Preface to the Special Issue “Current Technologies and Researches on Plant Factory and Intelligent Greenhouse”

Workshop chair: Kotaro TAKAYAMA\(^1\)

Guest editors: Hirokazu FUKUDA\(^1\), Noriko TAKAHASHI\(^1\) and Ryosuke ENDO\(^1\)

\(^1\) Graduate School of Agriculture, Ehime University, 3-5-7 Tarumi, Matsuyama, Ehime 790-8566, Japan

\(^2\) Osaka Prefecture University, Sakai, Osaka 599-8531, Japan

The 1st International Workshop named as “2017 CIGR World Workshop in Matsuyama” organized by Plant factory and intelligent greenhouse (PFIG) working group on the International Commission of Agricultural Engineering (CIGR, Commission Internationale du Génie Rural) was held at Ehime University in Japan (Date: 2nd-4th Sept. 2017). The most important objective of this workshop is to share the current situation on “Innovative but feasible technologies for plant factory and intelligent greenhouse”. The workshop consisted of an international symposium of “ICT on Plant factory and intelligent greenhouse”, three organized sessions (OS) and one general session (GS). In the international symposium chaired by Prof. Shimizu (Kyoto University), Prof. Onishi (Former President of Science Council of Japan) made the opening remark, and four lectures were provided, “Current and future topics on plant factory” by Prof. D. He (China Agricultural University, CN) and Prof. E. Goto (Chiba University, JP), “How plants sense and respond to environmental cycles” by Prof. A. Dodd (University of Bristol, UK) and Prof. H. Fukuda (Osaka Prefecture University, JP), “Daily plant data for intelligent environmental control in greenhouse” by Prof. E.V. Henten (Wageningen UR, NL) and Prof. K. Takayama (Ehime University, JP), “Advanced management strategies of greenhouse using ICT” by Prof. Sun-Ok Chung (Chungnam National University, Republic of Korea) and Prof. N. Noguchi (Hokkaido University, JP). And, Prof. S. Shibusawa (Tokyo University of Agricultural and Technology, JP) provide closing remark. The following sessions were OS1 “Precision measurement and modeling of dynamical plant information” chaired by Prof. H. Fukuda (Osaka Prefecture University, JP), OS2 “Plant biological information for greenhouse crop production” chaired by Prof. K. Takayama (Ehime University, JP), OS3 “Advanced agricultural food/bio-resource technology: Functional food, packaging, utilization” chaired by Assoc. Prof. N. Shimizu (Hokkaido University), and GS chaired by Dr. E. Raeza (Wageningen University, NL) and each session was composed of 4-5 lectures. The total attendance of this workshop reached 100 and was successfully closed.

To share the contents of this workshop with the people who could not attend this workshop, we would like to organize the special issue of “Current Technologies and Researches on Plant Factory and Intelligent Greenhouse” in Journal of Environmental Control in Biology with a strong support of Editor-in-Chief Prof. H. Shimizu. We hope our activity make a good reference material and be of great use for the readers of this journal.

The following is the outline of Plant Factory and Intelligent Greenhouse (PFIG) working group. The key members of this working group are Dr. H. Fukuda (Osaka Prefecture University, JP) as chair, Dr. E.J. Baeza Romero (Wageningen University, NL) as vice-chair, Dr. K. Takayama (Ehime University, JP) as secretary, Dr. N. Takahashi (Ehime University, JP) and Dr. R. Endo (Osaka Prefecture University, JP) as vice-secretary.

INTRODUCTION

The world population reached 7.3 billion as of mid-2015 and will continue to increase by 2100. To feed the growing world population, a dramatic improvement of land productivity and securing of stable food supply are strongly required. At the same time, demand for high value-added foods, not only high quality foods but functional foods that contribute to the health promotion, is also increased. To answer to these demands, the importance of “plant factory and intelligent greenhouse” as productive food production system has been increasing.

The plant factory is a facility achieving an extremely steady plant production under fully controlled environmental condition without sunlight. In a well-insulated and airtight facility, multiple culture shelves are vertically stacked and each shelve is equipped with electric lamps for photosynthesis of leafy vegetables. Moreover, agricultural production by controlling specific microorganism such as bacteria-free culture might be possible. And, the intelligent greenhouse is an advanced greenhouse equipped with an automated environmental control system and conducting year-round plant production of various plants including vegetables and ornamental foliage plants under the sun. Currently, the computerized plant

Corresponding author: Kotaro Takayama, fax: +81-89-946-9821,
e-mail: takayama@agr.ehime-u.ac.jp
production based on the concept of Speaking Plant Approach (SPA) attracts attentions as an implementable key technology to achieve a significant productivity improvement in plant factory and intelligent greenhouse. The concept of SPA defines that the optimization of cultivation conditions should be based on measurements of the plant biological and physiological information and it is getting feasible according to a recent development of information technology, i.e. artificial intelligence and bioinformatics symbolized by omics.

The research for the agricultural production in plant factory and intelligent greenhouse consist of wide-ranging studies on facility, energy, horticulture, plant physiology and ecology, mechanization and automation, computing and modeling, and measurement. Furthermore, the cutting-edge information technologies deserve to be involved in this research area. However, there is no integrated research community focusing on plant factory and intelligent greenhouse until now. By organic integration of relevant study fields, the productivity of plant factory and intelligent greenhouse must be taken one bold step further. Therefore, scientific and technological approaches of this area will be more and more important for CIGR activities. However, there is no existing technical section (TS) and working group (WG) covering the plant factory and intelligent greenhouse.

MISSION STATEMENTS

The plant factory and intelligent greenhouse have a completely different agricultural production strategy from the traditional arable agriculture. Hence, it is not easy to understand the significance of agricultural production in plant factory and intelligent greenhouse for researchers with different backgrounds, farmers, consumers, and government. In addition, plant factory and intelligent greenhouse mostly have a strong motivation of commercial success as an industrial activity. Our vision is to establish a global community on plant factory and intelligent greenhouse, in which we will conduct an intensive study and discussion to enhance the unique value of plant factory and intelligent greenhouse through industry-academia-government collaboration and ensure the stable, high quality and high value-added food supply to human being. These require us to:

1. Improve understanding of the uniqueness of agricultural production including facilities, instrumentations, energy and water use in plant factory and intelligent greenhouse.
2. Improve understanding of plant’s environmental response under artificial growing conditions, which must be investigated from the point of view of plant physiology and ecology.
3. Improve understanding of the importance of mechanization and automation to improve labor productivity in plant factory and intelligent greenhouse.
4. Improve understanding of the effectiveness of computing and modeling to find a way to increase productivity in plant factory and intelligent greenhouse.
5. Improve understanding of the availability of cutting-edge information technologies, i.e. artificial intelligence and bioinformatics, in plant factory and intelligent greenhouse.

OBJECTIVES AND AIM

The objective of this working group is to provide an open platform for researchers who are interested in the agricultural production of plant factory and intelligent greenhouse. And this working group aims to promote R&D, communication and education in this field by enhancing information sharing among the researchers, relevant professionals, and consumers and eventually promote the international standing of the CIGR’s plant factory and intelligent greenhouse working group in the field. Furthermore, younger generation play an important role in such a new agricultural production in plant factory and intelligent greenhouse, therefore the younger generation initiated researches and communications are strongly encouraged.

Specific objective 1.
Establishment of SPA system, i.e. environmental control based on plant diagnosis, for stable and efficient agricultural production in plant factory and intelligent greenhouse.

Specific objective 2.
Reduction of input resources by improving the energy and water use efficiencies in plant factory and intelligent greenhouse and minimize their environmental impacts (including vertical farming and supergiant scale plant production).

Specific objective 3.
Investigation to clarify the appropriate mechanization and automation maintaining well-balanced relations with human labor.

Specific objective 4.
Development of reliable models for accurate prediction of plant growth and yield and for labor control to improve the productivity.

Specific objective 5.
R&D for unprecedented agricultural production, e.g. new plant materials such as genetically modified plants and
pathogen-free vegetables, in plant factory and intelligent greenhouse.

Specific objective 6. Investigation of availability of artificial intelligence and bioinformatics symbolized by omics in plant factory and intelligent greenhouse.

Specific objective 7. Promoting human resource development and training for managers and labors of plant factory and intelligent greenhouse.

Specific objective 8. Establishing the younger generation initiated researches and communications in this field.

WORK PLAN

The plant factory and intelligent greenhouse (PFIG) working group is responsible for all the activities relating to plant factory and intelligent greenhouse in CIGR with close relationships with the existing TSs and WGs. The relevant TSs are TS II, TS III and TS VII. The TS II “Structure and Environment” put attention on traditional structure and environment for animal husbandry and cattle housing (our PFIG working group can provide a specific information on plant factory and intelligent greenhouse), the TS III provides technology and equipment for wide-range of plant production (our PFIG working group can promote the plant production under artificially controlled environment), the TS VII covers all the information technology (our PFIG working group intensively deals with application and implementation of information technology to plant factory and intelligent greenhouse). The chairs and the key steering committee members will create and activate a new PFIG working group to accomplish the above-mentioned purposes through the following activities:

Workshops/Seminars: The events will be held every two years, covering the main trends and new developments in the field worldwide. Internationally prominent experts in the field will be invited as invited speakers. Some sessions might be organized by younger generation researchers. Generally, the events will be held in the form of on-site meetings.

Website: The website of PFIG working group will be created on the web server of the research center for high-technology greenhouse plant production in Ehime University (JAPAN) and linked to the main CIGR website. The PFIG working group website consist of R&D trends, technical reports, events, networks, information on trainings and courses, case studies, links to relevant websites.

Working group activities: Regular group meeting is conducted by skype and email to discuss the action plan of working group and share the latest information. Administration support for the development of outreach materials/activities, partnerships and collaborations.

EXPECTED OUTCOMES

By organizing workshops and seminars on plant factory and intelligent greenhouse, effective collaborative R&D among industry-academia-government must be accelerated. Furthermore, activity of younger generation researchers in this field would be enhanced.

By publishing special issues in CIGR-Journal on plant factory and intelligent greenhouse, understanding of agricultural production in plant factory and intelligent greenhouse will be improved.

By updating the working group website, prompt sharing of up-to-date knowledge in this field is ensured. Increase in the number of individual member associate with CIGR.

KEY MEMBERS

The PFIG working group will administer activities relating to plant factory and intelligent greenhouse in CIGR. The chairs and the steering committee members are responsible for all the missions, objectives and aims, and work plan of this working group by keeping close communication with the CIGR Presidium. Furthermore, the chairs and the steering committee members should revise the work plan to keep high standard of the working group in the field according to changes in academic and social demands. The chairs are responsible for planning and management of this working group, as well as attracting funding/support/collaboration. The secretary is responsible for keeping updated records for the steering committee members and associated organization members, preparing meeting agenda and summary reports, and sometimes undertaking small cashier job for the working group if appropriate.