An implementation of smart agriculture for optimizing growth using sonic bloom and IoT integrated

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Abstract — This paper proposes the implementation of IoT-based agriculture monitoring with audio growth (sonic bloom) to optimize the growth of plants and harvest. Sonic bloom is a technology that combines high-frequency sound waves from living things, nature or music, and organic nutrients, which aims to make plants grow more optimally so that they can increase productivity. The method's main advantage is implementing an innovative IoT monitoring hybrid with audio growth systems to boost the plantation growth and maximize the yield. Our experiment in 10 planters using chilies has proven the proposed procedure. This work is backed up with literature studies of the audio growth (sonic bloom) in IoT technologies. In addition, four parameters were measured through different sensors such as light sensors, temperature, humidity, and soil moisture to validate our findings. It was found that the proposed method can achieve significant results against the comparison in terms of new sprouts for the harvest. At the end of the monitoring period, the total average of new chili sprouts harvested from the proposed method is up to 31.25% higher than the conventional methods.

Keywords – Agriculture, Smart System, IoT, Sonic Bloom, Audio Growth

I. INTRODUCTION

Internet of Things (IoT) terms were coined over decades ago. The development has proven vital to strive for the Sustainable Development Goals (SDGs). From all the 17 SDGs, Information and Communication Technology is a close driving force as the basic formula to achieve IoT agriculture as the innovative farming methods [1], a branch of IoT in agriculture which encompasses the information needed and gathered from environments, soils, crops, weather, and the farmer.

Ministry of National Development Planning divides the 17 SDGs into four pillars that classify sustainable development. The **first** pillar focuses on sustainable development in the global society, consisting of (1) no poverty, (2) zero hunger, (3) good health and well-being, (4) quality education, and (5) gender equality. The **second** pillar aims for sustainable economic developments, which factors (7) affordable and clean energy, (8) decent work and economic growth, (9) innovation and infrastructure, (10) reduced inequalities, and (17) partnership for the goal. The **third** pillar encompasses sustainable development for environments that includes (6) clean water and sanitation, (11) sustainable cities and communities, (12) responsible consumption, (13) climate action, (14) life below water, and (15) life on land. The **fourth** pillar is law and governance, (16) peace and justice [1].

Research in agriculture and utilization of technology from an agriculture perspective is vital to reach the SDGs, significantly contributing to SDGs number as follows: (1) **No Poverty**: IoT smart farming concept contributes to educating people about the advantages of technology in their everyday lives. IoT as a service could gain an edge to reduce poverty, such as optimizing growth using sonic bloom integrated with IoT could enrich lives and lower the risk of ongoing poverty for the foreseeable future; (2) **Zero**

Hunger: with the help of technology, zero hunger is possible to be achieved. IoT agriculture accelerates information starting with the required information from the plantation, maintenance, and harvest. Farmers can be included in the end-to-end process; (3) **Good health and wellbeing**: Technology, especially IoT, is able to touch, boost and help almost every aspect of human life. IoT monitoring, such as soil pH monitoring, water pH monitoring, pest occurrence, helps to boost the yield and at the same time bring an assurance of better food resources to promote good nation health and well-being.; (4) **Quality Education**: In the emerging digital world, farmers can have their technology awaken moment and interact flexibly with two channels (to the producer and customer). Hence the production cycle within the area is bridged by having the farmer adequately educated and not only 'harvest'-centric minds. Thus, the rural farmers can compete with outside imports and reach out to customer market sectors through proper alignment and enhancement from digital education; (5) **Clean Water**: Monitoring safe water in the area is among the essential features of intelligent farming ecosystem. Through intelligent water management circulated within IoT, the smart agricultural farm, correct water plantation, and irrigation can be mediated to increase the corps; (6) **Affordable & Clean Energy**: The solar power plant is sustainable to achieve affordable and clean energy and assist in technology development integrating renewable energy with IoT agriculture; (7) **Decent Work & Economic Growth**: Economic growth also impacts the possible works open concerning flourishing agriculture. One of the potential factors to increase the harvest is the sonic bloom/audio growth mechanism integrated with the IoT system; (8) **Industry, Innovation, and Infrastructure**: Agriculture needs to be knowledge-based from the perspective of weather, field, harvest, and the farmer's well-informed decision. More data means armoring the farmer with precise information hence, informed decision making. The utilization of automated machinates, such as water irrigation-based IoT able to boost the land condition, such as Ph, temperature, etc, can also give the farmer better field information and forecast information; (9) **Sustainable Cities and Communities**: Having smart agriculture will allow modern agriculture, such as monitoring from afar, and close the gap between the users (farmer and customer). Additionally, using technology to suit the greenhouse's optimum growth environment will make indoor-scale agriculture possible; (10) **Responsible Consumption and Production**: IoT monitoring aims to help reduce waste and detect if chemical waste appears. Not all crops are sold and distributed; hence, monitoring storage becomes vital to ensure sustainability in consumption.

Previous research has conducted a detailed discussion on the selection of frequency that is able to boost harvest and achieve significant results [2], [3],

[4]. Another study has reported on the ability of the audio/sonic bloom to boost plant productivity [5]. In [2] the frequency selection that is able to attain maximum productivity are also concluded, and example of the animal sound as nature sound are given. The research summary on agricultural optimization and productivity has been thoroughly reviewed, as depicted in Table 1. However, research that combines monitoring of agriculture through IoT with sonic bloom implementation and data processing through ThingSpeak for agriculture optimization is not yet found when this research is being conducted.

This study aims to build an Internet of Things (IoT) based agriculture monitoring suitable for generic implementation in the field with chili pepper plants as the object. The implementation of the system is defined in three stages. Firstly, this research delivers a thorough review regarding technology and its impact on agriculture, especially in audio growth. Therefore, a framework and hardware design for the deployment of smart agriculture using IoT. Lastly, implementing innovative IoT monitoring that hybridizes with audio growth systems to boost the plantation growth and maximize the harvest yield.

Chili pepper is one food commodity that fluctuates in terms of the stock and its price in the market. The reasons are due to several factors, including extreme weather that reduces the market commodity, festivals consumption which often requires chili peppers as the main ingredient, and chili farmers' contract with the industry. Fluctuation in chili peppers demand and price has been a recurring problem. Hence, for the implementation, this study chooses. Chili Pepper is the object to alleviate and minimize this problem through smart agriculture. Furthermore, as chili peppers are sensitive to weather changes, several sensors are needed to monitor the surrounding environment of the plants, such as monitoring the temperature, humidity, and soil moisture level.

The state of the art of this study can be stated as follows: (1) Optimizing the growth efficiency and productivity of agriculture through the implementation of sonic bloom/audio growth within a selected frequency range that has already proven to have a significant growth impact, based on the results of previous studies; (2) In the experimental application, this implemented system can monitor light intensity, humidity, soil moisture periodically, and send monitoring results to Thingspeak so that farmers can easily monitor using smart devices.

II. RESEARCH METHOD

A. Related Work

Various plants have been studied to see their influence under intelligent agriculture. This study scrutinizes the implementation of chili pepper plants as the object. Most of the works [2], [3], [4], [6], [7], [8], [9] , [10], [11], [12] are aimed to increase productivity

or accelerate the growth of plants using different artificial and natural signals or methods. Another work [10] focuses on a literature study of modern medicine and communication technologies applying quantum science for the growth of plants and animals. Our work in this article objected to observing the role of audio growth in developing smart agriculture monitoring using IoT implementation. The summary of research on agricultural optimization and productivity has been thoroughly reviewed, as depicted in Table 1.

Table 1. Summary of related work

Ref	Aims	Methods	Type of object, Features, or Characterizations of the observation
[2]	To increase the productivity of food plants	Adding sound spectrum based on natural animals. Estimating the frequency range of the sound spectrum	• The frequency range or frequency characterizations of the sounds generated by natural animals (no information about the plants).
[3]	To accelerate plant growths (Pak Choy)	Sonic bloom and monochromatic light	• Exposing more intense monochromatic light and sonic bloom to Pak Choy. • The analysis is based on the weight of Pak Choy compared to the one without treatment.
[4]	To improve rubber growth	Audio bioharmony, and Fertilizer N, P, K, Ca, and Mg	• Sound waves applied to rubber • 3000 Hz, 3500 Hz, 4000 Hz, 4500 Hz, and 5000 Hz + Fertilizer N, P, K, Ca, and Mg are observed.
[11]	Determine the effect of classical music, hard rock, and murottal on the growing of red spinach plants	Without and three different music treatments are applied for three hours per day in the morning until the 41st day	• Red spinach plants with ANOVA for the analysis of the effectiveness • Wet and dry weights of four different treatments are measured.
[9]	Determine the effect of sound wave frequency and length of exposure to the cabbage plants	Two different music types and different exposure times	• Sawi plants with ANOVA to analyze effectiveness with temperature and humidity measurements. • The plant height, number of leaves, leaf length, leaf width, and harvest mass were measured to identify the roles of the music types and different exposure times.
[6]	The role of sonic bloom technology to improve the productivity of red amaranth plants	Two different ranges of frequency and duration of exposures	• Red amaranth plants. • Plant height, number of leaves, plant length, the area of opening stomata, and wet mass of red amaranth plants were measured.
[12]	To investigate the effect of violin sound exposure on morphology characteristics and green mustard productivity.	Four combinations of treatment (control, 70-75 dB, 80-85 dB, 90-95 dB)	• Green mustard • Germination, plant height, leaf area, and wet weight were measured
[7]	To determine the effect of sound wave frequency and drought stress on stomatal opening, nutrient uptake efficiency through the leaf, and soybean yield	Sound waves consisting of four levels are combined with soil moisture content on three different days	• Soybean • Average stomata width, the efficiency of N uptake, the efficiency of P uptake, the efficiency of K uptake, fresh and dry weights are measured
[8]	The purpose was to determine the effect of cytotoxic activity and cell cycle modulation on Hela cells with exposure of murattal Al-Quran and cisplatin combination	Audio exposure murattal Al-Fatihah and its combination with cisplatin to HeLa cells were tested using the MTT method assay	• HeLa cells • Induction of apoptosis and modulation of cell cycle evaluated by flow cytometry method (treatment with Audio Murattal, Cisplation, the combination between them)
[10]	To determine the appropriate foliar fertilizer in the use of Sonic Bloom Technology to the yield quality of tomato	The main plot was Sonic Bloom Technology (with and without Sonic Bloom), and the subplot was four kinds of foliar fertilizer (Sonic Bloom Fertilizer, Growmore, Bayfolan, Hyponex)	• Tomato (Lycopersicum cerasiforme mil) • The quality parameters observed were number of open stomata, weight, and diameter of tomato, color, moisture, the content of total sugar and ascorbic acid
[13]	How modern medicine, and many of our communication technologies, already apply quantum science, it explains the nature of QBA, its potential, and how commercial agricultural projects in the EU are already integrating quantum theories	Literature study	• Blue-green algae, wine protein, potato, onion, fruit, eggs, flowers, horse health treatment center, and dairy cow • Controlling algae; influencing wine protein; disinfection of potato and onion; testing the product quality of fruit, eggs, and flowers; electromagnetism for the horse health treatment center and low-frequency electromagnetic fields to dairy cow to lower mastitis rates

In the context of methods, some works [2], [3], [4], [6], [7], [8], [9], [10], [11], [12] implement the exposure of audio signals to their object of observation. Some audio signals are also combined with the exposure of other treatments, such as monochromatic light [3], fertilizer [4], soil moisture content [7], foliar fertilizer [10], modern medicine, and communication technologies [13]. Concerning the methods of increasing productivity or accelerating the growth of our object observation, this study uses audio signals with proper monitoring to aid farmers in achieving significant improvement.

Relating the object observation, Pak Choy [3], rubber [4], red spinach [11], red amaranth plant [6], green mustard [12], soybean [7], HeLa cells [8], and tomato [10] are the examples of plants or animals for the object of experiments. However, [3] discusses the object of observation of algae, wine protein, potato, onion, fruit, eggs, flowers, horse, and dairy cow in a literature study. The mentioned objects differ from our object of observation, as this research implements the proposed methods towards chili pepper.

As one factor used to compare our work with other related works, the last factor is a feature or characterization used in the methods. For example, in [2], some types of artificial sound signals generated by animals are artificially used to verify the role of sound signals in increasing the productivity of food plants. Furthermore, the weight of the object of observation is used as an indicator of the effectiveness of methods in [3], [6], [7], [10]. Other works consider plant height [6], [9], [12] characteristic of leaves [6], [9], [12] P and N uptake [7], germination [12], the area of opening stomata [6], [7], [10], induction of apoptosis, and the modulation of the cell cycle [8], the content of total sugar and ascorbic acid [10], and mastitis rates [13] as essential parameters to verify the effectiveness of the methods for the growth of their objects of observation. This work uses four parameters measured through different sensors such as light sensors, temperature, humidity, and soil moisture.

Previous research has conducted a detailed discussion on the selection of frequency that can boost harvest and achieve significant results [2], [3], [4]. Another study has reported on the ability of the audio/sonic bloom to boost plant productivity [5]. In [2] the frequency selection that is able to attain maximum productivity are also concluded, and example of the animal sound as nature sound are given. However, research that combines monitoring of agriculture through IoT with sonic bloom implementation and data processing through ThingSpeak for agriculture optimization is not yet found when this research is being conducted.

B. IoT Based on Smart farming

According to [14], around 31% of working Indonesians are employed in agriculture, but many Indonesian farmers still use traditional farming methods. When implementing traditional farming methods, most farmers would like to increase the yield and the quality of farming conditions. However, inadequate supporting processes have forced them to probe the plant conditions in conventional ways.

The transformation of the Internet of Things in agriculture has changed several operating methods, such as plant disease diagnosis, humidity, water pressure monitoring, field monitoring, growth data analysis, product growth analysis, and other automated deployments. IoT devices can also control and measure the parameter, and the results can be implemented for other purposes.

Fig.1 shows that implementing the Internet of Things in agriculture will help enhance smart agriculture and simplify farming techniques. IoT works in different farming domains to provide farmers smart data, corp yield analysis, and improve farming techniques with auto spreading and field monitoring. Along with the features, the implementation of IoT for agriculture can help the farmers minimize and simplify farming techniques in solving the problem found in the field like Soil erosions, diagnosis of diseases, variable-rate of fertility, and helps control the water stress.
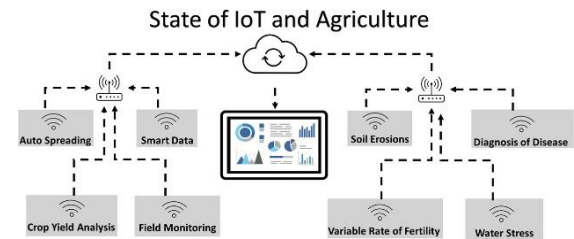

Fig.1 Role of IoT in agriculture

Regarding crop yield and growth, the Internet of Things is paving the way for agricultural automation in irrigation, harvesting, pesticide treatment, and farming. The application of intelligent agriculture concepts and advanced crop production will help farmers improve the quantity and quality of agricultural products.
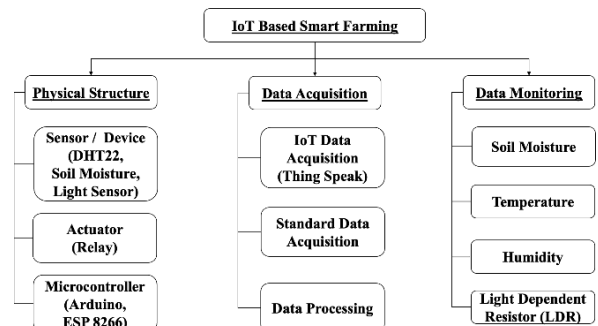

Fig.2 IoT based smart farming

Fig.2 shows IoT-based smart farming. Being placed in a field, smart sensors collect essential data, including the humidity, temperature, and other related data. All the data produced by the sensors is then forwarded to the data acquisition part. Data acquisition will retrieve, collect and prepare data measurement and analyze various data provided by sensors and represent it as the desired data for data monitoring purposes.

C. System Design

This study scrutinizes the implementation of chili pepper plants as the object. Chili pepper is one food commodity that fluctuates in terms of the stock and its price in the market. The reasons are due to several factors, including extreme weather that reduces the market commodity, festivals consumption which often requires chili peppers as the main ingredient, and chili farmers' contract with the industry. Fluctuation in chili peppers demand and price has been a recurring problem. Hence, for the implementation, this study chooses. Chili Pepper is the object to alleviate and minimize this problem through smart agriculture. Furthermore, as chili peppers are sensitive to weather changes, several sensors are needed to monitor the surrounding environment of the plants, such as monitoring the temperature, humidity, and soil moisture level.

This study aims to apply sonic bloom technology to chili plants to increase plant productivity. The experimental method distinguished two groups of chili peppers placed in two separate greenhouses, as represented by Fig.3. These greenhouses get the same average sunlight, temperature, and humidity. The selected system for monitoring is ThingSpeak. An open-source software essentially used to facilitate data retrieval and logging. The measurement results of the sensors mentioned above are then monitored through ThingView. Using thorough yet straightforward monitoring could help farmers and residents in urban areas perform monitoring with ease of access through smart devices (such as from their smartphones and tablets) affordably.
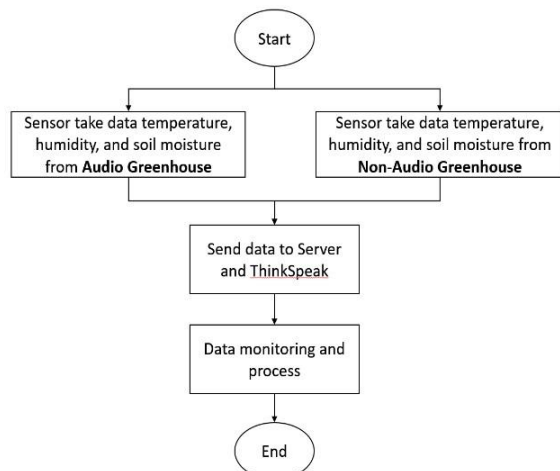

Fig.3. Flow chart of the system

a) Overall System Design

The overall system design of this research is shown in Fig.4. Fundamentally, the system consists of three major subsystems. Subsystem 1 involves sensors connected to the greenhouse area. It consists of the light intensity sensors, soil moisture sensors, temperature and humidity sensors that work with the system to collect and measure different data types. This subsystem collects the required data according to the current situation, namely the light intensity, local humidity and temperature, and soil humidity.

Subsystem 2 includes ESP8266 and data transmission. The sensor will communicate with the Arduino UNO microcontroller, which acts as a central processing unit (CPU), managing the data collected from the sensor through analog input pins. The data will be directly uploaded to the cloud supported by the ESP8266 module via a Wi-Fi connection. Lastly, subsystem 3 is the data acquisition and monitoring that consists of a ThingSpeak web-based application. The function of this subsystem is to monitor some primary greenhouse parameters conditions, such as temperature, humidity, and plant growth conditions. All collected data will be uploaded to the ThingSpeak platform and visualized in the form of tables, charts, or graphs for better understanding.
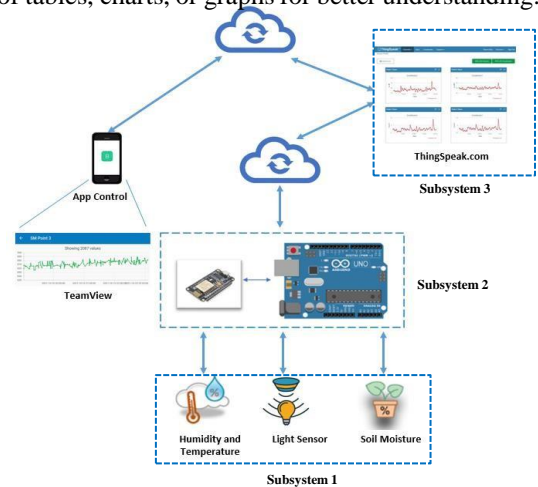

Fig.4 Block diagram system

The frequency range and the animal sound are following the latest research. In 2020, findings in [15] revealed that crops were found to have a better reaction towards frequency 3-5 kHz, which impacts their height growth. In 2019, a study in [2] ranging the sound of a cricket in the +- 4.5 kHz frequency range, is suitable for implementing the audio sonic bloom filter to optimize growth. Cricket sound is implemented in this study as it produces the optimum frequency of natural sound recourse in the 4.5 kHz sound range.

b)   Hardware System Design

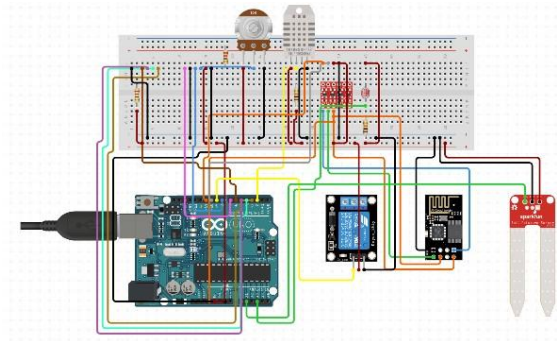The hardware system design of this research is described in Fig.5.

Fig.5. Hardware design for one planter pot

- Arduino UNO R3 ATMEGA328P
  Arduino UNO is a microcontroller based on the ATmega328P chip with 14 digital input/output pins, several PWM outputs, and six analog input pins.

- Node MCU ESP8266-12E
  NodeMCU is an open-source platform that is a development derivative module of the ESP8266 type ESP-12 IoT (Internet of Things) platform module. This device consists of hardware in the system on chip ESP8266, integrated to perform functions such as a microcontroller, internet connection (WiFi), and a communication chip in USB to serial. On the Node MCU ESP8266, there are several I/O pins to be developed into monitoring and controlling applications based on IoT.

- DHT22 Temperature Humidity Sensor
  The DHT sensors are made of two parts, a capacitive humidity sensor and a thermistor with a single wire digital interface to measure the surrounding air and spit out a digital signal on the data pin. Compared to the DHT11, this sensor is larger and more expensive, but it is more precise, accurate, and works in a more extensive temperature range or humidity.

- Capacitive Soil Moisture Sensor
  A soil moisture sensor is used to determine the water content in the soil. This sensor uses two probes to pass current through the ground, consisting of a set of sensor probe humidity sensors and a signal conditioning module. The output working voltage of the sensor is 5V DC. When the soil moisture increases, the output value decreases. Conversely, the lower the humidity, the higher the output value. The measurement results of the soil moisture sensor have the following ranges [15]:
  - 0 ~ 300 : dry soil
  - 300~700: moist soil
  - 700~950: wet ground

- LDR Resistance Sensor
  A light-dependent resistor (LDR) or photoresistor is a resistance that changes due to the amount of light falling on its surface. When light falls on the resistor, then the resistance changes. This sensor is usually used to recognize the presence of light.

- Relay module 5V/30A
  A relay is an electrically operated switch that works on the principle of an electromagnetic attraction. It produces the temporary magnetic field by energizing the electromagnetic field and moving the relay armature to open and close the connections.

- LCD 1602 16X2
  Liquid Crystal Display (LCD) is a component that is often used in microcontroller applications. An LCD can display numbers, letters, or symbols. It is widely used for many applications.

c)   Software and IDE used for the experiment
- Arduino IDE
  Arduino IDE (Integrated Development Environment) is software used to develop microcontroller applications starting from writing source programs, compiling, uploading compilation results, and testing in a serial terminal.
- ThingSpeak
  ThingSpeak is a web service (REST API) that allows users to collect and store sensor data in the cloud. It is an open IoT platform that is very easy to use for building IoT projects. This platform is able to bring the benefit in terms of monitoring online data, collecting and storing the data generated by the sensor in the cloud, developing Internet of Things applications, and performing online analysis of data that can communicate using REST API from any hardware.

III.   RESULT

This section discusses the results obtained during the monitoring period. Fig.6 below shows five IoT circuit devices implemented in every planter pot. In total, this project created ten IoT circuit devices that are attached to 10 planter pots. These planter pots are divided into two greenhouses, which grow chili pepper plants within an observation duration of four weeks.The five sensors are attached to the first greenhouse, referred to as Audio Greenhouse. The Audio Greenhouse is a greenhouse that the Sonic Bloom assists that received exposure to acoustic waves with a frequency of 4,5 kHz and exposure duration of ten hours per day.
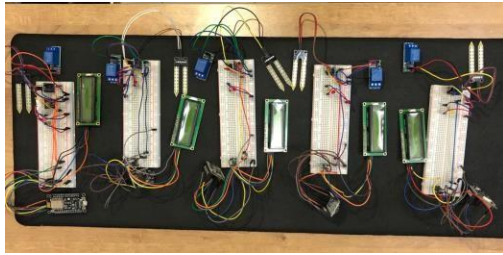
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Fig.6 IoT circuit device placed in one greenhouse

Meanwhile, the second greenhouse is called Non-Audio Greenhouse, using an exact and similar concept as depicted in Fig.7.

Fig.7 IoT circuit device placed for two separated greenhouse

The non-audio greenhouse is a greenhouse that grows its crops naturally without any sonic bloom assistance. The five IoT circuit devices are placed into separate containers, as depicted in Fig.7. The Audio Greenhouse runs the cricket sound acoustic through a speaker placed close to the planter pot, as highlighted in Fig.8.
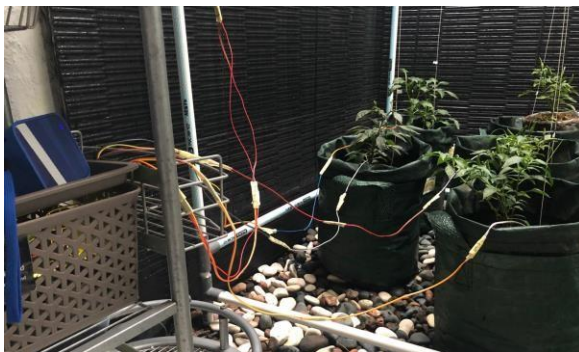
Fig.8 Audio greenhouse

Fig.9 below shows the Non-Audio Greenhouse, which naturally grows without any assistance from the audio.The data gathered in this research has amounted to 4 weeks of monitoring in 30 days. Both audio and non-audio greenhouse are placed in an environment where temperature, humidity, and lights are similar. The weather during monitoring time affects equally in both greenhouse since they are located in 10-meter proximity to ensure similar surroundings. The only difference between the greenhouses is the output speakers that emit the 4.5 kHz of animal nature sound. Hence, the influence of greenhouse growth is assured.

Fig.9 Non audio greenhouse

IV. DISCUSSION

A monitoring system is made using Arduino UNO and ESP8266 as the primary control system in one greenhouse. The main focus areas observed are the environmental light, temperature, and humidity parameters and the soil moisture in each pot in the two greenhouse areas. This system will replace the classic farming method, where farmers can find out the status of their fields remotely from anywhere through the ThingView free application as represented in Fig.10.
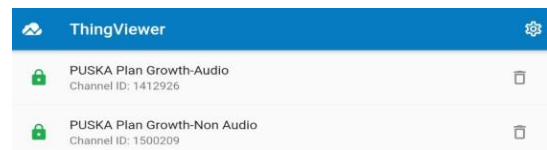

Fig.10 Audio and non audio greenhouse from ThingViewer

The Soil moisture sensor connected to ESP8266 was dipped in the soil of each pot within the greenhouse to get the value measurement and send the measurement value to the ThingSpeak channel. The data from environmental temperature and humidity measurements and soil moisture data can be monitored via the ThingSpeak channel.

Furthermore, the data displayed through ThingSpeak can also be monitored from the mobile phone device using the ThingView application. The Thinkview application is a message application that can retrieve sensor data in text and graphic formats. The user could get all real-time data on temperature, humidity, and soil moisture (represented by SM points 2, 3, 4 in the graphic) for greenhouse points from the mobile phone, as shown in Fig.11.
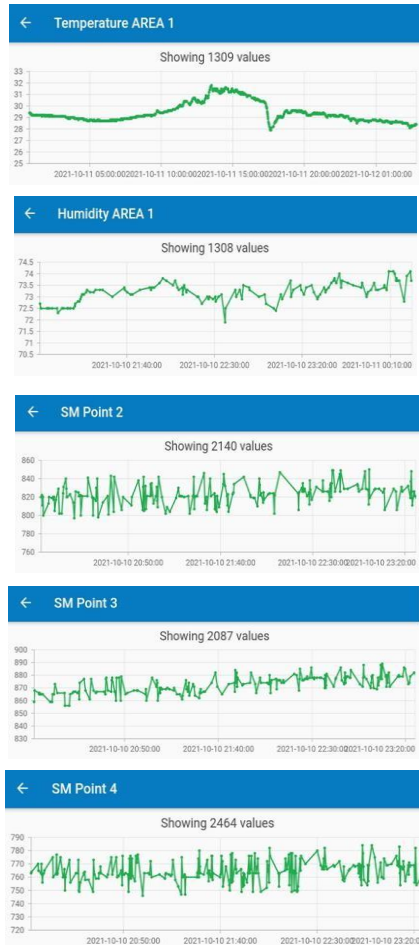
Fig.11 The monitoring result of audio greenhouse from ThingView

The results shown in Fig.12 and Fig.13 depict the measure of chili pepper plant height for non-audio growth and audio growth, respectively, during the period of observation. Fig.12 shows that one of the chili peppers plants achieved up to 30 cm, and the rest did not have significant improvement in terms of the height of the plant.
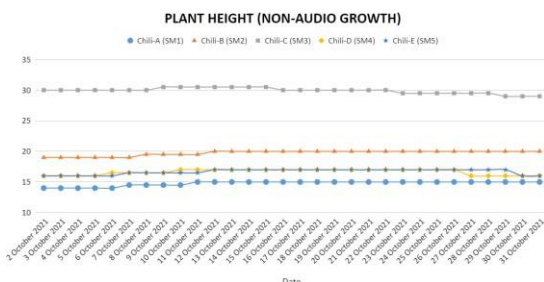

Fig. 12 Plant height Observation Result in Greenhouse with Non-Audio Growth

Fig.13, on the other hand, shows prospected growth in terms of the height of the chili pepper compared to the plants located in the area without the influence of the sonic bloom.
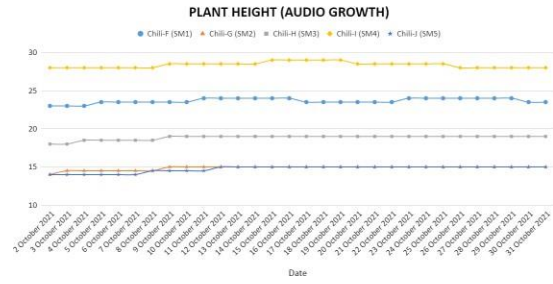

Fig. 13 Plan height observation result in greenhouse with audio growth

The second measure is based on the Chili pepper amount growing during observation. The plants without the audio growth (non-audio growth) cannot withstand the weather conditions, and after the sprout of chili pepper, the chili fruition dies before total growth, resulting in a lesser harvest, as shown in Fig.14.
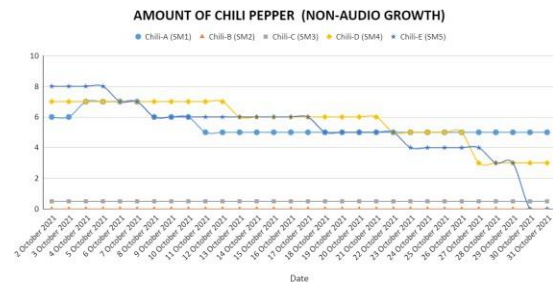

Fig. 14 Amount of chili peppers at greenhouse with non-audio growth

Fig.15, on the other hand, presents the chili peppers amount resulting in a greenhouse effect by the sonic bloom as the audio grows. The results show more chili pepper sprouts in the audio growth greenhouse.
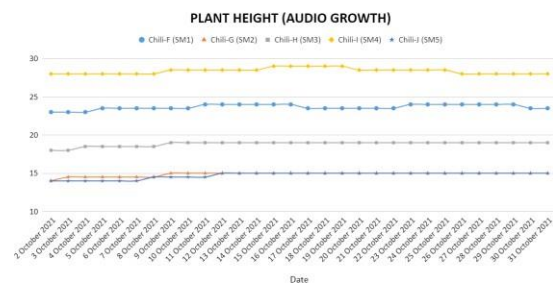

Fig. 15 Amount of Chili Peppers at Greenhouse with Audio Growth

In addition to the new sprouts, the plants with audio-growth are able to carry forward the new sprouts into a ripe chili pepper harvest. Both of the greenhouses are placed as Fig.16.
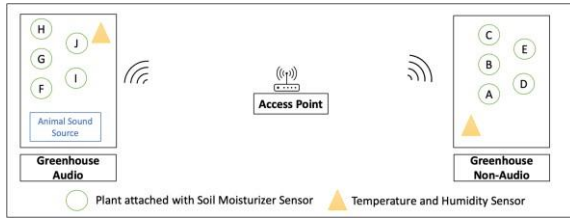
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Fig. 16 Audio and Non-Audio Greenhouses Placement

As in Fig.16, the output speaker is in proximity which only radiates and clouts the audio-greenhouse obtained from the animal sound. The audio is made available for a minimum of ten hours daily. Out of the five chili plants planted at the planter bag, three are red, and two are purple chilies. Both audio and non-audio have the exact combination. During the monitoring period, it is perceived that the purple chili has a different growth rate compared to the red chili. The red chili peppers are grown rapidly, while the purple chili peppers are slower in both conditions. The total average of chili harvested from the red chili plant in the non-audio plantation amounts to 16 chilis. In comparison, the total average of chili harvested from the audio plantation amounts to 21 chili peppers. Hence, the total average harvest of the audio growth can yield 31.25% higher than those without the audio booster.

V. CONCLUSION

The IoT has become a robust platform that assists humans in multiple aspects of everyday life. The most significant turning point of IoT is the possibility of being implemented as the answer to achieving sustainable development goals. This study shows that IoT smart agriculture monitoring combined with Sonic audio bloom is able to amplify the growth and results of the chili pepper harvest. THE RESEARCH OBSERVATION WAS CONDUCTED WITHIN FOUR WEEKS OF MONITORING IN 30 DAYS. BOTH AUDIO AND NON-AUDIO GREENHOUSE ARE PLACED IN THE ENVIRONMENT WHEREBY ITS TEMPERATURE, HUMIDITY, AND LIGHTS ARE SIMILAR. THE ONLY DIFFERENCE BETWEEN THE GREENHOUSES IS THE SONIC BLOOM METHOD USING ANIMAL SOUND APPLIED AT ONE GREENHOUSE. AT THE END OF THE MONITORING PERIOD, THE TOTAL AVERAGE OF THE CHILI HARVEST FROM THE PROPOSED METHOD IS UP TO 31.25% HIGHER THAN THE CONVENTIONAL METHODS. In the future development, this research will further improve in two stages, firstly to study the correlation between the frequency and the efficiency of growth improvement towards chili pepper, and thus to further reach the optimum frequency of the cricket sound implemented as the audio booster for Chili pepper. Secondly, the research will further integrate smart IoT for chili pepper growth, whereby the watering of the plants is done automatically following the maximum and minimum threshold of the soil moisture, thus obtaining the maximum growth through soil moisture optimization.

ACKNOWLEDGMENT

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