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Plant Factory (PF) on the Kasliwa-no-ha campus of Chiba University and workers working inside with sanitarian minded working wear

Plant factories changing the face of farming

Text and Photos by Haruka Uemura/Leslie Pines

PLANT factories with artificial light (PFAL) are used in Japan for commercial production of leafy vegetables. Their annual productivity per unit area is roughly 10-fold that in open fields.

PFAL can be built anywhere and in any building because they use neither solar energy nor natural soil and productivity is not affected by climate or soil fertility. Therefore, its productivity is independent of the outside climate and soil fertility.

The Plant Factory (PF) at the Chiba University in Kasliwa-no-ha Smart City - close to Tokyo - is a facility which keeps the environment suitable for the growth of crops and able to get high yield and high-quality products year-round. At the Kasliwa-no-ha Campus of Chiba University seven Plant factories, five of them for tomato production using sunlight and two of them for lettuce production using artificial light, are under operation.

At the recent, Multinational Observational Study Mission on Best Practices in Promoting Innovation and Productivity in Agriculture for Mass Media Practitioners in Japan, organized by the Asian Productivity Organization (APO), 17 journalists from 15 countries including Sri Lanka received a unique opportunity to visit Chiba University to witness this innovative mode of farming, that is rapidly changing the future of agriculture.

"Since plants are growing by photosynthesis, it is important to supply an adequate amount of water and carbon dioxide as raw materials to a plant factory. A sufficient amount of light should also be supplied as an energy source for photosynthesis. For these conditions, the technique of soilless culture is important. The air temperature, moisture contents of air and air flow should be controlled in the PF so that plant leaves can absorb carbon dioxide efficiently. We have to pay much attention to plant management and environment control for optimizing environment," says Dr. Toyoki Kozai, who is Professor Emeritus of Chiba University, Japan and the President and Chief Director of the Japan Plant Factory Association which is a non-profit organization. He also works on environmental control of greenhouse, plant factory and transplant production systems.

What is a Plant Factory?

A Plant Factory consists of 6 principal components namely, a thermally insulated and nearly air tight warehouse-like structure, floor to 20 tiers equipped with hydroponic culture beds and lighting devices such as fluorescent and LED lamps, air conditioners with air fans, a carbon dioxide supply unit, a nutrient solution supply unit with water

Senior Professor of Agri Business Management of Sabaragamuwa University, Prof. Rohana P. Mahipanyanarachchi

Workers generally enter the cultivation room of the PF only after taking a hot water or air shower and wearing clean clothes. Using PF high quality pesticide free plants are produced all year round owing to the optimal control of the aerial and root environment.

Leaf vegetables produced in a PF are clean and need no further washing before cooking or processing. The shelf life of PF grown vegetables after harvest is doubled compared to those produced in a greenhouse because the bacterial load is generally lower than that of field-grown vegetables after they are washed with tap water.

The largest PF in Japan, Spread Ltd., can produce close to 25,000 leaf lettuce heads per day or nine million heads per year. It is roughly estimated that 20% of PFs are making profit and 50% are breaking even. The number and percentage of PF that are profitable in Japan have been increasing steadily since 2009.

It is estimated that half the cost of setting up a PF unit is required to construct the outer structure, while about half is needed to equip the unit. The total initial investment of a PF with 10 tiers is said to be around 600 Euros (nearly Rs. 62, 820) per square metre. Then, it will take five to seven years to recover the initial investment.

The relative annual production capacity and sales volume of leaf vegetables per unit land area of a PF with 10 tiers are estimated to be, respectively, roughly 60-fold and 115-fold, compared with those in the open field.

"The technology for such factories is still being developed, but they are eco-friendly and in that, no waste is generated in the crop-growing process. Although the definitions of 'chemical free agriculture' differ, plants can be grown without chemicals in these factories. They also do not waste water and fertiliser," Dr. Toyoki Kozai states.

Commenting on the light technology that is used for the growing process inside Japanese plant factories, Masatoshi Miyaki, who works in the Solutions Business Promotion Department of the Panasonic Corporation Eco Solutions Company, says that the Panasonic Group is developing technologies for plant factories, determining the feasibility of related businesses and conducting

Professor Emeritus of Chiba University, Japan and the President & Chief Director of the Japan Plant Factory Association, Dr. Toyoki Kozai pausing for a photo session at the end of his 'week-long stimulation display at Lalaport shopping centre Kandy, Sri Lanka, Sri Lanka, Japan

Currents, most leaf vegetables and herbs produced in PF in Japan are not sold at supermarkets or grocery stores, but are sold to the food service industry including the home-meat replacement industry.

In such industries, the cost of hygiene processing is considerably reduced by using PF produced leaf vegetables, which, without washing, do not contain pesticides, contaminants and insects. In Japan, PF produced leaf vegetables are also used to produce paste for baby food and food for elderly and sick people. Research and development are now under way to use soft and high quality PF produced vegetables and medicinal herbs for use as raw materials in pickles, frozen foods, food and drink additives, soups, traditional medicine, supplements, cosmetics and more.

"The Japan Plant Factory Association aims at solving simultaneously problems of food, environment, energy and resources in the 21st Century by developing, demonstrating and expanding a sustainable PF system which enables food production that is resource-saving, environmentally-friendly, high quality and high yielding. We try to contribute to promoting quality of life by increasing job opportunities.

"We also work for promoting efficient utilisation of input resources and creating work places where people work joyfully, through establishing PF technology which meets our philosophy and goals," Dr. Kozai

Minimal plant factories where consumable leaf vegetables are grown at a domestic level

An example of a design of a desktop plant factory.

The Kasliwa-no-ha Smart City in Japan

Lettuce produced at the PF of Chiba University ready for delivery and consumption

Deputy Editor of Governance Now, Shushrutha Parth having a closer look at an example of a design of a desktop plant factory

system and light quality, improve automation in the PF, developing an integrated environment control and management system, integrating PF with other low-protection agriculture recycling systems, develop management systems for the production of medicinal and other functional plants, having third-part evaluation of the safety and security of plants produced, streamlining the cooperation process between outdoor agriculture and protected agriculture, using natural resource energy sources and implementing information technology and developing a universal design for PF for agriculture challenged persons with a user friendly design for all.

As the community of PF growers will have ample access to the latest communication methodologies, even the individual owners of small plant factories will not be left alone in the future, with growing internet technologies that allow them to link to a larger network of users that has access to the latest information on cultivation methods and plant varieties, download data from cloud servers,

Beginning in 2009, small plant factories were set up in a wide variety of non-traditional locations in Japan, including private residences, various educational institutions, public facilities, commercial premises, hospitals, hotels, restaurants, shopping malls and convenience stores. Such small plant factories can be installed even in a living room, allowing the family to grow fresh and tasty vegetables without the use of pesticides.

By controlling the quality and quantity of light generated, among other factors, it is possible to control the plants' rate of growth and nutritional value. Using a variety of plants are amenable to cultivate in these Japanese plant factories and for instance, leaf vegetables such as lettuce, spinach, Japanese mustard spinach, and per-berry mustard, herbs such as mint and basil, small fruits and vegetables such as grape tomatoes and strawberries, and small flowering plants are successfully grown in these units.

"These plants help create a soothing 'green interior' that benefits people's wellbeing as they spend time caring for their plants on a daily basis and eating them at the end," Dr. Kozai explained.

Sri Lanka's potential of PF for future agriculture

"It is true that there are a number of benefits of plant factories such as their capability of stable year-round production, possibility of establishing non-farmland areas such as industrial parks and vacant stores in shopping districts, cultivation of safe, high-quality agricultural produce with no pesticide use, and comfort of work environment in which the young population can work with respect.

"However, the challenges of this technology are the high energy costs and facility installation costs as the cultivation technology is yet to be established here. The lack of human resources with both cultivation skills and facility management skills and limited types of varieties of crops available for produc-

tion in PF have also to be taken into consideration. So, considering both positive and negative aspects of the plant factories, Sri Lanka should research in this regard with a good and strong feasibility study pertaining to the cost of energy, economic viability and competencies in the industry and the food market," says Senior Professor of Agri Business Management of Sabaragamuwa University Prof. Rohana P. Mahipanyanarachchi, who is also an expert in the Agri and Eco Tourism sector in Sri Lanka.

"My proposal at this stage is therefore that universities, private sector companies with the Department of Agriculture can collectively start experimental level plant factories in Sri Lanka to find out possible low cost units which can be operated with alternative energy sources, low establishment costs and with more crop varieties suitable to Sri Lanka.

"Accordingly, depending on the findings of these experiments, we can think of establishing commercial or domestic level plant factories in Sri Lanka. However, I think this is the best opportunity and time to experiment and research on this innovative approach at a time, land usage is encouraged to the minimum level in the present-day industry of agriculture in metropolitan areas. Therefore, overseas study missions as this, organized by the Asian Productivity Organization, are of greater importance to identify, introduce and learn about the innovative approaches of the global agriculture industry that is rapidly changing with the latest technologies to maximize productivity," he says.

Today, Japanese agricultural scientists and researchers are also eager to offer their expertise and actively identify the challenges of future developments of PF, such as making a comprehensive Life Cycle Assessment (LCA), developing schemes to use PF in hotels, restaurants, hospitals, schools, community centre sets, improving the lighting