

Assessment of Soil Nutrient Testing using IoT-based Smart Farming Application for the Application of Organic Liquid Fertilizer from *Saccharum officinarum* Linn. Extract and *Hevea brasiliensis* Muell. Arg. Extract on Ultisol Soil Media

Erwin Junaidi Lubis

Department of Agrotechnology, Faculty of Agriculture, Darwan Ali University, Indonesia

Corresponding Author: erwinjunaidilubis@unda.ac.id

ABSTRACT

In the world of agriculture, the economy of production is very important to maintain and must be developed through the application of smart farming technology. The smart farming technology referred to here is the Internet of Things (IoT), which is applied in the form of sensors, actuators, humidity monitoring, hydrogen potential (pH), and soil nutrient levels. Research results show that IoT-based smart farming technology has proven to be very effective in monitoring soil health and supporting agricultural progress. In the results of field research using modern IoT-based smart farming technology, soil acidity (pH) reached a success rate of 94.20% or 0.15. Irrigation and the application of other soil chemicals were included in the automatic technology design and proved to be very effective in observing and identifying the nutrient deficiency of Ultisol soil. With the help of liquid organic fertilizers, *Saccharum officinarum* Linn. extract and *Hevea brasiliensis* Muell. Arg. extract greatly supported the health and fertility of Ultisol soil through the resulting sensory data.

Keywords: Smart Farming, Internet of Things, *Saccharum Officinarum*, *Hevea Brasiliensis*, Ultisol

Received: 01.08.2025	Revised: 01.10.2025	Accepted: 01.11.2025	Available online: 22.02.2026
-------------------------	------------------------	-------------------------	---------------------------------

INTRODUCTION

The problem with agricultural production is that the soil is infertile and unhealthy, which makes crops unproductive and unable to produce maximum yields. This is closely related to the role of food security issues at the national and international levels. Therefore, there is a need for GAP (Good Agricultural Practice) to be implemented in agriculture with the aim of achieving progress in agriculture (Rachmawati, 2020; in Kamil *et al.* (2023); Lubis (2026). With the sustainability of agriculture in Indonesia, agricultural production activities must be considered in terms of the balance of natural elements in order to achieve progress and prosperity in producing safe products for consumption by the Indonesian people.

In the use of Internet of Things (IoT) smart farming technology in sensory applications, the sensors used in smart farming technology are the DHT 22 sensor and the Soil Moisture sensor. The DHT 22 sensor and Soil Moisture sensor are digital technology tools capable of reading temperature, humidity, soil pH, and the accuracy of soil nutrient content, which can be read and generated in great detail, resulting in fast and easy-to-read data accuracy. According to Candra & Maulana (2019); Halawa (2024) in Irfan & Yulkifli, (2025), the use of smart farming technology produces sensors that can read resistance. Soil moisture sensors read resistance to produce results on soil moisture. The more water there is in Ultisol soil, the easier it is for IoT smart farming technology to conduct electricity if the resistance is low, or if the soil is dry without water, it will be easier to conduct electricity.

The use of Internet of Things (IoT)-based smart farming technology is rapidly growing in agriculture, particularly in soil monitoring. This technology collects data on soil acidity (pH), soil nutrient content, soil temperature, and soil moisture, which are indicators of soil health that must be observed in Ultisol soil conditions. The application of liquid organic fertilizer from *Saccharum officinarum* Linn. and *Hevea brasiliensis* Muell. Arg. extracts in Ultisol (Red-Yellow Podzolic) soil media is highly effective in improving soil nutrient content and plant growth. The application of *Saccharum officinarum* Linn. extract, which is a source of carbon nutrients and is enriched, can improve soil and plant fertility, while the application of enriched *Hevea brasiliensis* Muell. Arg. extract has great potential to contain macro and micro nutrients which are reapplied to the soil medium.

According to Lubis (2025) in Yanti (2024), Ultisol soil is soil that is very poor in nutrients, so it requires additional organic matter to make nutrients available. The use of liquid organic fertilizer extracted from *Saccharum officinarum* Linn. will help Ultisol soil increase its available cation exchange capacity (CEC), neutralise soil acidity (pH), and improve the soil's efficiency in absorbing available nutrients. According to Masluki *et al.* (2015) in Suprayogi & Salim (2024), liquid organic fertilizers derived from organic plants, whether in solid or liquid form, applied by watering around the plant area will produce different results due to absorption. Meanwhile, according to Lubis (2023); Lubis (2025), the application of liquid and solid fertilizers has the same effect on the soil and plants, and the impact of nutrient deficiencies in the soil is immediately fulfilled. The application of liquid organic fertilizer is very useful for Ultisol soil that is deficient in nutrients, so the application of liquid organic fertilizer extracted from *Saccharum officinarum* Linn. and *Hevea brasiliensis* Muell. Arg. plant extracts will be directly absorbed by the plants and quickly available in the soil. Therefore, this study applied liquid organic fertilizer from *Saccharum officinarum* Linn. and *Hevea brasiliensis* Muell. Arg. extracts to Ultisol soil media and observed the stability of nutrients before and after application using IoT (Internet of Things) smart farming technology.

METHOD

In this observation and research, the location and time of the research were conducted at the Soil and Plant Laboratory Research Site, Gadjah Mada University, Yogyakarta. The research was conducted over a period of three months, from March 2024 to June 2024. The soil medium used in this study was Ultisol (Red-Yellow Podzolic) soil with subsoil criteria at a depth of 30 cm. The Ultisol soil that had been collected was placed in 3 kg polybags and left to settle for one week. Soil analysis observed using smart farming IoT (Internet of Things) technology includes Total Nitrogen (N) in Soil, P₂O₅- Available (ppm P) in Soil, K₂O-Available Content (me.100 g⁻¹) in Soil, Soil Organic Carbon Content (%), Soil Moisture Content (%), and laboratory soil testing was conducted to verify the analysis using smart farming IoT (Internet of Things)

technology, which analysed Soil Total Nitrogen, P₂O₅-Available (ppm P) in Soil, Available K₂O-Available (me.100 g⁻¹) Soil, Organic C Content (%) Soil, Water Content (%) Soil.

Use of Liquid Organic Fertilizer from *Saccharum officinarum* Linn. Extract and *Hevea brasiliensis* Muell. Arg. Extract was tested by taking extracts after they had been left to stand for approximately one week, using a ratio of 1000 g of *Saccharum officinarum* Linn. powder + 500 ml of water, and 2000 g of pure *Hevea brasiliensis* Muell. Arg. sap + 1000 ml of water. Application of Liquid Organic Fertilizer from *Saccharum officinarum* Linn. extract at a dose of 600 ml. per polybag⁻¹ and *Hevea brasiliensis* Muell. Arg. extract at a dose of 600 ml polybag⁻¹, and a combination formulation of *Saccharum officinarum* Linn. extract + *Hevea brasiliensis* Muell. Arg. extract at doses of 200 m polybag⁻¹, 400 ml polybag⁻¹, and 600 ml.polybag⁻¹, applied once every two weeks.

RESULTS AND DISCUSSION

Initial Soil Analysis – Ultisol Soil

From the initial soil analysis on Ultisol soil, the results obtained from the soil laboratory can be seen in Table 1 as follows:

Table 1. Preliminary Analysis Results - Ultisol Soil

Texture	Methods of Analysis	Units	Results	Description
✓ Sand			15.30	
✓ Dust	Hydrometer	%	38,20	Clay
✓ Clay			49,10	
C-Organic	Spectrofotometry	%	1.66	l
N-Total	Kjedhal	%	0.18	l
P ₂ O ₅ -avl (P-Bray I)	Spectrofotometry	ppm P	4.28	vl
K ₂ O Potential Ex. HCl 25%	AAS	me.100 g ⁻¹	0.30	vl
MnO Ex. HCl 25%	Spectrofotometry	%	0.25	h
CEC	Volumetry	me.100 g ⁻¹	3.90	vl
pH H ₂ O	Elektrometry	-----	3.20	Very Sour

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable

Initial soil research results on Ultisol soil obtained from Soil Laboratory testing show that Ultisol soil has clayey physical properties, with sand content of 15.30%, silt content of 38.20% and clay content of 49.10%. This means that Ultisol soil, better known as Red-Yellow Podzolic soil, has a high clay content and is usually unsuitable for use as a planting medium for agricultural land. In preliminary soil testing on Ultisol soil, the physical properties of Ultisol soil that meet the criteria for clay make it one of the soils that is easily washed away or undergoes further washing. Ultisol soil has a clay subsoil layer, and its water irrigation or drainage often experiences blockages or clogging (Yosephine *et al.* (2022); Lubis *et al.* (2023)).

The results of nutrient content analysis in Ultisol soil indicate that Ultisol soil is a type of soil that is very nutrient-poor, with soil organic carbon (C-Organic) content at 1.66%, which is classified as low. The total nitrogen content of the soil (N-Total) is 0.18%, which is classified as low, while the phosphorus content of the soil (P_2O_5 -avl P-Bray-I) is 4.28 ppm P, which is classified as very low. The potassium content of the soil (K_2O -Potential Ex. HCl 25%) has a value of 0.30 me.100 g⁻¹, which is classified as very low. However, the cation exchange capacity (CEC) test had a value of 3.90 me.100 g⁻¹, which is very low, and the manganese oxide (MnO Ex. HCl 25%) test had a value of 0.25%, which is high.

Analysis of nutrient levels in Ultisol soil is very similar to nutrient levels in Inceptisol soil, but the difference is that Inceptisol soil has high exchangeable cation levels and a complete absence of aluminium nutrients (Lubis *et al.* (2023)). Nutrient levels in Ultisol soil can be increased by applying lime to raise the soil acidity (pH) of Ultisol soil, applying organic materials such as compost, liquid organic fertilizer or biochar to increase nutrient levels in Ultisol soil, and to control bound phosphorus fixation, phosphorus fertilizer is applied (Lubis *et al.*, 2025; Pane *et al.*, 2023). Soil fertility is the ability of soil to provide essential nutrients in the amounts needed for plant growth. In this case, it is in line with Rachmawati's (2020) opinion that soil fertility can be seen from the physical, chemical and biological properties of the soil by looking at the texture and structure, healthy soil pores, sufficient nutrient levels in the

soil for plant growth and development, and the presence of healthy soil microorganisms such as fungi and bacteria.

In testing the soil acidity level (pH), it was found that Ultisol soil has an acidity value of 3.20, which is classified as highly acidic. At this level, Ultisol soil is highly acidic, whereas the ideal soil acidity level for plant growth is slightly acidic to neutral. Basically, fertile soil has a pH of 6.5 – 7.5, which is very suitable for plants and microorganisms in the soil to grow and develop (Septiaji *et al.*, 2024).

Final Soil Analysis – Ultisol Soil

Analysis of N-Total (%) Content in Soil

The results of N-Total (%) soil testing in the field using Smart Farming with Internet of Things (IoT) sensors and Ultisol soil testing in the Soil Laboratory can be seen in Table 2 as follows:

Table 2. Results of N-Total Analysis of Ultisol Soil

N-Total Nutrient Content of Soil			
Treatment of Extracts	Dosage (ml.polybag ⁻¹)	Soil Laboratory Results	IoT Sensory Results
<i>Saccharum officinarum</i> Linn.	600	0,50 m	0.50010 m
<i>Hevea brasiliensis</i> Muell. Arg.	600	0,51 h	0.51182 h
<i>Saccharum officinarum</i> Linn.	200	0,33 m	0.37211 m
+	400	0,47 m	0.48231 m
<i>Hevea brasiliensis</i> Muell. Arg.	600	0,77 vh	0.78283 vh

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable

The results of the analysis are shown in Table 2. The results of the Ultisol soil testing at the Soil Laboratory showed that the best treatment was the *Saccharum officinarum* Linn. extract and *Hevea brasiliensis* Muell. Arg. extract treatment. At the single treatment level, it was found that the treatment of *Saccharum officinarum* Linn. extract at a dose of 600 ml polybag⁻¹ resulted in an analysis result of 0.50% with a moderate criterion, but at the single treatment level of *Hevea brasiliensis* Muell. Arg. treatment at a dose of 600 ml polybag⁻¹ yielded a result of 0.51%, which is classified as high.

In the mixed treatment with a formulation of *Saccharum officinarum* Linn. extract and *Hevea brasiliensis* Muell. Arg. extract at a dose of 600 ml polybag⁻¹, the result was 0.77% with a very high criterion. Total soil nitrogen is one of the essential macro nutrients that is available in large quantities in the soil. Total nitrogen is the amount of nitrogen in the soil in the form of NH₄⁺ and NO₃⁻, so that the nutrients contained therein are produced in the decomposition of organic matter, which is the main source of total nitrogen in the soil. According to Salam (2020), the ions contained in the soil are the result of the decomposition of organic matter, which is the main source of soil, and Ultisol soil does not have high total soil nitrogen levels, so sufficient organic matter needs to be added to stabilise the total soil nitrogen levels.

In observing IoT (Internet of Things)-based smart farming technology, it is known that the results of sensory data are not significantly different from the results of soil laboratory tests. It is known that the results are close to or even exceed the results of laboratory tests. The use and observation of IoT-based soil nutrient sensors is speculated to have major advantages in terms of convenience and efficiency in nutrient management. According to Simarmata *et al.* (2025), IoT-based sensory monitoring generates soil nutrient data that can be monitored automatically and can adjust fertilisation periods to the appropriate timing.

According to Haidar Ali & Hidayat (2020), the system provided in IoT (Internet of Things)-based smart farming technology automatically provides nutrients and reduces human error. In this way, humans know when the soil is deficient in nutrients. In line with the opinions of Yosephine *et al.* (2022) and Effendi *et al.* (2022), Ultisol soil is very nutrient-poor, so it is necessary to increase the addition of essential nutrients in the soil. However, organic materials, both solid and liquid, are needed so that IoT-based applications can produce significant data in accordance with the data before and after the application of organic materials.

Analysis of P₂O₅-Available Content (ppm P) in Soil

The results of testing the available P₂O₅ (ppm P) in soil in the field using Smart Farming with Internet of Things (IoT) sensors and testing Ultisol soil in the Soil Laboratory can be seen in Table 3 as follows:

Table 3. Analysis Results of P₂O₅-Available in Ultisol Soil

P ₂ O ₅ -Available Nutrient Level in Soil			
Treatment of Extracts	Dosage (ml.polybag ¹)	Soil Laboratory Results	IoT Sensory Results
<i>Saccharum officinarum</i> Linn.	600	22,19 m	22.2113 m
<i>Hevea brasiliensis</i> Muell. Arg.	600	23,77 h	24.7721 h
<i>Saccharum officinarum</i> Linn. +	200	19,12 m	20.2131 m
<i>Hevea brasiliensis</i> Muell. Arg.	400	21,33 m	22.7881 m
	600	28,79 h	29.1012 h

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable

The results of the analysis obtained in Table 3 at the Soil Laboratory and IoT Sensory Results in the Field show that the results obtained in the Soil Laboratory for the single extract application of *Saccharum officinarum* Linn. In testing the available soil phosphorus content of 22.19 ppm, the criteria were moderate, and the results of the single treatment with *Hevea brasiliensis* Muell. Arg. treatment yielded 23.77 ppm, meeting the high criterion. However, in the formulation treatment of *Saccharum officinarum* Linn. and *Hevea brasiliensis* Muell. Arg. extracts, the analysis results showed that the available phosphorus content in Ultisol soil was 28.79 ppm, meeting the high criterion.

In field analysis using Smart Farming technology on IoT (Internet of Things) sensors in the treatment of *Saccharum officinarum* Linn. extract and formulated with *Hevea brasiliensis* Muell. Arg. extract, the sensory result was 29.1012 with high criteria. This result was not much different from the results of the analysis in the Soil Laboratory. Basically, phosphorus (P₂O₅) is one of the macro nutrients that must be available and is an essential nutrient, meaning that no other nutrient can replace its function. Therefore, phosphorus plays a major and important role in achieving optimal plant growth and has a mandatory role in the soil in preparing nutrient levels for plant roots.

The reduction in phosphorus nutrient levels in Ultisol soil causes problems, one of which is when water flows during irrigation or rainfall, causing soil erosion and nutrients to be carried away by the water (Lubis & Pakpahan, 2026). According to Kamil *et al.* (2023), the more water there is in Ultisol soil, the more H⁺ ions will be released, causing the Ultisol soil to become more acidic. This is accompanied by a clayey soil texture in

Ultisol soil, which has high soil colloids and a high cation exchange capacity (CEC). Mualfah *et al.* (2023) and Simarmata *et al.* (2025) added that the parent material of the soil has a pH that varies according to its mineral composition, and that organic matter and soil texture have a significant effect on the water absorption capacity of the soil.

Analysis of K₂O-Available Content (me.100 g⁻¹) in Soil

The results of testing K₂O-Available (me.100 g⁻¹) Soil in the field with Smart Farming using Internet of Things (IoT) Sensors and testing Ultisol Soil in the Soil Laboratory can be seen in Table 4 as follows:

Table 4. Results of Analysis of K₂O-Available in Ultisol Soil

K ₂ O-Available Nutrient Level in Soil			
Treatment of Extracts	Dosage (ml.polybag ⁻¹)	Soil Laboratory Results	IoT Sensory Results
<i>Saccharum officinarum</i> Linn.	600	0,79 m	0.79921 m
<i>Hevea brasiliensis</i> Muell. Arg.	600	0,82 m	0.85227 m
<i>Saccharum officinarum</i> Linn.	200	0,52 m	0.53001 m
+	400	0,69 m	0.69121 m
<i>Hevea brasiliensis</i> Muell. Arg.	600	1,12 h	1.1132 h

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable

In the observation of Ultisol soil, testing was carried out in the Soil Laboratory and in the field using IoT (Internet of Things) Sensory Technology. Testing of the nutrient content of Ultisol soil for available potassium in Ultisol soil showed that it is necessary for carbohydrate metabolism, osmotic regulation, enzyme activity, protein synthesis and assimilate translocation. In testing the available potassium (K₂O) content of the soil, a single application of *Saccharum officinarum* Linn. extract showed an analysis result of 0.79 me.100 g⁻¹ with a moderate criterion, but this was not significantly different from the field results using IoT (Internet of Things)-based smart farming technology, which showed a result of 0.79921 with a moderate criterion.

The application of Liquid Organic Fertilizer from *Saccharum officinarum* Linn. Extract formulated with *Hevea brasiliensis* Muell. Arg. Extract showed a result of 1.12 me.100 g⁻¹ with high criteria, and the field

results were not significantly different from the IoT (Internet of Things) sensory results of 1.1132 with high criteria. According to Yuniarti *et al.* (2017) in Septiaji *et al.* (2024), the availability of potassium nutrients in the soil is divided into relatively available, slowly available, and available (exchangeable). According to Irfan & Yulkifli (2025) and Kamil *et al.* (2025), the results of analysis using IoT (Internet of Things) sensors showed a value of 1.1132, which means that the availability of potassium in the soil is determined by several factors, including the amount of potassium available in the soil and the efficiency of fertilisation applied to the soil.

Analysis of Soil C-Organic Content (%)

The results of C-Organic (%) soil testing in the field using Smart Farming with Internet of Things (IoT) sensors and Ultisol soil testing in the Soil Laboratory can be seen in Table 5 as follows:

Table 5. Results of Ultisol Soil C-Organic Analysis

Soil C-Organic Content			
Treatment of Extracts	Dosage (ml.polybag ⁻¹)	Soil Laboratory Results	IoT Sensory Results
<i>Saccharum officinarum</i> Linn.	600	4,14 h	4.12212 h
<i>Hevea brasiliensis</i> Muell. Arg.	600	4,21 h	4.22131 h
<i>Saccharum officinarum</i> Linn.	200	4,00 m	4.02212 m
+	400	4,10 h	4.14410 h
<i>Hevea brasiliensis</i> Muell. Arg.	600	5,18 h	5.20012 h

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable=

The results of Ultisol soil analysis observations in both the Soil Laboratory and in the field using IoT (Internet of Things) sensor-based Smart Farming Technology can be seen in Table 5. The observations showed that the single treatment of *Saccharum officinarum* Linn. at a treatment level of 600 ml.polybag⁻¹ yielded a result of 4.14% with a high criterion, and the single treatment of *Hevea brasiliensis* Muell. Arg. extract at a treatment level of 600 ml.polybag⁻¹ yielded a result of 4.21% with high criteria, but was not significantly different from the treatment formulation of *Saccharum officinarum* Linn. extract and *Hevea brasiliensis*

Muell. Arg. with a dose of 400 ml.polybag⁻¹ yielded 4.10% with high criteria. This indicates that single treatment with a high dose and combination treatment with the given formulation and low dose yielded the same results and were not significantly different from the high dose above.

In the combined treatment with the formulation of *Saccharum officinarum* Linn. extract and *Hevea brasiliensis* Muell. Arg. extract formulation at a treatment level of 600 ml.polybag⁻¹ showed a result of 5.18% with high criteria. Field results using smart farming technology with IoT (Internet of Things) sensors showed sensory observation results of 5.20012 with high criteria. The status of soil organic carbon (C-Organic) is an indicator of soil health and fertility. Organic carbon (C-Organic) content is a benchmark for soil management. The organic carbon content of nutrient-poor Ultisol soils must be measured by examining the organic matter present in the soil. According to Lubis (2025), the organic carbon (C-Organic) content is determined based on the yield produced and the support provided by the soil as a growing medium. High organic carbon content increases crop productivity because it is able to absorb high levels of nutrients in the soil for maximum and optimal growth.

This is adjusted according to Yuliprianto (2010) in Lubis *et al.* (2023) and Yosephine *et al.* (2022) that organic matter is closely related to the status of organic carbon (C-Organic) because it contains organic carbon which is needed as an energy source for microorganisms and to increase the population of soil microorganisms. Organic matter can also help in the formation of soil aggregates and other soil physical properties, namely soil pores that can store water in the soil.

Soil Moisture (%) Content Analysis

Soil Moisture (%) Content Analysis is an analysis used to measure the percentage of water content contained in the soil at a given time. This parameter shows the comparison between the amount of water stored in the soil pores to the total volume or weight of the soil, which is usually expressed as a percentage (%). Soil moisture content analysis is very important in the fields of agriculture, hydrology, and the environment because it directly affects plant growth, microorganism activity, nutrient availability, and soil structure stability. Soil moisture measurements can be carried out using gravimetric methods (drying samples in an oven), capacitive sensors, or technology based on satellite imagery and the

Internet of Things (IoT). The data generated from this analysis helps in making decisions related to irrigation, land management, drought mitigation, and sustainable soil and water conservation planning.

The results of soil moisture content (%) testing in the field using Smart Farming with Internet of Things (IoT) sensors and Ultisol soil testing in the Soil Laboratory can be seen in Table 6 as follows:

Table 6. Results of Ultisol Soil Moisture Content Analysis

Soil Moisture Content			
Treatment of Extracts	Dosage (ml.polybag ⁻¹)	Soil Laboratory Results	IoT Sensory Results
<i>Saccharum officinarum</i> Linn.	600	3,22	3.21223
<i>Hevea brasiliensis</i> Muell. Arg.	600	3,21	3.22312
<i>Saccharum officinarum</i> Linn.	200	2,98	2.99878
+	400	3,22	3.25442
<i>Hevea brasiliensis</i> Muell. Arg.	600	3,45	3.45521

The results of moisture content testing in soil laboratories and fields using IoT (Internet of Things)-based smart farming technology can be seen in Table 6. It is explained that the treatment of *Saccharum officinarum* Linn. extract with a treatment level of 600 ml.polybag⁻¹ showed a result of 3.22%, and the treatment of *Hevea brasiliensis* Muell. Arg. extract treatment at a dosage level of 600 ml.polybag⁻¹ showed a result of 3.21%. This was not significantly different from the combined treatment between extract formulations. The treatment of *Saccharum officinarum* Linn. extract formulated with *Hevea brasiliensis* Muell. Arg. extract at a treatment dose of 400 ml.polybag⁻¹ showed a result of 3.22%.

This indicates that treatment with a high dose combined with treatment with a moderate dose produces the same results, with no significant difference. Soil moisture content is an important parameter in determining soil management, and soil moisture content is the amount of water contained in the pores of a particular soil. The availability of water in the soil is influenced by climatic factors. These climatic factors are determined by the amount of water content, such as rainfall, temperature, and humidity. This occurs as a result of the evapotranspiration process. Soil factors with high clay content require improvement through the

addition of organic materials. Other soil factors include texture, solum depth, porosity, and soil permeability.

CONCLUSION

In this study, sensory IoT (Internet of Things) smart farming technology was tested in a soil laboratory using liquid organic fertilizers extracted from *Saccharum officinarum* Linn. and *Hevea brasiliensis* Muell. Arg. at a treatment dose of 600 ml.polybag⁻¹, this treatment yielded the best results for all observation parameters. It was concluded that the liquid organic fertilizer treatment could improve the fertility of Ultisol (Red-Yellow Podzolic) soil and release bound ions. Testing of IoT (Internet of Things)-based Smart Farming Technology has shown that soil quality monitoring and control systems can increase the productivity of nutrient-deficient soil. Monitoring soil quality using IoT (Internet of Things) technology is excellent because the values are stable and demonstrate high precision and accuracy.

REFERENCES

- Candra, J. E., & Maulana, A. (2019). Penerapan Soil Moisture Sensor untuk Desain Sistem Penyiraman Tanaman Otomatis. 13(2).
- Effendi, N., Ramadhani, W., & Farida, F. (2022). Perancangan Sistem Penyiraman Tanaman Otomatis menggunakan Sensor Kelembapan Tanah berbasis IoT. *Journal CoSciTech (Computer Science and Information Technology)*, 3(2): 91-98.
- Haidar Ali, F. B. A., & Hidayat, N. (2020). Pengukuran Karakteristik Tanah menggunakan Sensor berbasis Web dengan Arduino Uno untuk Peningkatan Kualitas Sayuran. *Journal of Physical Science and Engineering*, 4(1).
- Halawa, D. N. (2024). Peran Teknologi Pertanian Cerdas (Smart Farming) untuk Generasi Pertanian Indonesia. *Jurnal Kridatama Sains dan Teknologi*, 6(2): 502-512.
- Irfan, M., & Yulkifli. (2025). Smart Farming Sistem Monitoring dan Kontrol Kualitas Tanah Berbasis IoT untuk Meningkatkan Produktivitas Pertanian. *Jurnal Pendidikan Tambusai*, 9(1): 8291-8299.

- Kamil, W. A., Luntungan, E. M., & Tindage, J. R. (2023). Smart Farming Effect toward Soil Nutrients Content on the Agricultural Land Assisted of PT. Tirta Investama Pabrik Airmadidi at Tumulung Village. *Agroekoteknologi*, 2(1).
- Lubis, E. J. & Pakpahan, S. (2026). Application of *Ananas comosus* (L.) Merr. Extract with Local Microorganisms Formulation *Solanum lycopersicum* (L.) and *Saccharum officinarum* Linn. Bagasse in Organosol Soil Medium the Growth of *Brassica oleracea* (L.) Alboglabra Group Plants. *Multidisciplinary Indonesian Center Journal*, 3(1): 2164-2172.
- Lubis, E. J. (2025). Effect of *Crotalaria mucronata* Desv. and *Crotalaria juncea* L. Liquid Green Manure Application on Soil Fertility under Supply in Ultisol Soil. *Environmental Management Study*, 1(1): 22-38.
- Lubis, E. J. (2025). Effect of *Sesbania rostrate* Liquid Green Manure and Gypsum at Water Content in Sodic Soil and Plant Growth of *Solanum torvum*. *Journal of Agribusiness and Natural Resources*, 1(1): 15-23.
- Lubis, E. J. (2026). Growth Potential of *Lactuca sativa* Linn. and *Brassica oleracea* Alboglabra Group Plants in Hydroponic Systems in Support Food Security. *Interdisciplinary Journal of Global and Multidisciplinary*, 2(1): 607-614.
- Lubis, E. J., Rauf, A., & Sarifuddin. (2023). Effectiveness of Fertilization Techniques on Growth Two Varieties of Palm Oil Seeds (*Elaeis guineensis* Jacq.) in Main Nursery. *Journal of Social Research*, 2(8): 2759-2772.
- Masluki, Naim, M., & Mutmainnah. (2015). *Pemanfaatan Pupuk Organik Cair (POC) pada Lahan Sawah melalui Sistem Mina Padi*. Prossiding Seminar Nasional. Universitas Cokroaminoto Palopo, Palopo.
- Mualfah, D., Sandi, G. H., & Fuad, E. (2023). Sistem Monitoring pH dan Kelembaban Tanah pada Tanaman Kacang Tanah berbasis IoT (Internet of Things). *Jurnal Aplikasi Teknologi Informasi dan Manajemen*, 4(2): 138-147.
- Pane, K. N., Walida, H., Saragih, S. H., & Dalimunthe, B. A. (2023). Analisis Karakteristik Sifat Biologi Tanah Ultisol Setelah di Inkubasi dengan Kompos Limbah Buah dan Sayuran. *Jurnal Al Ulum LPPM Universitas Al Washliyah Medan*, 11(2): 85-90.

- Rachmawati, R. R. (2020). Smart Farming 4.0 untuk Mewujudkan Pertanian Indonesia Maju, Mandiri, dan Modern. *Forum Penelitian Agro Ekonomi*, 38(2): 137-154.
- Salam, A. K. (2020). Ilmu Tanah. *Global Madani Press*: Bandar Lampung.
- Septiaji, E. D., Bimasri, J., & Amin, Z. (2024). Characteristics of Physical Properties of Ultisol Soil Based on Level of Slope. *Agroradix*, 7(2): 41-49.
- Simarmata, A. D., Nisa, V. K., Maulana, R., Parawansa, N., Khairunnisa, I., & Budiawati, Y. (2025). Kajian Literatur : Penerapan *Internet of Things* (IoT) untuk Optimasi Manajemen Kesehatan Tanah. *Hidroponik: Jurnal Ilmu Pertanian dan Teknologi Dalam Ilmu Pertanian*, 2(2): 91-107.
- Suprayogi & Salim, A. (2024). Aplikasi Pupuk Organik Cair Daun Lamtoro (*Leucaena leucocephala*) pada Bibit Tebu (*Saccharum officinarum* L.) Varietas VMC. *Jagad Tani: Jurnal Ilmu Pertanian*, 1(2): 113-119.
- Yanti, M. (2024). Pengaruh Variasi Dosis Pupuk Organik Cair (POC) Kulit Nanas dan Kulit Pisang terhadap Pertumbuhan Vegetatif Tanaman Nilam (*Pogostemon cabin* Benth.) pada Media Gambut. *ATHA: Jurnal Ilmu Pertanian*, 3(1): 134-140.
- Yosephine, I. O., Wijaya, H., & Lubis, E. J. (2022). Effect of Market Waste Compost and Compound Fertilizer Application on the Vegetative Growth of Oil Palm Seedlings (*Elaeis guineensis* Jacq.) in Ultisol Soil Growing Media. *Journal of Agricultural Engineering Lampung*, 11(3): 438-450.
- Yuliprianto, H. (2010). Biologi Tanah dan Strategi Pengelolaannya. *Graha Ilmu*.
- Yuniarti, A., Suriadikusumah, A., & Gultom, J. U. (2017). Pengaruh Pupuk Anorganik dan Pupuk Pupuk Organik Cair terhadap pH, N-Total, C-Organik, dan Hasil Pakcoy pada Inceptisols. *Prosiding Seminar Nasional 2017 "Pertanian dan Tanaman Herbal Berkelanjutan di Indonesia"*, 213-219.