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Smart Farm Solar Soil and Weather Real-time Monitoring System for Farmers

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Abstract

Most people in Thailand make most of their money from farming. But it's getting increasingly expensive as people move from rural to urban areas, where they can make more money in less time. There are many reasons for this. Greatly affecting the efficiency of vegetable crops. Both weed problems and inadequate care Therefore, in this research, a real-time soil, solar, and weather monitoring system was created for farmers to enable them to know the actual conditions of their crops and to calculate the correct watering and fertilization. It saves time in agriculture.

From the research, the researcher has set up a program to monitor humidity, temperature, and pH. Then, put the equipment and the screen into the steel box so that it is easy to set up at the vegetable plot. Once the system is set up correctly, farmers can use their own cell phones to look at information about their vegetable plots. The experimental results found that using equipment to monitor the environment of the vegetable plots helped farmers spend less time caring for the plots. Also, the productivity of the vegetable plots that have been set up with this kind of system is good. The researchers tested it with farmers who grew kale. The cultivated kale yielded good yields similar to those of normal kale but took less time. We compared kale growth between kale grown in greenhouses and kale grown outdoors. The results showed that the overall increase in the first period was not different, and the later period of kale grown at the farm showed better growth.

Keywords

Smart farm, Thailand agriculture, Monitoring System, Internet of Things, Smart devices.

INTRODUCTION

The agriculture sector served as the main source of food [1] [2] and had a significant role in livelihoods. Furthermore, population growth has a significant impact on urban food security. This is due to the fact that most cities are commodity consumers who rely almost entirely on outside supplies. To meet the demand for grains, fruits, and vegetables. The use of technology in agriculture has sparked interest [3] [4] [5]. Thailand is an agricultural country due to its location in a landscape conducive to agriculture. As a result, most of the country's main occupation is agriculture. Agricultural products are essential to Thailand's [6] economy in terms of domestic consumption and exports. The current condition of agricultural food production in Thailand began to make people realize the importance of producing safe food crops for domestic consumption and export. However, due to the health problems of the country's increasing population and restrictions on international trade related to the export of agricultural products to countries [7] that have regulations on farm products to be imported into that country, they must pass international certification standards. Therefore, Thailand, in addition, must be ready to adapt to keep up with the changes. It's essential to use technology appropriately. Especially when using the internet for agriculture, it is also necessary to accelerate the development [8] of knowledge of innovation and new technologies. In addition, the impact of the lack of human labor in the future, especially in agriculture and among farmers, is now entering an aging society. We are coupled with changes in weather conditions and the increasing severity of global warming, which affects ecosystems and other environmental systems. As a result, agricultural products cannot grow and be harvested as needed. We are using automation systems in smart agriculture, which is a new type of farming [9]. We are using various technologies with high accuracy to help in the work by focusing on the safety of consumers, the environment, and the best use of resources. In an era when labor in agriculture has been declining over the years, the agricultural sector needs to adapt by applying technology to solve this problem.

The goal of this study of kale farming in Thailand's Maha Sarakham Province is to use the Internet of Things to make a smart farm model. The wireless network system is more readily applicable in agriculture.

MATERIAL AND METHODS

Overview of the system

A smart farm system uses technology, digitization, innovation, and data to maximize production at the lowest cost. IoT devices are cheaper and easier to find, making the smart farmer concept more feasible. The Smart Farm system must be installed to meet farmers' needs and help them get good yields. As indicated in Figure 1, a real-time monitoring system was created for this study to be aware of the surroundings of the vegetable fields. In this study, a real-time monitoring system was built to constantly be aware of the surroundings of the vegetable fields, as shown in Figure 1.

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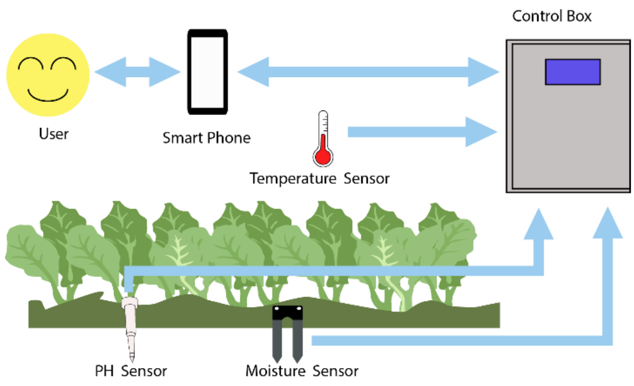


Figure 1. The smart farm system.

Sensor calibration

Temperature sensor: The researcher first prepares a temperature bath, thermometer, and thermal sensor to calibrate the thermal sensors. Then, a hotplate heated a water bath to nine discrete temperatures. We use a thermometer as the standard measure of water bath temperature. The temperature was allowed to stabilize at each increment before immersing the temperature sensor in the water bath. Upon immersion, we used a temperature sensor and thermometer to measure the temperature in the temperature bath every 10 seconds for 6 minutes. After that, we compare the temperature the thermometer recorded with the temperature the sensor recorded, and we use statistics to examine the difference between the two data [10].

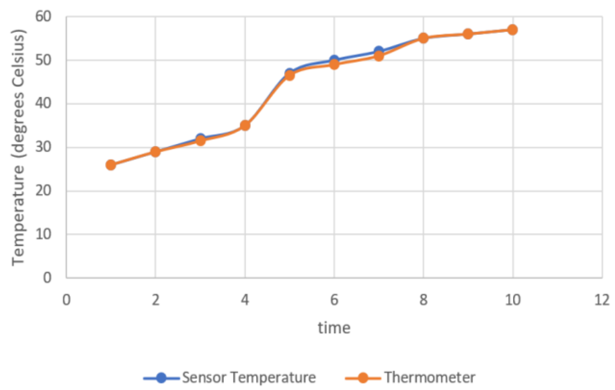


Figure 2. Sensor temperature and thermometer.

Moisture sensor: First, prepare the soil. The soil samples used in the test were loam of medium resolution. Next, we mixed soil samples with water ratios of 10:1, 7:0.7, and 5:0.5 by weight or reference soil moisture. Next, the researcher measured the soil sample weight and temperature at different locations and used the measured values to calculate the soil gravimetric water content (GWC%) from equation (1). Then, we compare the value obtained from the sensor with the actual value.

$$GWC\% = \frac{wet\ soil\ weight - dry\ soil\ weight}{dry\ soil\ weight} \times 100 \quad (1)$$

Statistical analyses

The growth results of plants grown under different conditions were compared in this study. The researcher also relied on static analysis results to ensure correct growth analysis results. The t-test is a statistical hypothesis test for comparing means. A one sample t-test can be used to compare the sample mean to the key hypothesis or target value. If you have two pairs of test subjects (e.g., before and after measurements), you can compare the means of two samples using a 2-sample t-test. As a result, in this study, a statistical t-test was used to test the differences in growth of plants grown at this time [11] [12] [13].

RESULT AND DISCUSSION

Soil and weather monitoring box

The installation of a weather and soil monitoring box in proximity to the vegetable garden necessitates waterproofing measures. When farmers arrive at the vegetable plot without a smartphone, the researcher has attached an LCD panel to a data report from various sensors at the front of the box, as shown in Figure 3a. In addition, to enable farmers to connect to external equipment to modify the plant environment, the researcher included a relay in the circuit for monitoring soil and air variables, as shown in Figure 3b.

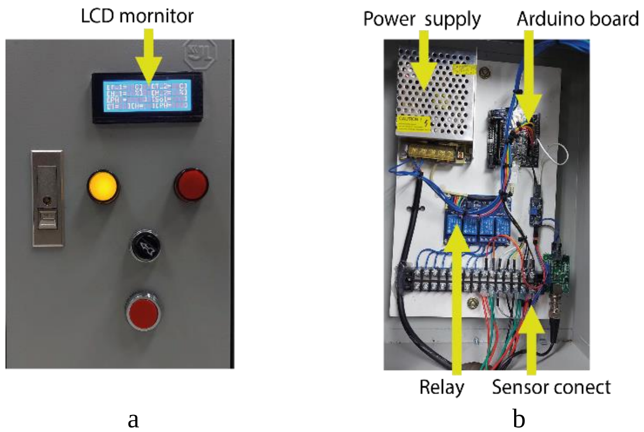
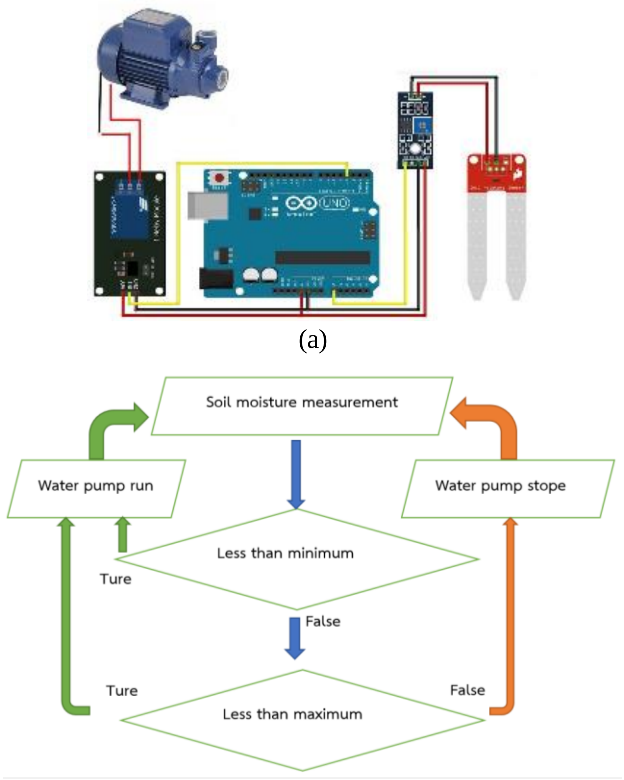


Figure 3. Control box (a) LCD monitor (b) System components

Smart Farm is made up of three main modules: IoT Module, Data Mining Module, and Mobile Application Module, which will automatically use solar energy to work and thus reduce farmers' costs. The soil moisture sensor detects soil moisture, and the air humidity sensor detects temperature and humidity. The soil moisture detector is an ultra-low-cost digital and mobile temperature and humidity sensor.

Program design for monitoring soil and air conditions

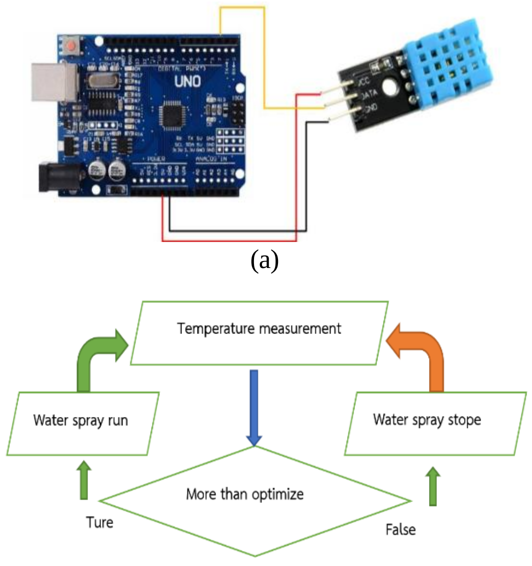
In this study, the researchers installed soil moisture sensors to monitor soil moisture and use that data to control water pumps. Farmers do not understand how to convert soil moisture values to percentage values, which makes setting value systems difficult. As a result, the researcher requested that the farmer modify the values displayed on the board by engaging various buttons. When the LCD panel shows a value of 1, it signifies that the moisture level is considered suitable, whereas a value of 0 indicates that the moisture level is low. We assumed a sensor corresponding to the proposed design's maximum wet and dry threshold conditions. Therefore, the water pump exhibits an absence of functionality in cases of high moisture levels, as it is presumed that the soil contains enough water for agricultural purposes. On the other hand, the water pump will operate at high speed during dry soil conditions to provide sufficient water for the farmland. As shown in Figure 4,



(a)

(b)

Figure 4. (a) Soil moisture measurement circuit and (b) Diagram of soil moisture control program



(a)

(b)

Figure 5. (a) Temperature measurement circuit and (b) Diagram of the temperature control program.

The temperature control program's circuit and schematic diagram are shown in Figure 5. We need to lower the temperature inside the farm because the ideal growing temperature for kale is between 18 and 30 degrees Celsius. When the temperature inside the house is higher than the present value, the spray unit activates and stops when the temperature is equal to or lower than the present value.

Measurement of Chinese kale growth

Chinese kale is a popular vegetable in Asia and is now sold fresh and cooked in restaurants. This green vegetable is sold in bunches consisting of bolts or shoots with flower buds and young leaves. Chinese kale grows year-round and prefers temperatures between 23 and 28 °C [14], but it can tolerate higher temperatures. Preferably, Chinese kale should develop in fertile soils with good drainage. The study collected experimental data on plant growth, such as fresh weight, plant height, leaf width, leaf length, and leaf number of kale [15]. Finally, we compared the growth results of vegetables grown in smart greenhouses with those grown naturally. This study proposed an innovative architecture based on the concept of IoTs, combining wireless and distributed specific sensor devices with the simulation of climatic conditions to track the evolution of kale.

The experiment compared conventional cropping to cropping with smart farm systems to help control variables. The researchers compared the growth of kale plants planted in both types. Every 7 days, plant height, leaf length, and leaf width were measured to compare the growth of the two kale varieties. According to the experimental results, the mean plant height was not significantly different at the ages of 7, 14, 21, and 28 days after sowing, but it was at the ages of 35–49 days after seed germination. Both planting methods produced statistically significant differences in height growth. Kale grown at Smart Farm for 49 days had an average plant height of 17.10 cm. However, the height of trees grown outside Smart Farm was 13.98 cm, as shown in Figure 6. Table 1 displays the statistical difference test results for kale height. Furthermore, when comparing the width of the leaves, we discovered that the average leaf width was not significantly different from 7 to 21 days after sowing. But at 28 to 49 days after sowing, the statistical analysis revealed that both plantings' leaf width growth rates were significantly different. Table 2 shows the statistical difference test results for kale width. Kale grown in a smart farm system had a maximum leaf width of 16.5 cm. The width of the plant without the Smart Farm system was 12 cm, as shown in Figure 7. The comparison of leaf length revealed that there was no significant difference in mean seed leaf length from 7 to 28 days of age. There were statistically significant differences in mean leaf length. Table 3 shows the statistical difference test results for kale length. The kale grown with the Smart Farm system had the longest leaf length of 17.86 cm, as shown in Figure 8.

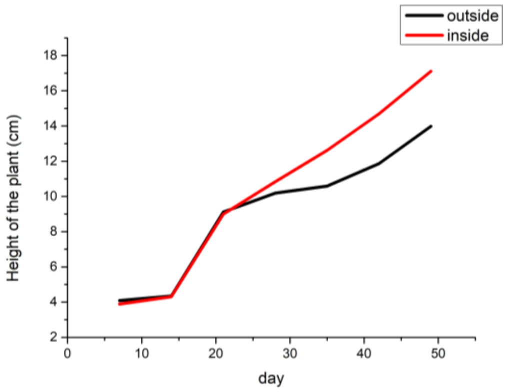


Figure 6. Compare the height of the kale leaves.

Table 1. Statistical difference test results for kale height.

Paired Samples Test

Paired Differences			t	df	Sig. (2-tailed)
Std. Error Mean	95% Confidence Interval of the Difference				
	Lower	Upper			
.55283	-3.91686	-.39814	-3.903	3	.030

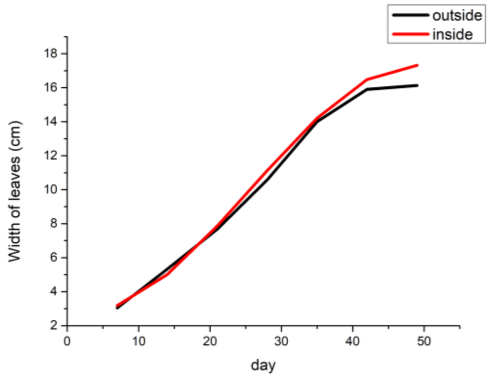


Figure 7. Compare the width of the kale leaves.

Table 2. Statistical difference test results for kale width.

Paired Samples Test

Paired Differences			t	df	Sig. (2-tailed)
Std. Error Mean	95% Confidence Interval of the Difference				
	Lower	Upper			
.53400	-3.91193	-.51307	-4.143	3	.026

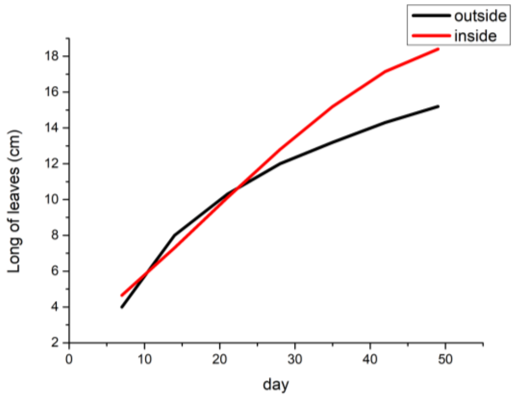


Figure 8. Compare the length of the kale leaves.

Table 3. Statistical difference test results for kale length.

Paired Samples Test

Paired Differences			t	df	Sig. (2-tailed)
Std. Error Mean	95% Confidence Interval of the Difference				
	Lower	Upper			
.53400	-3.91193	-.51307	-4.143	3	.026

CONCLUSION

This research focused on the study and design of soil and air monitoring systems. There are four sensors in this monitoring system, including a soil moisture sensor, air temperature sensors, air humidity sensors, and pH sensors. In addition to obtaining an inconsistent temperature value, we have calibrated it. The statistical test results show that the temperature sensor can measure the temperature no differently than a traditional thermometer. Then the researcher tried using the system to grow vegetables for farmers. The experiment included the growth of kale in two different systems: conventional kale cultivation and kale growth with a soil and air monitoring system. Both types of kale were assessed for growth using standardized measurements, including tree height, leaf length, and leaf breadth. After that, the growth of the two crops was compared and confirmed by statistical test results. The results showed that in the first period (0–28 days), the growth of plants grown with both systems was not statistically significantly different. Kale grows later (28–49 days) than the other two types and was significantly different statistically. Kale grown in the smart farm system has better growth. Real-world farming trials showed that the smart farming technique is capable of effectively satisfying agricultural output requirements.

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