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Monitoring of Regosol Soil Moisture with Internet of Things in Capilar Irrigation and Liquid Organic Fertilizer on Growth of Mustard Greens (*Brassica rapa. L*)

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Abstract
Regosol is soil that has a low level of soil fertility and water availability. According to internet of tings information system used to monitor soil moisture, water use will be more efficient. This study aims to apply the Internet of Things information system to monitor soil moisture in capillary irrigation and liquid organic fertilizer, study the capillary irrigation system and liquid organic fertilizer on the growth of mustard greens (Brassica rapa. L) and soil characteristics. The method used in this study was a completely randomized design (CRD) with two factors. namely Type of fertilizer, consisting of 4 levels, 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. The second factor is the number of wick of capillary irrigation, consisting of 3 levels: I0: No capillary irrigation, I1: 1 wick capillary irrigation, I2: 2 wicks capillary irrigation. The results showed that the soil moisture during the growth of mustard greens was 16.59 to 23.48 %, the more capillary wicks, the higher the soil moisture. The average water requirement for mustard plant growth is 3.16 liters. Mustard plants begin to wither and lack water at 6.47 % soil moisture. Liquid organic fertilizer and capillary irrigation had a significant effect on leaf width, but had no significant effect on plant height, plant wet weight, plant dry weight, soil moisture, soil pH. Liquid organic fertilizer has a significant effect on soil C-organic and soil NPK levels, while capillary irrigation has a significant effect on water volume.

Keywords: Internet of Things, capillary irrigation, liquid organic fertilizer, Regosol soil

INTRODUCTION

The use of the internet of things in agriculture is carried out to monitor soil moisture. Internet of Tings information and communication technology during the Covid 19 pandemic has developed rapidly through the fields of health, agriculture and energy. 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 increasing 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, 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 limited water available to plants can be done by capillary irrigation by adding limited water shortages to the soil by using a container as a water reservoir accompanied by a hole with a capillary wick underneath. The goals of capillary irrigation are: To save water use of plants, reduce rapid water loss due to evaporation and infiltration, help meet the water needs of plants at the beginning of planting so that it will also increase the utilization of soil nutrients by plants.

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 that can increase plant growth. In

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order to improve the quality of liquid organic fertilizer from household waste, the Biduri plant has the 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. Mustard (*Brassica rapa* L) is a vegetable plant that is easy to develop in any climatic condition, based on statistical data, the demand for vegetable commodities in Indonesia continues to increase in line with the increase in Indonesia's population, in 2018 it increased by 420.998 tons or 19.1% from the previous period. the previous year [1]. The purpose of this study was 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 the growth of mustard greens (*Brassica rapa*. L) and soil characteristics.

LITERATURE REVIEW

The application of the Internet of Things (IoT) in the manufacturing and agricultural industries is very important in the future [2]. From the results [3], agricultural land with wet, moist and dry soil conditions can be monitored with a soil moisture sensor. The role of water in agriculture is important, especially in the needs of the body, the process of photosynthesis, in the dissolution of 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 [4]. Sensors can monitor the environment and soil [5]. Sensor networks are used to continuously record soil and environmental properties [6].

Regosol soil type is strongly influenced by the parent material, for example volcanic ash from the eruption of Mount Merapi, the size of the fraction is dominated by sand, so it has high porosity and results in low fertility and water availability, this is because nutrients and water are easily leached. The results of the study by [7], showed that the characteristics of Regosol soil had low nitrogen content (0.15%), very low available N content (0.01%), low CEC (13.57 me%), Low organic C (0.99 %), neutral pH (6.75) and sandy texture with sand content (44.96 %).

Capillary irrigation is a technique for adding water to the soil in a limited manner by using a tube as a water reservoir accompanied by a hole with an wick capillary underneath [8]. Water will come out slowly in the form of seepage into the soil which is limited to wetting the soil. The holes and water wicks can be arranged in such a way that enough water only wets the soil around the roots. Watering plants every day can be done with the internet of things information system [9].

The potential of household waste as raw material for organic fertilizer is very large, on average each household produces 1.46 liters of waste/person/day or 0.38 kg/person/day according to the category of SNI 19-3964-1994 [10], to deal with the problem of fertilizer scarcity at the beginning of the growing season, the quality of liquid organic fertilizer fermented by household waste is in accordance with quality standards [11].

Mustard (*Brassica rapa* L.) is a vegetable plant that is easy to grow in any climatic conditions. Plants that are tolerant of high temperatures, but are better planted in loose soil, rich in organic matter, good drainage, neutral pH 6-7 [12].

RESEARCH METHOD

The experiment was carried out in the greenhouse of the Faculty of Agriculture, UPN "Veteran" Yogyakarta. 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. Monitoring of Regosol soil moisture by using the Soil Moisture Sensor Internet of Things, the method used in this study was a completely randomized design (CRD) with two factors. namely type of fertilizer, consisting of 4 levels, 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. The second factor is the number of wick of capillary irrigation, consisting of 3 levels: I0: No capillary Irrigation, I1: 1 wick capillary irrigation, I2: 2 wicks capillary irrigation. Soil moisture monitoring was carried out every week for each treatment combination, using a soil moisture sensor. Observations on plant growth included: leaf width, plant height, plant wet weight and plant dry weight. Soil analysis before treatment included: soil texture, pH H_2O, soil CEC, total N, P_2O_5, K_2O, organic C. Soil analysis after experiment included: pH H_2O, NPK, C-organic soil. Analysis of observational data and laboratory analysis was carried out using variance at the 5 % level, to determine the difference between treatments used the Duncan Multiple Range Test with a real level of 5 % [13].

FINDING AND DISCUSSION

The characteristics of Regosol soil and liquid organic fertilizer used in the study are listed in table 1. The soil used in this study has a neutral pH. The low organic matter content causes this soil to have low elemental and water holding capacity. The texture of the soil is rough, causing this soil to be poor in nutrients, especially nitrogen, phosphorus, potassium and very low cation exchange capacity, this is due to the leaching process.

The liquid organic fertilizer used in the study had a neutral pH, the C-organic content of the soil exceeded the quality standard (6 %), the total nitrogen nutrient content, available phosphorus, available potassium was below the quality standard (3-6 %), this is because the anaerobic fermentation process takes longer, so that the availability of elements from the waste has not been completely decomposed, and the source of compost from household waste is dominated by vegetable waste. According to [14], 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 %), low C/N ratio (14.87), available phosphorus (P_2O_5) high (14.66 %).

Table 1. Characteristics of Regosol soil and liquid organic fertilizer used in research

Characteristics	Soil	Household waste liquid organic fertilizer	Biduri leaf liquid organic fertilizer
Tekstur			
a. Sand (%)	90,97		
b. Silt (%)	3,83		
c. Clay (%)	5,20		
Class Texstur	Sand	-	-
Volume Weight (g/cm3)	1,21		
pH (H_2O)	7,0	6,9	7,4
C- organic (%)	1,78	20,45	10,71
N- total (%)	0,42	1,56	1,28
P_2O5 (ppm)	9,53	84,77	12,64
K_2O (me %)	0,39	32,28	19,32
CEC (Cmol(+) Kg-1)	3,46	-	-

Soil moisture planted with mustard greens is the amount of water in the soil during its growth. The results of monitoring soil moisture are listed in table 2.

Table 2. Monitoring of Regosol soil moisture (%) during the growth of mustard plants

Treatment	Week O	Week I	Week II	Week III	Week IV	Week V	Average
TLP							6,47
I0P0	16,41	22,47	15,37	12,75	16,92	15,61	16,59
I0P1	16,34	20,23	15,82	15,5	16,48	16,63	16,83
I0P2	18,18	23,26	16,78	15,67	21,17	23,09	19,69
I0P3	20,39	24,66	18,91	18,58	21,58	22,39	21,09
I1P0	22,11	21,08	22,31	23,21	21,83	22,98	22,25
I1P1	21,49	19,43	23,06	22,6	20,87	17,41	20,81
I1P2	21,44	20,73	21,49	21,36	22,19	22,58	21,63
I1P3	20,88	20,83	21,17	21,43	20,1	21,01	20,90
I2P0	20,73	17,13	21,71	22,08	21,99	22,55	21,03
I2P1	23,05	21,68	22,92	22,84	24,76	22,9	23,03
I2P2	23,62	21,93	23,93	23,85	24,79	22,73	23,48
I2P3	23,66	21,8	22,61	23,22	21,19	23,22	22,62
Average	20,69	21,27	20,51	20,26	21,16	21,09	

Regosol soil moisture during the growth of mustard plants every week ranged from 20.26 percent to 21.27 percent, the lowest average humidity (16.59 %) was achieved in the treatment without fertilizer (P0) and without wick, while the highest humidity (23,48 %) in the treatment of biduri leaf compost with 2 wicks. Mustard plants begin to wilt and lack water at the permanent wilting point with soil moisture of 6.47 percent

Table 3. Soil moisture, water volume, pH (H_2O), C-Organic and NPK content in the combination of liquid organic fertilizer and capillary irrigation

Treatment	Soil moisture (%)	Water volume (L)	pH (H_2O)	C-Organic (%)	NPK contents (%)
I0P0	16,59 a	3,10 aqr	6,20 a	1,57 d	3,29 d
I0P1	16,83 a	3,10 aqr	5,77 a	1,77 bc	3,45 c
I0P2	19,69 a	3,10 aqr	6,13 a	1,86 abc	3,57 bc
I0P3	21,09 a	3,10 aqr	6,07 a	1,79 c	4,61 a
I1P0	22,25 a	3,37 ap	6,23 a	1,73 d	3,08 d
I1P1	20,81 a	3,17 ap	6,10 a	1,83 bc	3,80 c
I1P2	21,63 a	3,00 ap	5,83 a	1,87 abc	3,76 bc
I1P3	20,90 a	3,60 ap	6,07 a	1,80 c	4,51 a
I2P0	21,03 a	3,25 ar	6,20 a	1,67 d	3,27 d
I2P1	23,03 a	3,15 ar	6,13 a	1,86 abc	3,84 c
I2P2	23,48 a	2,98 ar	5,83 a	1,77 bc	4,14 bc
I2P3	22,62 a	2,95 ar	5,53 a	1,74 c	4,73 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

Capillary irrigation has a significant effect on the volume of groundwater, the average volume of water needed by mustard plants during 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 very depending on the growth of the mustard plant. According to research by [15], it was shown that giving water once every 3 days and organic matter treatment of 300 g/pot was the best dose to increase N, P and K

The treatment of liquid organic fertilizer had a significant effect on the C-Organic of the soil, because household waste and Biduri leaves that become compost will supply organic C so that it significant affects on increasing soil organic matter levels. The highest organic C content was achieved in the treatment of Biduri leaf liquid organic fertilizer at 1.87% organic C content.
The treatment of liquid organic fertilizer had a significant effect on nitrogen, phosphorus and soil potassium. 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 contents were achieved in the treatment of NPK fertilizers with NPK contents of 4.73 percent.

Table 4. Leaf width, plant height, plant wet weight and plant dry weight in combination treatment of liquid organic fertilizer and capillary irrigation

Treatment	Plant parameters			
	Leaf width (cm)	Plant height (cm)	Plant wet weight (g)	Plant dry weight (g)
I0P0	6,33 bq	23,30 a	25,49 a	10,34 a
I0P1	9,37 aq	32,57 a	35,58 a	10,84 a
I0P2	8,67 aq	27,20 a	34,61 a	10,19 a
I0P3	7,83 aq	28,67 a	35,99 a	11,27 a
I1P0	7,70 bp	25,47 a	27,99 a	10,46 a
I1P1	9,33 ap	31,13 a	34,25 a	10,67 a
I1P2	10,00 ap	29,33 a	35,49 a	10,67 a
I1P3	10,40 ap	34,63 a	44,66 a	11,24 a
I2P0	8,17 bp	25,30 a	28,49 a	10,43 a
I2P1	9,33 ap	28,87 a	38,58 a	10,63 a
I2P2	9,60 ap	28,37 a	32,04 a	10,68 a
I2P3	10,17 ap	30,33 a	34,17 a	11,01 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 results of variance showed that the treatment of liquid organic fertilizer and capillary irrigation system had a significant effect on mustard leaf width and had no significant effect on plant height, plant wet weight and plant dry weight. The best treatment was achieved in the treatment of NPK fertilizer with a one-wick capillary irrigation system. This is because NPK fertilizer will increase nutrients with a 1 wick irrigation system will increase aeration in conditions that are not too dry and not too wet, so that plant growth can increase. The highest mean leaf width of the mustard plant during its growth was achieved in NPK fertilizer (P3) with 1 wick of capillary irrigation of 10.40 cm, the lowest leaf width (6.33 cm) in the treatment without capillary irrigation wick and without liquid organic fertilizer.

The mean value of mustard plant height was achieved in a combination of NPK fertilizer with 1 wick of capillary irrigation of 34.63 cm. The highest average wet weight of mustard plant was achieved in the combination of NPK fertilizer with 1 wick of capillary irrigation of 46.66 g. The highest average dry weight of mustard plant was achieved in the combination of NPK fertilizer with 1 wick of capillary irrigation of 11.27 g. Based on the results of research [16], that the best combination for the growth of mustard greens is a combination of soil with a dusty clay texture with wood sawdust as much as 50% with a capillary wick material of flannel cloth which is better than the stove wick.

CONCLUSION AND FURTHER RESEARCH

The average Regosol soil moisture during the growth of mustard greens is 16.59 to 23.48 %, the average weekly soil moisture is 20.26 to 21.27 %, the more capillary wicks, the higher the soil moisture. The average water requirement for mustard plant growth is 3.16 liters. Mustard plants begin to wilt and lack water at the permanent wilting point with soil moisture of 6.47 %. Liquid organic fertilizer and capillary irrigation significant effect on leaf width, but did not significant effect on plant height, plant wet weight and plant dry weight. Liquid organic fertilizer had a significant effect on soil C-organic and soil NPK levels. but did not significantly affect soil moisture, water volume and soil pH. Capillary irrigation had a significant effect on water volume, but had no significant effect on soil moisture, soil pH, soil NPK leve, and soil organic-C.

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