Development of Phenotypes Technology for Chlorophyll Content Detection in Hydroponic Lettuce

I. Title of Research: Development of Phenotypes Technology for Chlorophyll Content Detection in Hydroponic Lettuce

II. Research Team Members

Department	Name	Position
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III. Development Idea

The precipitation hardening (PH) stainless steel with excellent mechanical strength, better wear resistance, and good atmospheric corrosion resistance can be formed by adding additional elements such as copper, aluminum, titanium, niobium, and molybdenum to the iron-chromium-nickel stainless steel, followed by a solution treatment and an aging treatment. The PH stainless steel can be widely used in golf club heads, gas turbine blades, oil pipeline valves and nuclear energy reaction components, etc.

This product focuses on developing a detection technology for chlorophyll content in hydroponic lettuce phenotypes. Using hydroponic lettuce as the research subject, it leverages an imaging detection system to capture critical data on the plant's growth environment. Through this system, researchers can obtain real-time insights into the growth status of hydroponic lettuce, analyzing its development. Detailed observations of leaf surface phenotypes, external plant shapes, and characteristics are conducted, facilitating a better understanding of the growth process.

The commercialized outcome integrates an IoT real-time monitoring system into the hydroponic system, including sensors and data transmission devices. With a user-friendly interface or mobile application, users can visually monitor the state of hydroponic lettuce while tracking key indicators such as chlorophyll content. This enhances the development of Taiwan's innovative agricultural technology.

IV. Technological Competition and Industrial Application

The greenhouse cultivation and plant factory industries are estimated to generate an annual output value of approximately NT$15 billion. The annual revenue from plant factory agricultural facilities and vegetable sales ranges between NT$30 million and NT$300 million, with the overall annual output value of plant factories reaching around NT$10 billion. This technology has the potential to boost the annual output value of the greenhouse industry by 11.3% and that of plant factories by 5%, offering new possibilities and applications for the development of Taiwan's agricultural sector.

V. Merchandise Statement of Achievement

This product focuses on developing a detection technology for chlorophyll content in hydroponic lettuce phenotypes using hydroponic lettuce as the research subject. It comprises three main components: establishing an imaging detection system, in-depth analysis of leaf surface phenotype imaging, and a real-time monitoring system for analyzing chlorophyll content and lettuce growth status.

The developed imaging detection system captures critical data about the plant's growth environment. Through this system, researchers can obtain real-time key information on the growth conditions of hydroponic lettuce, enabling detailed growth analysis. It also facilitates intricate observations of leaf surface phenotypes, external plant morphology, and characteristics, improving understanding of lettuce growth processes.

The commercialized outcome integrates an IoT real-time monitoring system, which includes sensors and data transmission devices, into the hydroponic system. Using a user-friendly interface or mobile application, users can visualize the growth state of hydroponic lettuce while tracking key indicators such as chlorophyll content.

The imaging system, composed of conventional cameras paired with optical filter lenses, is compared with multispectral cameras as a cost-effective alternative to high-priced multispectral equipment. This system, combined with leaf phenotype analysis, measures the reflection spectra of leaves across different wavelengths. The by-products of lettuce, such as chlorophyll, carotenoids, and anthocyanins, are reflected in these spectra. This approach enables simultaneous measurement of chlorophyll and other by-products, offering advantages such as non-destructive testing, simplified measurement methods, and cost reduction. Additionally, IoT integration allows real-time recording of lettuce growth and by-product content, achieving low-cost and real-time detection.

This technology could be implemented in the plant factory industry to enable brilliant production, improve crop quality, predict yields, and save resources, enhancing industrial competitiveness. Key applications include:

1 Research on artificial light-based environmental control and supplemental lighting in plant factories. 2 Establishment of continuous non-destructive monitoring technologies for Boston lettuce leaf composition and phenotype growth using multispectral imaging. 3 Development of a digital twin for plant factories through AI-enhanced deep learning applied to decision-making in demonstration facilities.

Establishing a highly valuable digital twin demonstration facility that integrates AI with multispectral imaging technology offers significant potential for Taiwan's smart agriculture. It holds great promise for applications in the plant factory industry, driving advancements in technology and productivity.

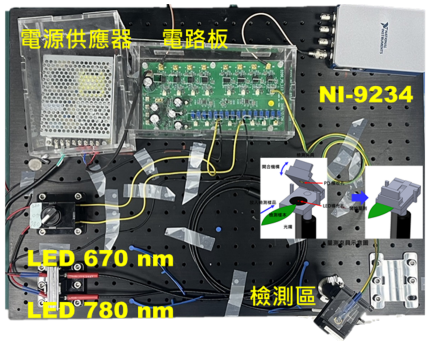

Fig. 1: A light intensity detection system capable of measuring the chlorophyll content (in ppm) of leafy vegetables.

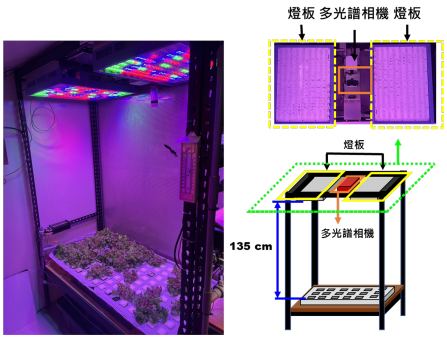

Fig. 2: A multispectral detection system capable of capturing the chlorophyll content and leaf area of leafy vegetables.

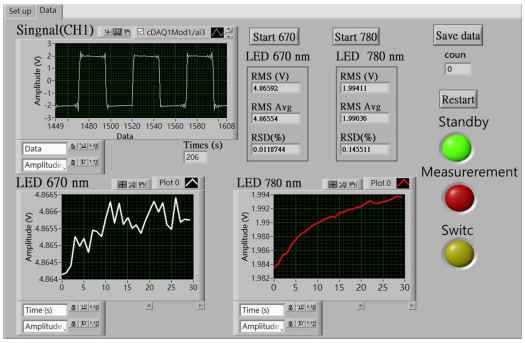

Fig. 3: A light intensity detection system with a user interface for real-time monitoring and data recording.

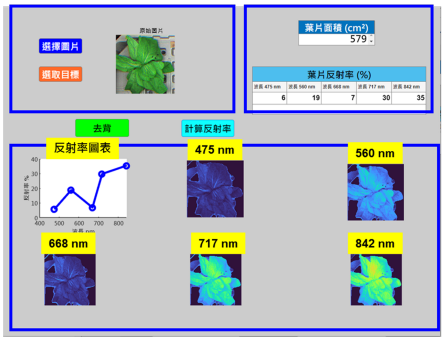

Fig. 4: A multispectral detection system with a user interface for real-time monitoring, data recording, and analysis.