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PH MONITORING FOR LIQUID FERTILIZER MANAGEMENT IN BLACK PEPPER FARMING

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Abstract:

There is lacking technology application in black pepper farming to automate daily routine activities in monitoring black pepper vines growth and nutrient need. With the revolution of Industry 4.0 (IR4.0), and tremendous improvement in the internet of things (IoT), the application of precision agriculture to pepper farming is a thing to consider for its benefit. This paper to explore the use of IoT to monitor fertilizer requirement for pepper vines using pH sensor. The pH sensor attached to Raspberry Pi 3 will be collecting the data and forwarding it to the cloud database for farmer reference and take decision based on data presented in form of a digital report from the database. The Python environment provides the space for coding in Raspberry Pi. SQL and PHP software is used to design the user interface and data management in the relational database management system. The information about pH provides a better understanding of how pH parameter affects the growth of pepper vines. The farmer will be able to access the information anywhere and anytime. Therefore, our proposed system will greatly help the pepper farmers in Sarawak in managing the usage of fertilizer as a way to minimize farm inputs, thus increase their profit.

Keywords:

Internet of Things, Raspberry Pi, Python, PH Sensor, Pepper

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Introduction

In Sarawak, pepper is produced and planted by rural dwellers which are concentrated in certain districts of Kuching, Samarahan, Sri Aman, Betong and Sarikei Divisions. The crop is very important to Sarawak as the crop supporting the livelihood of about 67,000 rural farmers. The present estimated planted area is about 17,000 hectares (Ting, 2019). However, the current practice for pepper production, from land clearing, stem nursery, pest management to harvest is maintained and monitored via traditional methods (Adama et al., 2018). Fertilizer is the most costly farm inputs for pepper farmers to boosting the farm yield, the soaring price of fertilizer both for organic and inorganic thus reduce the profit they reap from the pepper product. Therefore, the application of precision agriculture could be the mitigation step forward to reduce the farm input specially the usage of unnecessary fertilizer for the pepper vines need. As Sarawak moving toward digital technology and the smart farming is a way forward, hence a small-scale prototype development of IoT for black pepper farming is a necessary to gauge its benefits. With IoT, it can help farmers operate and maintain their irrigation equipment remotely, as well as help them monitor the moisture, nutrient requirements, growth and soil pressure levels.

Motivation

The agriculture sector in Sarawak will experience drastic changes over the next five years with the application of Smart Farming, in line with the state's vision in transforming its economy and being in the forefront of the digital world (Ahmad, Ahmad & Saad, 2020). However, the black pepper farmers still employ the traditional practice of farming from site preparation to harvesting. With escalating cost of farm inputs such fertilizer, pesticide, and labour, it is very hard for pepper farmers to sustain their farm. Furthermore, pepper requires large volumes of nutrients to maintain significant growth and yield (Sulok, Ahmed, Khew & Zehnder, 2018). According to Yap (2012) nutrient uptake of a mature stand of pepper amounts to 202 kg N, 13 kg P, 156 kg K, 18 kg Mg, and 68 kg Ca per hectare per year. Hence, there is a need to explore some other alternatives with is cost effective and able to monitor the usage of farm input in systematic manner. Thus, this paper is to propose the usage of IoT in black pepper farming to transform traditional practices to smart farming.

Objectives

The objectives of this paper are:
- To manage the usage of fertilizer in pepper farming.
- To develop apps based using Raspberry pi.
- To record the information of fertilizer usage in pepper farming.

Literature Review

There are numerous researches have been conducted on agriculture domain to improve yield production and at the same time to reduce agriculture input such fertilizer, pesticide and labour cost. The Fourth Industrial Revolution (IR 4.0) represent a new dimension in the way we live, work and communicate with one another. Sony M. (2020) in his study found that, there are more advantages in implementing IR 4.0 such as Internet of Things (IoT) that combine hardware, sensors, software's, data storage, microprocessors, and connectivity to unleash a new wave of competition wherein the traditional manufacturers will have a tough time to survive. Due to huge benefits that can be reaped by the farmers in implementing IoT, this paper is to explore the potential of IoT in pepper farming. There are many environmental variables that could affect the growth and production of pepper vines. These include the condition and type

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of the soil, rainfall count, humidity, and light intensity. It is widely acknowledged that sensitivity to weather condition and moisture stress can also contribute to the plant being attacked by diseases (Yap, 2012). Therefore, fertilizer application and management are important in sustaining the plant's growth and achieving higher yield.

This paper is focusing on the soil pH environment. Nugroho, Pratama, Mustika & Ferdiana (2017) developed a monitoring information system and integrated the previous application with progressive web app approach for palm oil plantation. Their system can be accessed via smartphone or desktop by employee. Saraf & Gawali (2017) introduced the smart farm irrigation system for monitoring and controlling of drips through wireless sensor network using android phone. They used cloud computing to monitor and control a set of sensors and actuators to assess the plants water need. Remote monitoring soil parameters such as pH, temperature and soil moisture were designed by Na,Isaac,Varshney & Khan (2016) to support user to make decision regarding the application of fertilizer and choice of crops sown. The entire system developed using STM32 Nucleo platform. Fukatsu & Hirafuji (2014) developed an application called Open Field Server to provide information in effective, individualize and practical manner which incorporate weather monitoring for growth prediction, insect counting for pest damage forecasting, crop growth monitoring with image data, wild animal surveillance, and farm operation recognition. The field server can be managed via remote management program. Hsu, Wang & Kuo (2018) research on agricultural management monitoring system based on the Internet of things. Their system captured the agriculture environment parameters which is using humidity sensor, a temperature sensor, a carbon dioxide sensor and a Wi-Fi module to design a wireless agricultural monitoring system. The system able to control remotely watering equipment or opening sun visor. The research help to manage the farm effectively and efficiency. The application of IoT in hydroponic system was proposed by Patil, Patil, Uttekar & Suryawanshi (2020) to monitor water and nutrients depending on input from sensors using temperature and humidity (DHT 11), pH sensor and electric conductivity circuits. Their system able to reduce the usage of water and nutrients for hydroponic system as required by the crop. The authors (Zhang et al., 2017) developed an IoT system to monitor citrus soil moisture and nutrients for Chongqing mountain citrus orchard, with combination of ZigBee technology, artificial intelligence and decision support technology. The result in their research claimed that the system could help the citrus grower to scientifically fertilize or improve the precision operation level of citrus production, reduce the labour cost and reduce the pollution caused by chemical fertilizer. Badhe, Kharadkar, Ware, Kamble & Chavan (2018) examined the soil monitoring system using various sensors to measure temperature, moisture and light, humidity and pH value. Their system intended to help the farmers to know the accurate parameters of the soil thus making the soil testing procedure easier. Through in-depth comparison and analysis on these systems, it is foreseeable that different type of technologies could be used to determine the everchanging variables such as soil's pH level, temperature, and humidity. Therefore, by being able to determine the precise value for every variable, future farmers can manage fertilizer deployment efficiently to achieve a much more sustainable growth and higher yield.

System Design

This research consists of six modules that begin with data collection. Data collection was done automatically through the sensor. Figure 1 shows the architecture of the proposed system. The six modules for liquid fertilizer management in black pepper farming as depicted in Figure 1.

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1. Micro controller – Raspberry Pi
2. pH sensor
3. Fertilizer Pump
4. GSM Module
5. Web Database
6. Fertilizer Management Apps

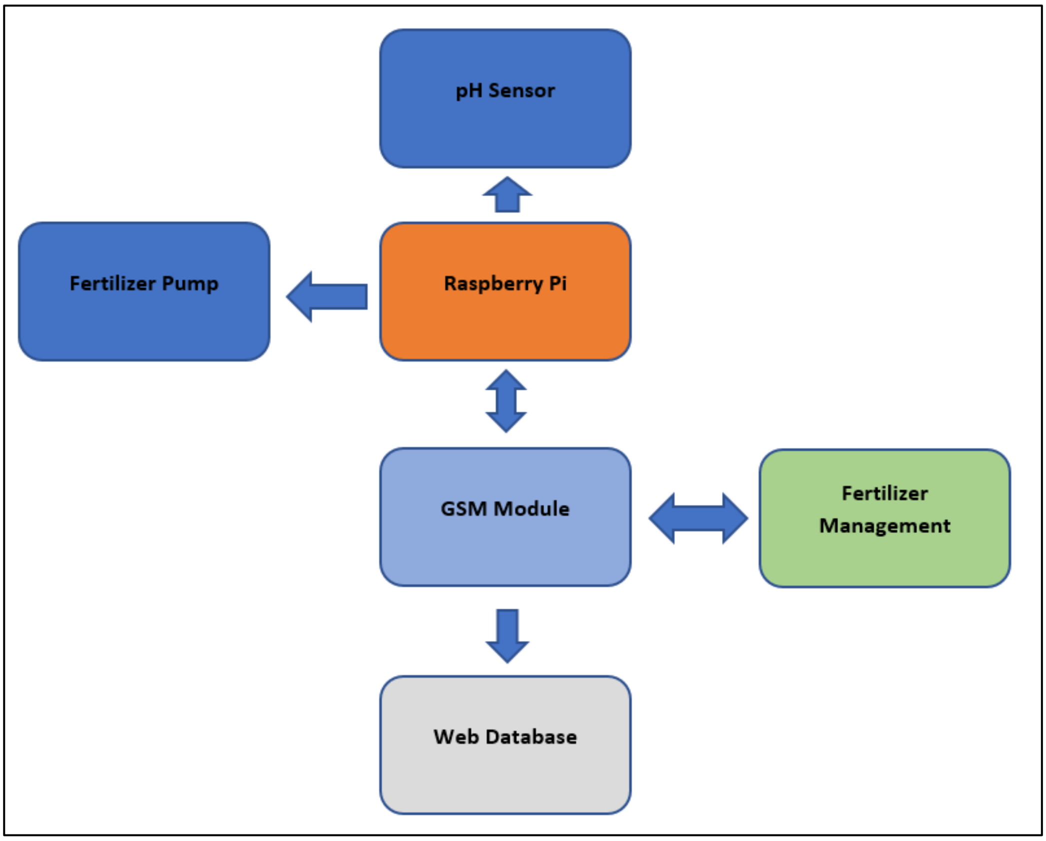

Figure 1: Fertilizer Management Using IOT

The pH sensor collected data from pepper environment and sent data to Raspberry Pi module. The Raspberry Pi module sent data via GSM module to website database. Farmer can see the real-time parameter information and on the mobile phone or through the website. Based on pH value obtained from the sensor, farmer will be able take necessary actions on pepper farming activities. Farmer can control the fertilizer and water pump via Fertilizer Management application. This application is controlled by raspberry pi to switch on or off the fertilizer pump All the data of fertilization and watering of the farm will be recorded in the database.

Microcontroller – Raspberry Pi

Figure 2 shows the architecture of the fertilizer management system using IoT technology. The central processing unit which consists of Raspberry Pi 3B+ model performs the main role of the entire system. It is responsible for controlling the pH sensor to get the soil acidic or alkaline status in real time mode. Raspberry Pi has a wide range of IDEs that provide developers with good interfaces to develop applications. In our case, we are using Python integrated development environment to enables us to develop programs in communicating with pH

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sensor, fertilizer pump controller, GSM module, fertilizer management apps and web database. The data from the sensor is then send to the web database for storing and monitoring by the farmers.

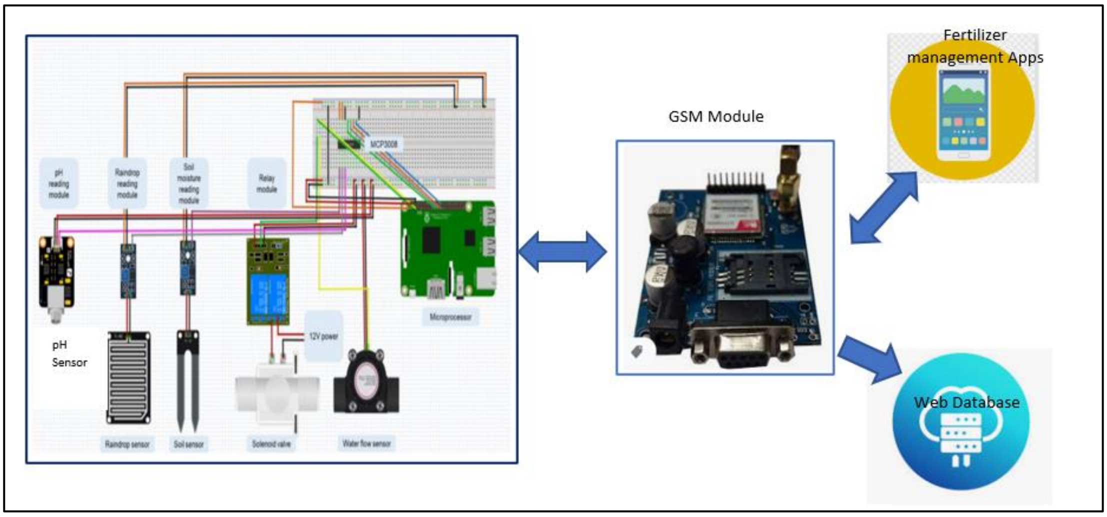

Figure 2: System Architecture For Fertilizer Management using IOT

PH Sensor

In this project we are using DFRobot Gravitity Analog pH sensor which is designed to measure the pH of the solution and retrieve the acidity of alkalinity of the soil. It is also called the hydrogen ion concentration index. The pH is a number between 0 to 14, the neutral condition for the soil is pH = 7; pH < 7, which means the soil condition is acidic; pH>7, which means the soil condition is alkaline. For black pepper vines to grow healthily, the pH should be between 5.5 to 6.5. The pH sensor collected data from pepper environment and sent data to Raspberry Pi module. The Raspberry Pi module sent data via GSM module to website database. The expected output as shown in Figure 3: pH data on web and Apps. Based on pH value obtained from the sensor, farmer will have some insights on the fertilizer requirement for the pepper vines and thus able to make sound decision on pepper farming activities as shown in Figure 4: Graphical pH report representation. For pepper vines, the pH value should be between 5.5 to 6.5 and which indicates that the vines have enough nutrients for the uptake. If the pH value less than 5.5, it indicates that the plot requires farmer action to put up fertilizer such with contain calcium and magnesium to the soil (Yap, 2012).

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#	Date	PH Value	Status
1	2020/08/01	5.97	Optimal
2	2020/08/02	5.87	Optimal
3	2020/08/03	5.99	Optimal
4	2020/08/04	5.97	Optimal
5	2020/08/05	6.47	Optimal

Figure 3: PH Data On Web And Apps

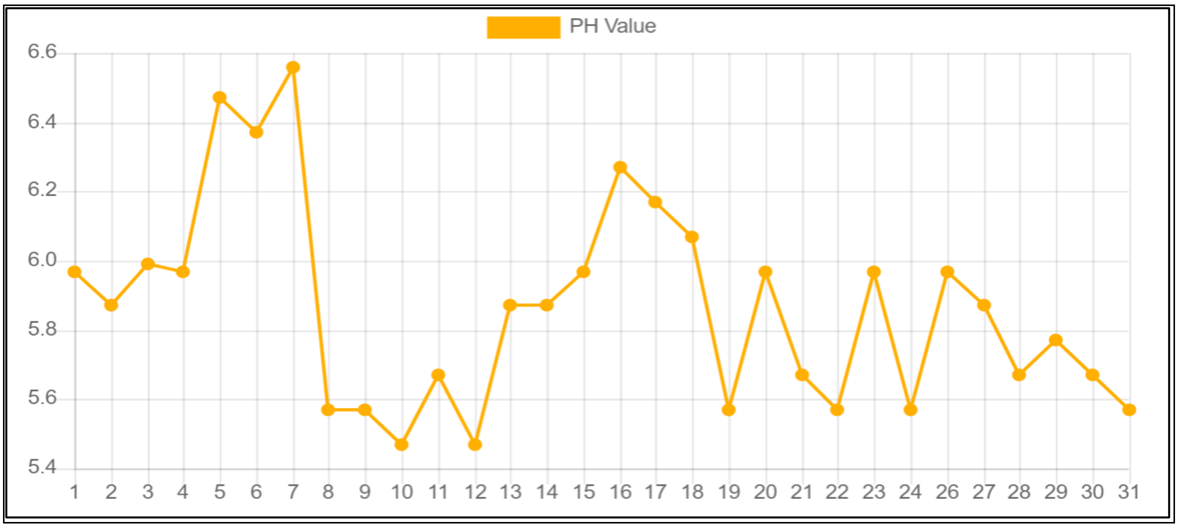

Figure 4: Graphical PH Report Representation

Fertilizer Pump

The conventional fertilization methods from site preparation to harvesting system usually result in wasting lots of fertilizer. The high or low amount of water or fertilization can damage the pepper vines' roots leading to unhealthy crops. The pepper vines are very sensitive to over watering or fertilization which causes diseases to settle in. Pepper is a plant of the humid tropics and requires 2000-3000 millimetres rainfall annually (Sivaraman, K et al 1999). Hot humid conditions are good for growth of pepper plants but continuing humidity over long periods of time favours the incidence of fungal diseases, such as Phytophthora foot rot. Based on pH data presented on the web database, the user will be able to make sound decision to either switch on the pump using fertilizer management apps from his/her mobile device.

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GSM module

As our system need to communicate with sensor, fertilizer pump, web database and fertilizer management apps, GSM module also called GSM modem is mandatory. We subscribed with Celcom provider for our SIM card for data transmission from Raspberry Pi and pH sensor to the web database and to switch on and off the fertilizer pump from Fertilizer Management Apps. To communicate with all the devices in our system, the python program is developed.

Web Database

MySQL is most popular and open source relational database and driving force behind the mushroom of dynamic websites and is one of the best ways of storing data for web applications. Our system employed the MySQL as relational database to store data from sensors such as pH, soil moisture, temperature and farmer information. In this system we are focusing on storing pH sensor and fertilizer pump management. The data is stored and can be viewed via website www.agrofarming.info. The interface as shown in Figure 5: Web Interface and Figure 6: Mobile Interface.

Figure 5: Web Interface

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Figure 6: Mobile Interface

Fertilizer Management Apps

Farmer can control the fertilizer and water pump via app's switch On or Off button that can control the pump. This application is controlled by raspberry pi to switch on fertilizer pump. All the data of fertilization and watering of the farm will be recorded in the database. The system will send the data such as status of the pump, time and day. Then, the output will be shown from the agrofarming.info website, the farmer can track every record when the fertilizer was used. The process involved between Apps and Raspberry Pi as shown in Figure 7.

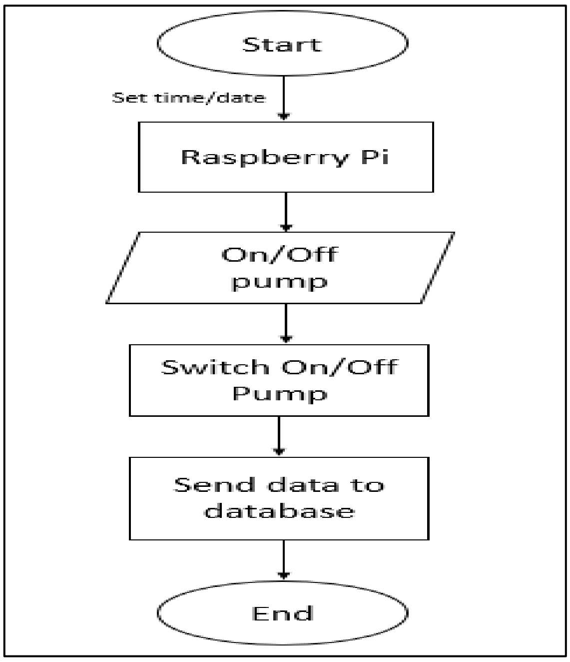

Figure 7: Communication Between Apps And Raspberry Pi

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Result and Discussion

Fertilizer Management Apps

To help pepper farmers with efficient, reliable and well informed for their pepper vines status, the apps is developed using android platform. This section will explain the apps developed for pepper farmers specifically in Sarawak region. All the data from sensors, pH data and water and fertilizer information are sent via wireless to the web-based database, MySQL. Hostinger is used as a webserver and PHP as the tool to develop the interface between IoT system, database and users or farmers. Below is the description of the Android application for the project. The app system has the interface as shown in Figure 8.

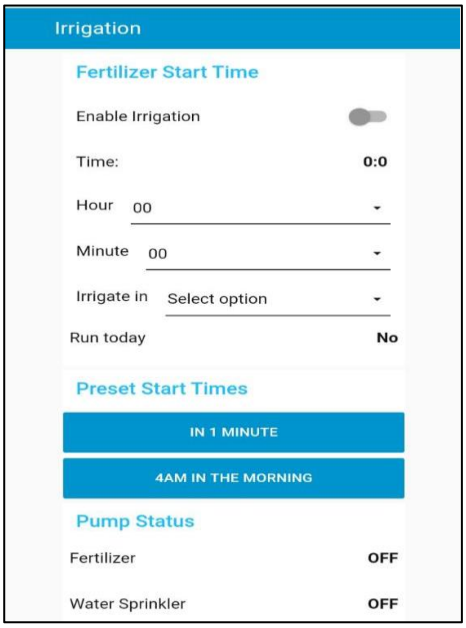

Figure 8: Fertilizer Management Apps Interface

Pump Duration Operation Time

In this apps, once the pump on, the system will record the duration of pump operation time. This is important to provide optimum watering and fertilization of pepper vines. Too much water and fertilizer will cause fungal or diseases infections to the pepper vines.

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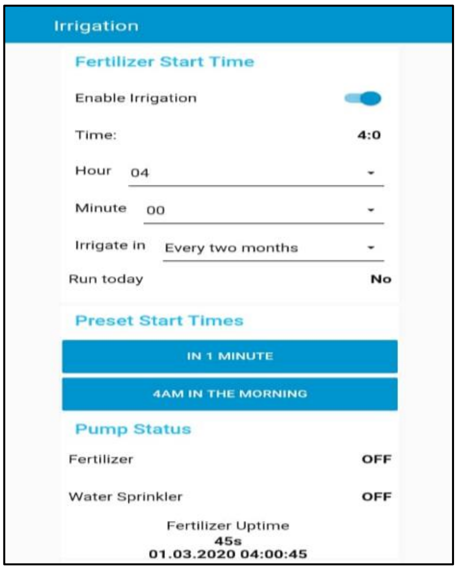

Figure 9: Pump Operation Time

Scheduling Water And Fertilizer pump

Farmer may schedule the watering and fertilization of the pump when they sure about the condition of the farm environment. This can be done when farmer have local weather data that can determine when a farm should be watered or fertilized. The interface for the module as shown in Figure 10.

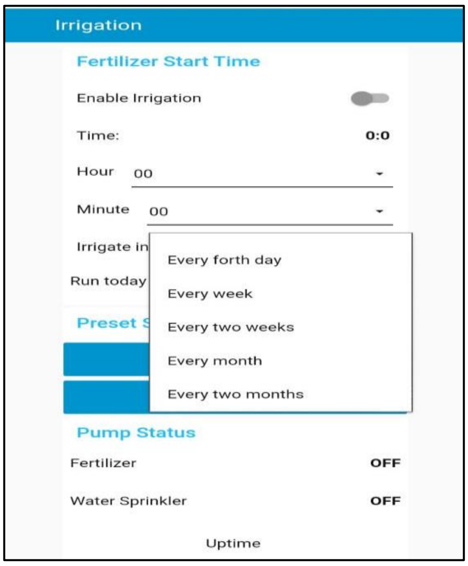

Figure 10: Scheduler

Manual Switch On/Off

The apps also provide manual switch on and off the water and fertilize pump when the farmers noticed that pH readings are below 5.5 or more than 6.5. Below shows the recommendation action to the farmer when the pH reading as shown in Table 1 Environment factor and Fertilization.

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Table 1: Environment Factor and Fertilization

Environmental Factor	Description	Fertilization Recommendation
Soil pH	Below pH 5	Apply lime
	Between pH 5 to 7 – Normal	Fertilization or fertigation regime
	above pH 7	Apply Urea (nitrogen) / peat moss

Summary

The results show that the proposed system is proven to be able to manage the application of the fertilizer in black pepper farming. The system delivers accurate information to the farmers regarding the soil pH status and making it easier for the them to make sound decision on pepper farming activities such as predicting the exact amount of water and fertilizer required. The adaptation of precision farming through IoT implementation enables a much more sustainable agricultural practices that allow farmers to maximize their yields and reducing the wastage of natural resources.

With precision farming, they will gain better access to precise data and information regarding external variables affecting overall plant growth and health. Different district has different type of soils and weather conditions depending on their location and topography. Therefore, such data could be the key to determine the solution needed to manage the fertilizer’s deployment effectively and efficiently. Previous records of such variables could also be used to simulate future outcome in future planting season. Therefore, by having data collected from farms all over Sarawak, the farmers would be able to work around the environmental variables to their advantage as they already have the solution for any given weather condition.

However, further research needs to be carried out to determine how such system could be implemented in remote and interior part of Sarawak. The sustainability of the IoT system in off-grid locations would present a much greater challenges for the system developers as most of the pepper farms are in rural areas which lack connectivity to the state’s power grid. The other challenges would be in term of financial impact on the farmers in acquiring the systems and having them deployed on larger farms. Most of the farmers are from low income group thus it is important to include this cost-to-own factor in future system development to make it affordable for the masses.

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