Modular Agricultural Production System
State-of-the-art Controlled Environment Plant Factory

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Abstract

The main objective was to develop and test core technologies for plant production systems. Modular agricultural production system (MAPS) is a system that performs planned production of crops with high degree of environmental control and automation, which is identical to the manufacturing plant. Within MAPS, continuous, rapid, and mass production of high quality crops is possible regardless of natural environments. Creative applications of plant factory, such as insured food security and safety against recent climate changes, as a tool for agricultural industry, have gained significant attention from private companies and government. Recently, research for the future growth engines (FGEs) of conversion/fusion technology is ongoing on an international scale, and the plant factory technology is regarded as one of them. In collaboration with the University of Guelph in Canada, the research team at the Kuwait Institute for Scientific Research (KISR) has designed, built, and test-run a modular agricultural production system based on common element technologies of plant factory. This has resulted in the development of a fully-controlled multilayer plant growing system that has the latest advancements such as emerging lighting, nutrient management, and control systems, which will enable extreme environment food production. A value-added sustainable crop production technology has been developed for enhancing the health promoting characteristics in vegetables and fruits. It also contributes to resolving the challenging food security facing Kuwait by overcoming ecological and public health concerns surrounding conventional greenhouse agriculture, including high resource consumption, long distance food transport, and food safety. Kuwait will achieve the goal of producing agricultural products with less land and water, energy use, environmental impact, and carbon emissions compared to similar crops grown using conventional methods and seasonal production.

The Focus and Content of Study

- **Development and testing of a protected plant production system through the development of core technologies of plant factory**
  - Designing, building and test-run of a modular plant production system based on common element technologies of plant factory.
  - Development of a fully-controlled multilayer plant growing system.
  - Enabling extreme environment food production through emerging lighting, nutrient management, and control systems.

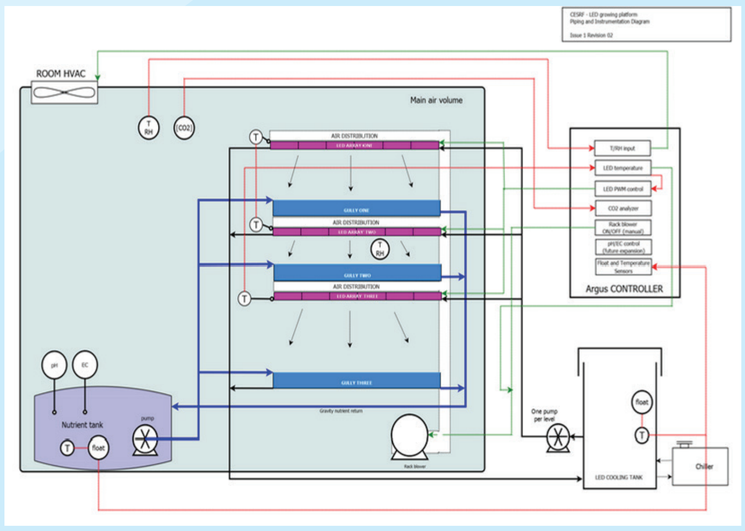
- **Development of technologies for reduction of energy consumption, and efficient use of artificial lights in plant factory**
  - Development of energy-saving, high-efficient LED light sources and lighting modules.
  - Development of a physiological control method of crops by combination of different light wavelengths.
  - Analysis of crop photosynthetic characteristics at different wavelengths and its applicable technology.

- **Development of cultivation systems optimized for modular plant production systems**
  - Development of nutrient solution and nutrient supply systems for introduction of new crops.
  - Development of root media applicable in plant factory cultivation system.
  - Selection of cultivars suitable for plant factory and establishment of crop database.

General overview of the system and its components

- The prototype modular plant production system was designed as a single plant growing bench with 3 levels of LED powered.
- Modelling was performed to provide engineering details that would facilitate final component selection.
- The current prototype design details include a 2.1 m x 1.2 m growing area with integrated air distribution and hydroponics.
- The LED spectrum on each level include ultraviolet-A, blue, red and far red wavelengths, as well as a broad spectrum and high efficiency white LED.

- **The MAPS as it is currently configured consists of five primary subsystems:**
  - Main bench and supports
  - Air delivery system
  - Argus control system
  - LED lighting system and control
  - Hydroponics system



MAPS – Schematic sketch diagram

MAPS facility at KISR

Necessity and benefit for Kuwait

- Regardless of rising attentions on this “vertical” plant production system as well as emerging plans on installation of plant factory in various forms, there have been limited knowledge and core technologies are not domestically established.
- The development of cultivation systems optimized for plant factory using energy-saving, high-efficient LED light sources and lighting modules can lead to the selection of cultivars suitable for plant factory and the establishment of crop database.
- A value-added sustainable crop production technology can be developed for enhancing the health promoting characteristics in vegetables and fruits.
- It also contributes to resolving the challenging food security facing Kuwait by overcoming ecological and public health concerns surrounding conventional greenhouse agriculture, including high resource consumption, long distance food transport, and food safety.
- Kuwait will achieve the goal of producing agricultural products with less land and water, energy use, environmental impact, and carbon emissions compared to similar crops grown in open field conditions or greenhouses using conventional methods and seasonal production.

Future research scope

- It is proposed to advance to the next phase of infrastructure development at KISR.
  The next phase of collaborative activity for infrastructure development is the construction of a pilot- scale production facility consisting of twenty one modules contained in three separate production chambers.
- The facility includes seeding and propagation space, utilities and workshop, systems control office and a gowning area to reduce potential pest contamination and dust infiltration.
- The proposed facility is to be located at KISR’s research station at Kabd and is designed to be integrated into the proposed research greenhouse facility, the design phase for which has recently been completed.
- This pilot scale modular production system will provide extensive research, training and technology transfer capability to KISR’s program in controlled environment agriculture.

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