An Implementation of Paprika Green house System Using Wireless Sensor Networks

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Abstract

This research paper suggests the 'Paprika green house system' (PGHS), which collects paprika growth information and greenhouse information to control the paprika growth at optimum condition. The temperature variation range of domestic paprika cultivation facilities are relatively quite big and the facility internal is kept at relatively dry condition. In addition, the concentration of CO2 is not uniform, giving bad impact on the growth of paprika. In order to cope with these issues, the 'Paprika green house system' (PGHS) based on wireless technology was designed and implemented for the paprika cultivating farmers. The system provides with the 'growth environment monitoring service', which is monitoring the paprika growth environment data using sensors measuring temperature, humidity, illuminance, leaf wetness and fruit condition, the 'artificial light-source control service', which is installed to improve the energy efficiency inside greenhouse, and 'growth environment control service', controlling the greenhouse by analyzing and processing of collected data.

Keywords: *USN, Paprika, Green house*

1. Introduction

Recently domestic horticultural industry achieved substantial growth both in quantity and quality with its technology and capital-intensive industry characteristic. Now it became a competitive industry with big potential in overseas export demand, in addition to existing domestic demand [1].

Paprika is one of horticultural products that create high added-value. The production quantity of paprika varies dependent on sunlight quantity, illuminance and sunlight hours [2]. The cultivation cost of paprika is comprised of heating cost, agricultural material cost and labor cost. Among them, the weights of heating cost and agricultural material cost are very high, giving difficulty to the cultivating farmers [3].

This research paper suggests the establishment of a 'Paprika green house system' (PGHS) in the paprika-cultivating green houses, which need precise growth management. 'Paprika green house system' (PGHS) utilizes IT technology in collecting the crops-growth environmental-information in real time and controls the environmental system in the cultivation facility. 'Paprika green house system' (PGHS) reduces the deviations in growth, development, production-quantity and quality of crops. It also maintains optimum environment in the cultivation facility using biometric data and creates optimum condition at paprika root zone. The system optimizes the management of production elements and reduces

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the loss of energy, fertilizer and water, which will result in the decrease of production cost. The artificial light-source from artificial lighting makes pleasant growth-environment so that continuous supply of high quality, fresh vegetable would be possible. Farmers will be able to increase the productivity and income by having their cultivation facilities as continuous supply source of high quality fresh vegetable to clients. 'Paprika green house system' (PGHS) is designed and realized to enable all above based on wireless sensor network.

This research paper is comprised of followings. Chapter 2 introduces the technologies related to the monitoring system applied to the agricultural environment in Korea and overseas. Chapter 3 explains the conFigureuration elements and services provision by 'Paprika green house system' (PGHS) suggested by this research. Chapter 4 explains the implementation content of 'Paprika green house system' (PGHS). Chapter 5 will be the conclusion.

2 Related researches

2.1 Agricultural monitoring system using integrated sensor module

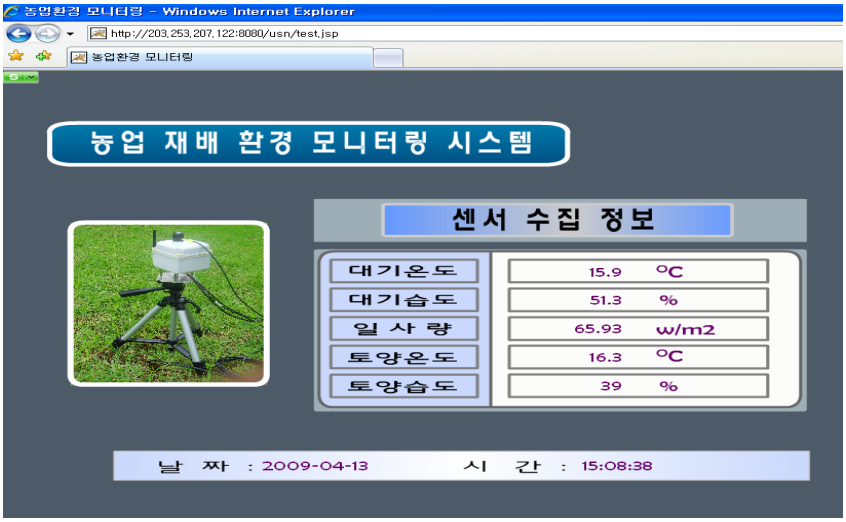

Figure. 1. Monitoring System

This system uses various environmental sensors to collect information required for the cultivation environment of crops. It is a real-time agricultural environment monitoring system based on sensor network. Most of existing wireless sensor nodes based on sensor network need separate conversion/control module for each sensor characteristic. To overcome this issue, an integrated sensor module was developed, which can integrate various sensors used in getting the information required for the crops cultivation, into a single node. New sensors and network monitoring system were also developed to let them fit with the new integrated sensor module and they were integrated to the test environment, in order to examine the operation of newly developed system [4]. Sensor node is also installed to measure the environmental information so that real-time monitoring would be possible [4].

2.2 Greenhouse environment integrated management system

Figure. 2. Monitoring System GUI

The 'greenhouse environment integrated management system' enables the monitoring of greenhouse status in real time through Internet. With its remote control capability, it enables users to manage their farms without restriction of time and place, as long as Internet connection is available [5]. In order to make ubiquitous agricultural environment, a sensor network was built in the greenhouse to measure the environmental elements affecting cultivation environment, such as temperature, humidity, amount of insolation, CO2, ammonia, wind velocity and precipitation. Also, a 'greenhouse environment monitoring system' – comprised of ventilators, windows, heaters, humidifiers, lightings and video processors – is suggested to control the devices activated by the change of measured environmental elements [5].

2.3 Ubiquitous Field Server System

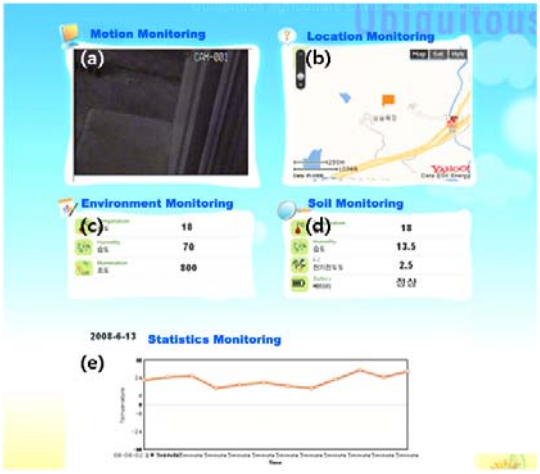

Figure. 3. UFSS's GUI

This system uses solar energy [6]. The UFSS(Ubiquitous Field Server System) can monitor and collect the information of field environments and the system's location using the environment and soil sensors, CCTV camera, GPS (Global Positioning System) module, and solar cell module without restriction of the power supply and the system's location [6]. This system composes of three layers [6]. The devices layer includes sensors, GPS, CCTV camera, and solar cell [6]. The middle layer consists of the soil manager, the location manager, the motion manager, the information storage, and the web server [6]. The application layer provides with the soil and environments monitoring service, the location monitoring service, the motion monitoring service, and statistics service.

2.4 Greenhouse Auto Control System

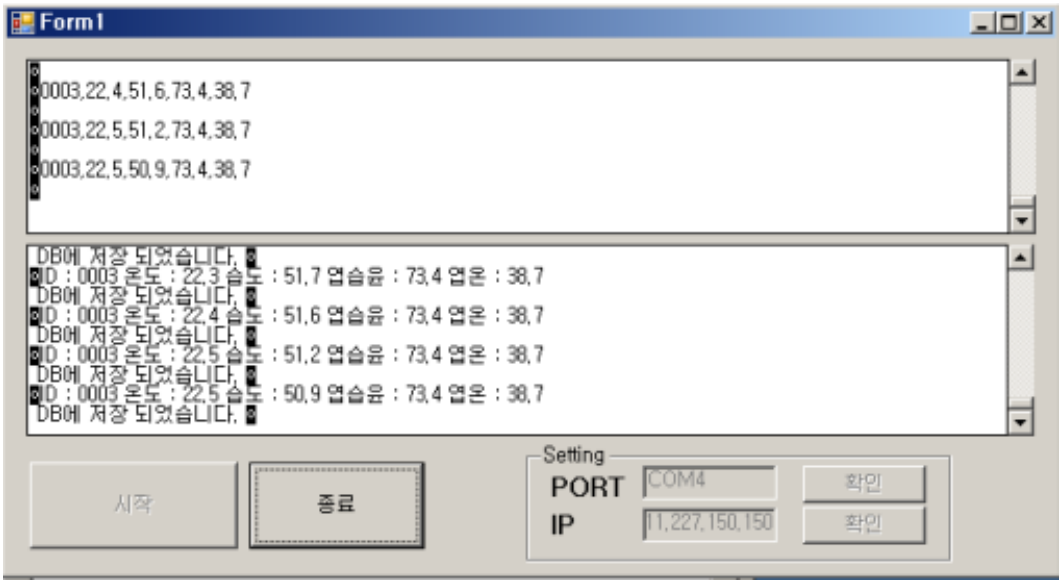

Figure. 4. Greenhouse GUI

Sensor nodes with 2.4GHz zigbee bandwidth and actuator nodes are designed in this System [7]. The information of greenhouse environment and crop's status is periodically collected from temperature, humidity, leaf temperature and leaf wetness sensor so the producer can monitor the greenhouse information anywhere by using Web [7]. Also, this system can automatically control windows, fans, heaters of greenhouse based on this data [7]. When apply to this system, producer can management greenhouse environment and crop's growth effectively, compared to the existing system.

3 Paprika Green House System

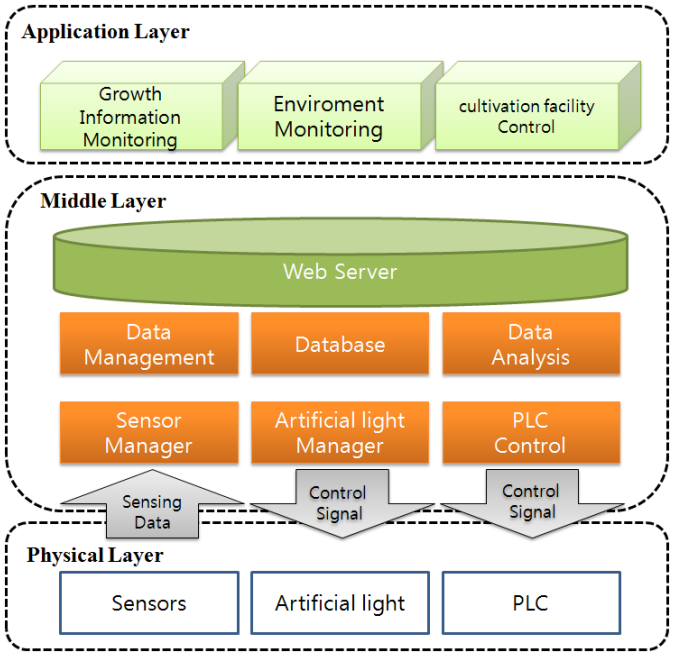

Figure. 5. Paprika Green House System Structure

3.1 System conFigureuration

'Paprika green house system' (PGHS) is comprised of following three layers. The physical layer has 'environmental sensor', collecting environmental information, 'artificial light-source growth control device' and PLC. The middle layer has data analysis and system control. The application layer has GUI and control.

3.1.1 Physical Layer : Physical layer has a sensor device which collects information from paprika culture media and sends the raw data to middle layer. It also has 'artificial light-source growth control device' which controls the wavelength and light quantity of LED light-source for the most optimum growth of paprika. PLC controller controls the temperature, humidity and growth-environment at the root zone based on the collected environmental information. It collects environmental information of cultivation location and makes a control platform to perform the monitoring and control of 'Paprika green house system' (PGHS) through each module.

3.1.2 Middle Layer : The middle layer is comprised of 'data filtering module', 'data analysis module', 'environment control module', 'artificial light-source control module', 'vermin database', 'Database' and 'web server'.

'Data filtering module' processes the raw data transmitted from sensors and saves the temperature, illuminance, humidity and root zone environment data in the database. 'Data analysis module' analyzes the cultivation location environment and crop status based on the information saved in the database. 'Environment control module' transmits the control signal

to the PLC of physical layer. 'Artificial light-source control module' transmits the control signal to the artificial light-source controller.

'Vermin Database' provide vermin information for vermin prevention. 'Database' saves the environment data and analysis data of paprika cultivation location. 'Web server' distributes the service to users through GUI Application.

3.1.3 Application Layer : The application layer is comprised of GUI Application, which provides user with service from 'Paprika green house system' (PGHS).

3.2 Service provided

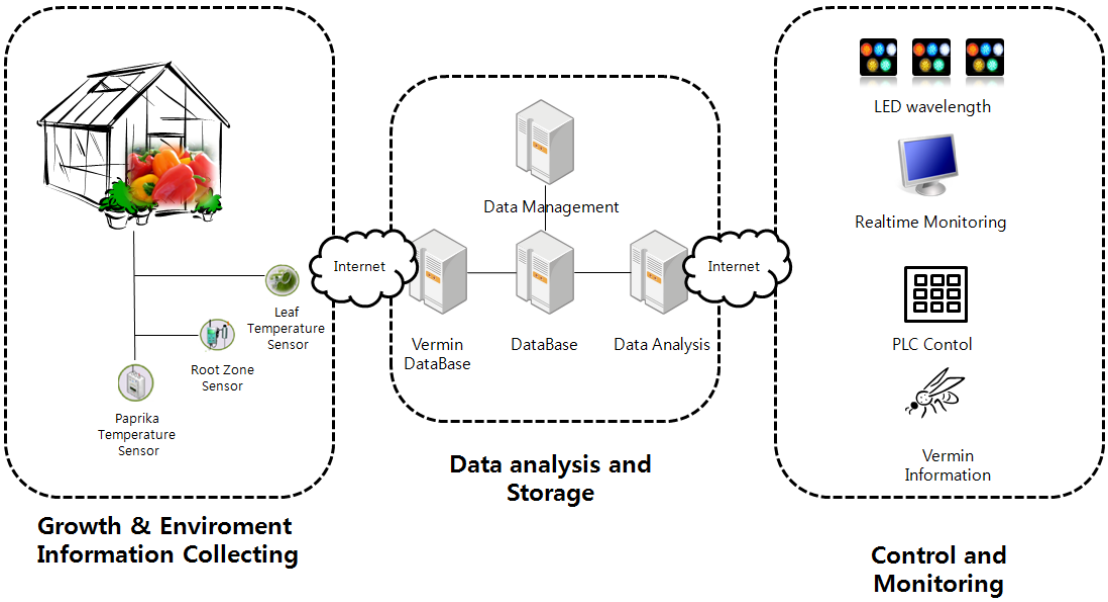

Figure. 6. Providing Service of Paprika Green House

There are 'paprika growth information monitoring service', 'growth environment monitoring service', 'root zone environment monitoring service' and 'artificial light-source control service' and 'cultivation environment control service'. Details of them are as following.

3.2.1 'Growth environment monitoring service'

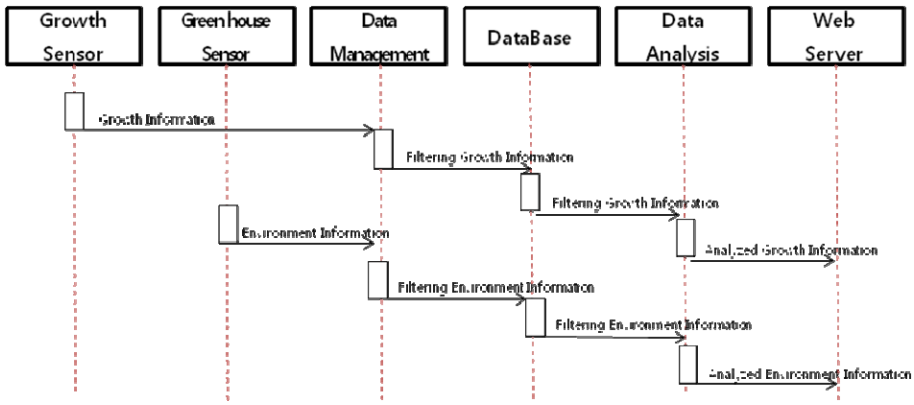

Figure. 7. Growth Environment Monitoring Service Sequence Diagram

'Growth environment monitoring service' provides with paprika growth information and Greenhouse information. During paprika cultivation, if the temperature difference between paprika and atmosphere would be more than 4oC, there will be dew condensation and paprika will suffer diseases like grey fungus. To cope with this problem, sensors to measure the temperature of paprika fruit and paprika leaves are located at the fruit surface and within 5cm of the leaves rear-side. The sensors will collect the temperature data in 2 minutes cycle. User can know the temperature difference between paprika and atmosphere through these sensors and can cope with the temperature difference problem caused by temperature difference between crop and atmosphere, in an active way.

Additional sensors for temperature, humidity and illuminance are installed in the greenhouse so that the user can know the situation through web and identify the growth environment of paprika culture media.

The activation process of 'growth environment monitoring service' is as following. Sensors installed in the greenhouse and on the crops collect the raw data. Data management will extract the leaf temperature, leaf wetness and greenhouse environment information (temperature, illuminance, humidity) and save them in the database. The saved data are analyzed and provided to user through web server in the form of web page.

3.2.2 'Root zone environment monitoring service'

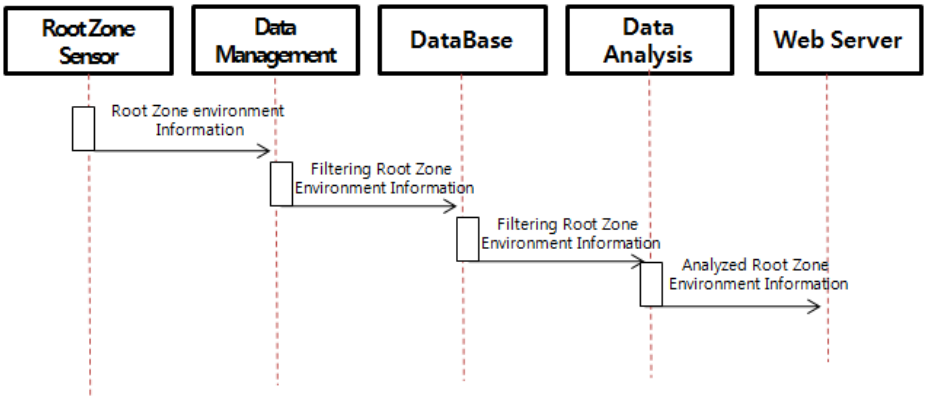

Figure. 8. Root Zone Environment Monitoring Service Sequence Diagram

Paprika cultivation is mostly done by culture medium; therefore, the root zone management is very important because it gives big impact on the absorption efficiency of culture medium. The root zone of the crop means the soil environment, which changes as the growing roots absorb nutrient and save it. EC and PH are especially important. If EC in soil is not enough, fruit does not grow compared to the leaves growth. If EC is too high, production decreases. If the fertilizer content in the soil becomes higher, PH decreases [8].

This service utilizes such characteristics of EC and PH and monitors the root zone environment. The activation process is same as 'growth environment monitoring service'

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3.2.3 Artificial light-source control service : LED can save 80% energy than existing incandescent light bulbs. LED prevents vermin and adjusts the growth velocity of crops so that shipping timing can be adjusted. As seen in following table, the wavelengths of LED give various impacts on the crops. This service applied those impacts [9] to the 'artificial light-source control service' and let it contribute in the control of paprika growth-speed and quality improvement.

Table 1. Artificial light-source Impact

Wavelengths	Impact
1400~1000 (IR-A)	No specific impact on crops. Gives heat impact
780(IR-A)	Promotes specific elongation effect on crops
660(red)	Maximize chlorophyll reaction (655)
610(red yellow)	Not good for photosynthesis. Prevents vermin (580~650)
430~440(blue)	Maximize photosynthesis (430), Maximize chlorophyll reaction (440), Entice vermin.
400 ~ 315(UV-A)	In general, makes leaves thick. Encourages the coloring of pigments. Entice vermin.
280(UV-B)	Important reaction in many synthetic processes (makes antibody), Harmful if too strong
100(UV-C)	Let crops wither rapidly.

3.2.4 'Cultivation environment control service'

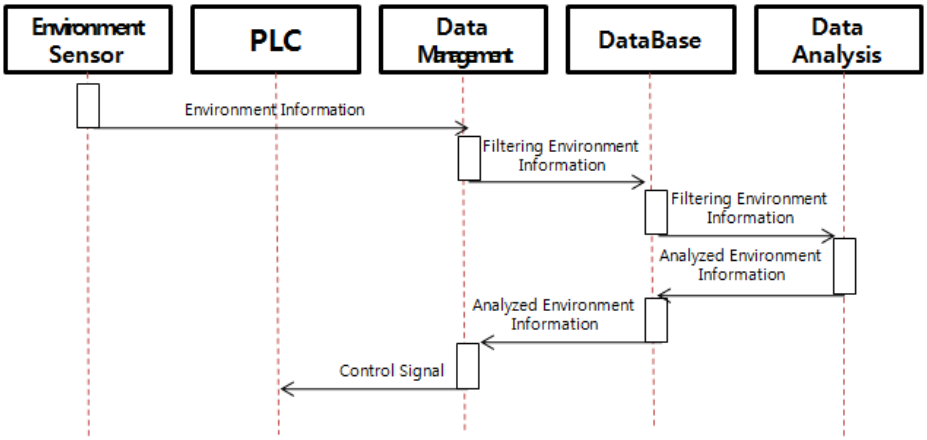

Figure. 9. Cultivation Environment Control Service Sequence Diagram

'Cultivation environment control service' controls the devices installed in the paprika greenhouse based on the data collected from sensors and saved in the database. The service maintains the optimum environment for the growth of the crop.

The activation environment is as following. The environmental information sent from cultivation location is transmitted to the data management in the middle layer. They are saved in the database after the correction of overlapping or wrong data. Then the saved data is sent to the 'data analysis module', where optimum control information for paprika growth would be analyzed. That information is saved again in the database and signals will be sent to PLC so that it would automatically control the devices such as ventilators and fan heaters.

3.2.5 'Vermin information service'

Vermin which damage to crops are investigate with influence to crops and occurrence conditions of paprika diseases to provide the information for farmers.

The occurring conditions of paprika diseases and vermin will be made into database and show the information, so that farmers can actively cope with the diseases and vermin in advance.

4. Implementation

Various devices such as sensors, ventilators and fan heaters were installed in the paprika greenhouse to examine the performance capability of 'Paprika green house system' (PGHS). Figureure 10 and Figureure 11 are sensors measuring the fruit temperature, leaf temperature and leaf wetness. Figureure 12 is sensors collecting the root zone environment information. Figureure 13 is GUI Application, providing users with 'Paprika green house system' (PGHS) service. Information collected from paprika fruits and leaves in Figureure 10, Figureure 11 can be confirmed in (b) of Figureure 13. Root zone information collected in Figureure 12 can be confirmed in (c) of Figureure 13 and (d) show the vermin information as Figureure 14

Figure. 10. Fruit Sensor

Figure. 11. Leaf Sensor

Figure. 12. Root Zone Sensor

Figure. 13. GUI Application

The greenhouse environment information values measured in Figureure 15 can be confirmed in (a) of Figureure 13. Data collected at the sensors go through server and the most optimum growth data will be sent to Database. Then the server sends signals to artificial light-source controller of Figureure 16 and PLC controller of Figureure 17.

It has been demonstrated that the 'Paprika green house system' (PGHS) shows optimum control performance for the best growth of paprika.

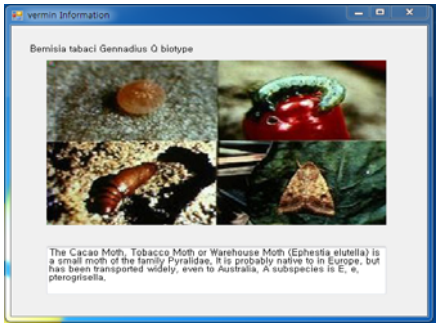

Figure. 14. Vermin information

Figure. 15. Environment Sensor

Figure. 16. Artificial Light Controller **Figure. 17. PLC controller**

5. Conclusion

This research paper realized the paprika greenhouse environment monitoring system for the precise growth-management of high added-value crop, paprika. The suggested system 'Paprika green house system' (PGHS) makes a network comprised of sensors measuring temperature, humidity, illuminance and others. The system also controls ventilators, humidifiers, lightings and video-processing through GUI Application by analyzing the measured data.

The suggested 'Paprika green house system' (PGHS) will contribute in the farmers' income increase, which is the top priority task in domestic agricultural industry. The system will create other research results by providing with the growth environment information from numerous paprika cultivation locations. Enhancement of price competitiveness of domestic horticultural industry can also be achieved by improving the distribution rate of new paprika species.

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