Plant Factories with Artificial Lighting (PFAL) for Sustainable Agriculture

Toyoki Kozai (Japan Plant Factory Association)

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More and more people are recently interested in plant factories with artificial lighting (PFALs) or vertical/indoor farming, partly because that water and fertilizer productivities (kg of produce per kg of irrigated water and per mol of fertilizer supplied, respectively) are inherently high in a PFAL, and that the yearly yield of leafy vegetables is over 100 times higher in the PFAL than in the open field. On the other hands, people complain about the high production costs and its agricultural and social roles of its existence.

The major components of the production cost of existing PFALs are depreciation (initial investment), labor (working hours) and electricity costs. Since around 2016, the monetary (sales/costs, both in Euro), working hours (kg of produce/hour) and electricity (kg of produce/kWh) productivities for leaf lettuce in Japan have improved considerably in many PFALs. These recent improvements of productivities are the result of introducing LEDs, robotic/automated units, improved cultivation systems with production management software and increase in public acceptance A similar trend is observed in several other countries.

However, even in improved PFALs in Japan, recent advanced technologies such as artificial intelligence, the Internet of Things, non-invasive plant phenotype measurement, solar cells with batteries, OMICS (genomics, proteomics, metabolomics, etc.) and breeding using DNA markers are rarely implemented. By introducing those technologies, efforts are being made to improve the monetary and resource productivities of medicinal plants, tomato, strawberry, blueberry, etc. to make the production of those crops profitable.

The next-generation PFAL (n-PFAL) to be developed by integrating these technologies will considerably improve productivity. The n-PFAL is expected to solve many of today's interrelated social and economic issues concerning functional foods, the environment, resources and quality of life amid the increase in urban population, decrease in agricultural population, arable/fertile land area and water availability, and changing and vulnerable climate. The n-PFAL reduces food mileage and loss of fresh produce, and enhances local production for local consumption, and so will play an essential role in achieving a substantial portion of the 17 Sustainable Development Goals (SDGs). This presentation looks at basic viewpoints, concepts and ways to develop the n-PFAL for achieving some of the SDGs, keeping in mind that we are still at the initial technological and scientific stages of the n-PFAL.