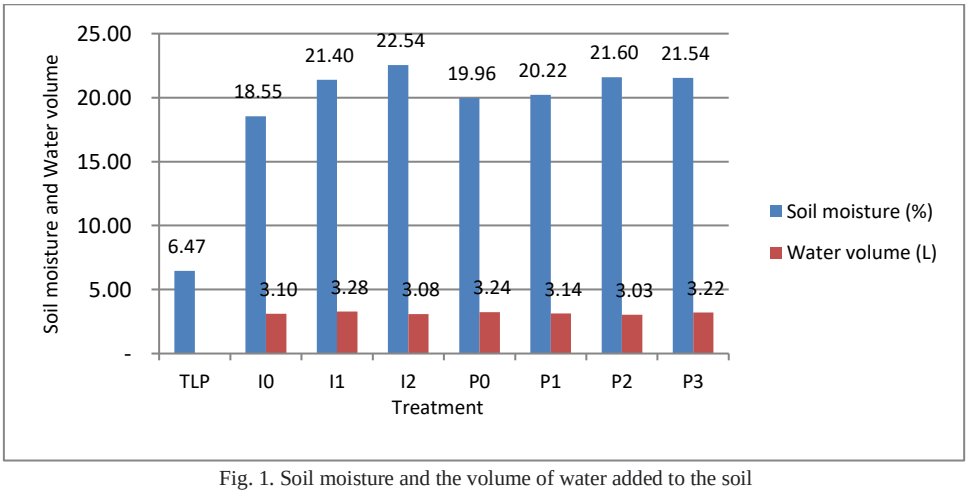

Fig. 1. Soil moisture and the volume of water added to the soil

Note:
P0: No liquid organic fertilizer
P1: 5 liters/ha Household waste liquid organic fertilizer
P2: 5 liters/ha Biduri leaf liquid organic fertilizer
P3: 300 kg/ha NPK fertilizer.
I0 : No capillary Irrigation
I1 : 1 wick capillary irrigation
I2 : 2 wicks capillary irrigation

The effect of liquid organic fertilizer treatment and capillary irrigation system on soil moisture and volume of water added to Regosol soil is shown in Figure 1.

The lowest average humidity (18.55%) was achieved in the treatment without fertilizer (P0) and without wick (I0), while the highest humidity (22.54%) was in the treatment of organic biduri leaf fertilizer with 2 wick of capillary irrigation. Mustard plants began to wilt and lack of water/permanent wilting point (TLP) at 6.47% moisture. The more wick of capillary irrigation, the greater the soil moisture. Capillary irrigation has a significant effect on the volume of ground water, the average volume of water needed by mustard plants during their growth is achieved in a combination of NPK fertilizer with 1 wick of capillary irrigation of 3.6 liters, the volume of water in the treatment of 2 wicks of capillary irrigation is the lowest, this is highly dependent on the growth of mustard plants. The results showed that giving water every 3 days and organic matter treatment of 300 g/pot was the best dose to increase N, P and K [14].

Treatment of liquid organic fertilizer and capillary irrigation system on soil pH, C-organic content, total N content and soil C/N ratio in table II.

TABLE II. Soil pH, C-organic content, total N content and soil C/N ratio

Treatment	Soil pH	C-Organik (%)	Total-N (%)	C/N ratio
I0	6,90 p	1,75 p	0,32 p	5,59 p
I1	6,74 p	1,81 p	0,28 p	6,62 p
I2	6,71 p	1,76 p	0,33 p	5,67 p
P0	6,84 a	1,66 d	0,30 bc	5,61 cd
P1	6,85 a	1,82 bc	0,31 b	6,06 bc
P2	6,85 a	1,83 abc	0,26 bcd	7,23 a
P3	6,60 b	1,78 c	0,37 a	4,94 d

Note: Numbers in the column followed by the same letter are not showed a significant difference, based on the DMRT test at 5% level.
P0: No liquid organic fertilizer
P1: 5 liters/ha Household waste liquid organic fertilizer
P2: 5 liters/ha Biduri leaf liquid organic fertilizer
P3: 300 kg/ha NPK fertilizer.
I0 : No capillary Irrigation
I1 : 1 wick capillary irrigation
I2 : 2 wicks capillary irrigation

The capillary irrigation system had no significant effect on soil pH, C-organic, total N, and C/N ratio, but there was a slight decrease in soil pH. This is thought to be caused by the decomposition of household waste into compost which will produce organic acids so that it has a lowering effect on soil pH.

Liquid organic fertilizer treatment had a significant effect on soil pH, C-organic, total N, and C/N ratio. This is because household waste and Biduri leaves into compost will supply C-organic so that it has an effect on increasing soil organic matter levels. The highest organic C content was achieved in the treatment of liquid organic fertilizer from Biduri leaves with an organic C content of 1.87%.

Treatment of liquid organic fertilizer and capillary irrigation system on available P, available K, CEC and soil NPK levels in table III.

TABLE III. Levels of available P, available K, CEC and soil NPK levels

Treatment	P_2O_5 (ppm)	K_2O (me %)	CEC (Cmol(+)Kg-1)	NPK (%)
I0	7,97 p	0,34 p	4,48 p	3,73 p
I1	9,56 p	0,35 p	4,52 p	3,79 p
I2	9,63 p	0,36 p	4,63 p	3,99 p
P0	7,62 a	0,35 b	4,35 cd	3,21 d
P1	8,42 a	0,35 b	4,28 d	3,70 c
P2	9,80 a	0,32 b	5,03 a	3,82 bc
P3	10,37 a	0,40 a	4,51 bcd	4,62 a

Note: Numbers in the column followed by the same letter are not showed a significant difference, based on the DMRT test at 5% level.
P0: No liquid organic fertilizer
P1: 5 liters/ha Household waste liquid organic fertilizer
P2: 5 liters/ha Biduri leaf liquid organic fertilizer
P3: 300 kg/ha NPK fertilizer.
I0 : No capillary Irrigation
I1 : 1 wick capillary irrigation
I2 : 2 wicks capillary irrigation

The capillary irrigation system had no significant effect on available P, available K, CEC and soil NPK levels. Liquid organic fertilizer treatment had a significant effect on available P, available K, KPK and soil NPK levels. The best treatment was achieved with the addition of NPK fertilizer. This was because the supply of nitrogen, phosphorus and potassium from NPK fertilizer was greater than liquid organic fertilizer from household waste and Biduri leaves. The highest soil N, P, K levels were achieved in the treatment of NPK fertilizer with an NPK content of 4.73 percent [15].

IV. CONCLUSION

Regosol soil characteristics are dominated by sand fraction, nutrient content of C-organic, total N, available P, available K and low CEC, average soil moisture is 18.55 to 22.51 percent, the more capillary wick, the higher the soil moisture, the average water requirement for mustard plant growth is 3.16 liters. Liquid organic fertilizer has a significant effect on pH, C-organic soil, total soil nitrogen, C/N ratio, available potassium, soil CEC and soil NPK levels. Capillary irrigation had no significant effect on soil characteristics.

ACKNOWLEDGEMENT

The authors would like to thank the Institute for Research and Community Service at Universitas Pembangunan Nasional Veteran Yogyakarta, Indonesia, for providing funds for this research.

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