PLANT FACTORY FOR ASIA MONTHOON REGION

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ABSTRACT

To enhance agriculture productivity, vegetable production, especially those that grew in protected cultivation (plant factory as a most advanced type) has been in public attention because of its high potential to increase productivity in Japan. The situation is the same in the Asian region. To accomplish this goal advanced techniques are necessary and must be assembled. Breeding new cultivars, nursery systems, environment control, integrated nutrient management (INM), integrated pest management (IPM), information and communication technology (ICT), robot technology, such as a series of advanced technologies are necessary to build up efficient production system. ICT is one of most important technologies that ensures the reliability of agricultural products. For the small farmers, ubiquitous environment control system (UECS) is most suitable ICT tool. UECS should be a standard of communication system.

Package strategy is also an important aspect for sipping the greenhouse technologies. To produce high quality Japanese horticultural products, assembled technologies as a package is an important concept, and the project “Development of the Asian monsoon model plant factory system to promote the informatization of agriculture, forestry, fisheries and food industry, and innovation of production system” has been started in the Project of the NARO Bio-oriented Technology Research Advancement Institution (R&D matching funds on the field for Knowledge Integration and innovation)

Keywords: IGM (Integrated Greenhouse Management), Seedling raising, System Integration, UECS.

INTRODUCTION

COMPONENT TECHNOLOGIES IN GREENHOUSE

Seedling raising in artificial lighting Plant Factory

Japanese proverb of horticulture. “A seedling is 50% of harvest.” That interpretation is “Please note the making of good seedlings. Good seedlings (pest free and good taking root) will promise good harvest.” Raising seedlings (transplant) is important in protected cultivation (Kozai 2015). Recently raising seedlings in closed system has been getting popular in commercial market in Japan. We developed new closed system with LED commercially (Fig. 1).

This system introduced red and blue LED alternating irradiation, that lead energy saving up to 60% of conventional florescent lighting. Moreover, recently we developed new system to produce bigger seedling of tomatoes in closed artificial lighting system (Fig. 2), which make the time of growing in the greenhouse shorter. This system will reduce the occurrence of pests and diseases.

Integrated Fertilizer Management in greenhouse

We established organic fertigation system (Nakao et al. 2000, 2002) with organic liquid fertilizers. The concept consisted of two points, one point is the use of organic liquid fertilizer by top dressing little by little within the decomposition ability of soil microbe, another point is addition of deficit element e.g. Ca in advance as Ca material or high Ca content manure.

We attempted to establish an organic fertigation system by using corn steep liquor (CSL) as liquid organic fertilizer, instead of the usual inorganic fertilizers. Combination of CSL (some products are certified as a fertilizer suitable for organic farming) and manure showed stable production even in the first-year production of organically fertigation system (Nakano and Uehara 2007, Fig. 3). Recently, for organic production of blackberry liquid corn and fish fertilizers are shown as good options for fertigation (Fernandez-Salvador et al. 2015). Organically certified liquid fertilizer from molasses of sugarcane has also been in the market, organic fertigation would be more popular
Balanced fertilizer application is a basic concept to reduce soil borne diseases, because there is the causal relationship between excess phosphorus (P) in the soil and incidence for clubroot disease (Murakami et al. 2004). And some elements have special effect to resist the disease. For example, on silicon in lower concentration, cucumber is likely to be susceptible to disease and causes reduction in the yield (Voogt et al. 2001).

Fig. 1 LED lighting for raising seedlings. LED ai (alternating irradiation) system, SHOWA DENKO K.K.

Fig. 2. Controlled atmosphere big seedlings (CABS) was made by light and humidity transparent film (FUJIFILM Corporation).
Integrated Pest Management in greenhouse

Integration of technologies is basic approach to suppress pests, so it is, integrated pest management (IPM). IPM consist of four main aspects physical control, chemical control, biological control and agronomic control. The systematic integration of these techniques has effects on greenhouses because of higher control (Fig. 4, Nakano 2017).

Fig. 3. Effect of top dressing of organic liquid fertilizer to manure applied soil
Organic fertigation system (OFS), which could be controlled by UECS, is one of the techniques of IFM (Integrated Fertilizer Management).

Fig. 4. Technology integration for sustainable vegetable production
This is an example of IPM (Integrated Pest Management).
Screen is one of basic physical control in greenhouses, insect invasion is restricted by screen with mesh. Solar heating (solarization) of soil for control of soilborne pests is considered a classic method at present. In the greenhouse, isolated beds (as the same Root-proof Sheet, Uehara 1990) surely has an effect to control tomato bacterial wilt disease caused by *Pseudomonas solanacearum*, because the root area is restricted.

Powdery mildew is probably one of the most common and widely distributed diseases of plants in greenhouse production. In the greenhouse, powdery mildew tends to be more problematic in the spring and fall when day-night temperatures favor high relative humidity (RH) but it can develop at any time during any production cycle. Environmental control will contribute to successful management of this disease. On the other hand, powdery mildew caused by *Podosphaera pannosa* is a major disease of greenhouse roses (Kobayashi et al. 2013), and chemical fungicides are necessary for disease control. Ultraviolet supplementary radiation suppresses the development of powdery mildew disease in greenhouse roses by systemically acquired resistance.

A novel repellent, acetylated glyceride has been developed against sweet potato whitefly, *Bemisia tabaci* (Kashima et al. 2014). Acetylated glyceride is a food additive which is considered safer materials than ordinal agricultural chemicals. Stinkbug (*Tupiocoris cucurbitaceus*) could be a predator of the greenhouse whitefly (*Trialeurodes vaporariorum*) in tomato crops (López et al. 2012). In well-controlled greenhouse condition, natural enemy is easy to propagate to the effective population. Introduction of natural enemy could contribute to reduced labor cost of spray and production of safer agricultural products.

**ICT technology in greenhouse**

The plant factory implements science-based environmental controls based on a large number of measurement items. The UECS (ubiquitous environmental control system, Fig. 5) we developed features like open set of regulations for control methods, and a system that is well-known for allowing information to be acquired easily.

![Fig. 5. Development of UECS (Ubiquitous Environmental Control System)](image)

**ICT AND SYSTEM INTEGRATION**

In facing and coping with domestic social and agriculture problems, technology integration has led to the development of the plant factory as a platform. To enhance the export of agricultural related products, distribution of agricultural products will be more reliable and safe through an effective traceability system. Furthermore, the upbringing of human resources in advanced greenhouse production system is also important to social implementation of high production system. It is desired in plant factories to become resilient especially in Japan.

**System integration in greenhouse**

The technical features of NARO plant factory in Tsukuba consists of many advanced technologies (Nakano et al. 2012). Summing up the three main results have been put to practical use. (1) Investigation of cultivars for
hydroponics: productivities of tomato, cucumber and paprika cultivars are investigated with hydroponics and developed new tomato cultivar “Ringyoku”. (2) Environment control system for low carbon emission: newly developed ubiquitous environment control system (UECS) is installed to investigate the effectiveness of integrative environment control and demonstrate the effective use of heat accumulation from sunlight and use of bio mass fuel. (3) Improvement of work environment by use of automation and ICT: comfortable environment for workers is established and efficient improvement using automatic conveying system is established.

Finally, from a series of accomplishments, we developed an environmental control tool and a robot that helped to achieve a 50% reduction in labor and a 30% increase in profits as compared to conventional cultivation in Japan. This research system with the targets will lead to the innovation of Japanese greenhouse production including the plant factory.

**Authenticity of the geographical origin and production methods of agricultural products**

On the aspect of consumers, safety and high quality of agricultural products are primal. Multi-element analysis including stable isotopes can be used as a possible indicator for food safety and security including organic products. For the certification of geographical origin, the analytical methods can be performed in two ways: one in which multivariate analysis is used to determine the concentrations of omnipresent elements such as Al, Ca, Cl, Mg, Mn, Fe, and Zn and the other focuses on special elements such as the stable isotope ratio of Sr, O, and H. For the certification of production methods, especially for organic products, δ¹⁵N values could be a potential indicator, particularly in protected cultivations such as a plant factory (advanced-type greenhouse horticulture, Nakano et al. 2003). Because the accuracy of these values is affected by production conditions, predicting δ¹⁵N values of products more accurately is possible under controlled conditions, e.g., in a plant factory by using δ¹⁵N-evaluated fertilizer, medium, and water.

ICT technology and chemical analysis should be combined to make sure that food products are reliable.

**PACKAGE OF JAPANESE TECHNOLOGY**

Package strategy is also important aspect for sipping the greenhouse technologies in Japan. To produce high quality Japanese horticultural products, assembled technologies as a package is an important concept, and the project “Development of the Asian monsoon model plant factory system to promote the informatization of agriculture, forestry, fisheries and food industry, and innovation of production system” has been started in the Project of the NARO Bi-oriented Technology Research Advancement Institution (R&D matching funds on the field for Knowledge Integration and innovation).

In the near future, we will establish the packaged system by this consortium from Japan which provides high yield and high quality of horticultural products with high safety and high reliability even in Asian monsoon climate condition. It is assumed that this system makes the profit for agriculture in whole Asian countries.

**REFERENCES**


