Harvesting the sun efficiently

Accepted 5th October, 2013

ABSTRACT

Food production, energy use and environmental conservation are all closely linked. To supply sufficient food for an increasing global population, food production that requires more energy use and conservation of the environment is becoming more difficult to maintain. The light efficiency of plant production is an average of less than 1%, which means that large amounts of free energy are wasted. Basic innovation to improve this efficiency is necessary, and innovation of genetically modified plants and animals adapted to more severe climates are strong measures to overcome future food shortages despite the decrease of arable farmland and prevention of stable food production in open fields as a result of weather changes attributable to global warming. Controlled Environment Agriculture (CEA) is a potential method to increase food production with small artificial energy inputs. Artificial energy can be used to harvest the sun efficiently.

Key words: Control environment agriculture (CEA), tower greenhouse, urban agriculture, vertical farming.

INTRODUCTION

Historically, the hanging gardens of Babylon (2012) were constructed by Nebuchadnezzar II in BC600s as the first attempt to have open gardens in an open space of a building with various steps. An improved living environment and a better landscape were its purposes but local production of food for local consumption was conducted.

Several interesting topics were addressed at the symposium on Urban Agriculture in Tokyo Metropolitan (2010): A New approach of Metropolitan Area Tokyo; Architectural Greening; Metropolitan Rooftop Garden; Regina Project for Residential Housing Units Integrated Greenhouse in Canada; Energy Focus for Sustainable Agriculture in Metropolitan Areas; and Environmental Control for Sustainable Agriculture in Metropolitan Areas.

Urban farming using free space in an urban area including roofs of buildings, land over tunnels, and over parking lots would be excellent spaces for farming.

According to the Report on roof greenery, Taisei General Construction Company and Environmental Engineering Laboratory, (The University of Tokyo, 1989), over 86% of all roof tops are vacant in the Tokyo Metropolitan area. A simulation revealed that, if it were covered by greenery, the peak cooling load in summer would be reduced by 310,000 kW, with 31% reduction of the peak cooling load per 1000 m² for the top floor of an apartment. The heat island phenomenon would also be reduced by greenery.

A larger project of this research was proposed to Tokyo Electric Power Company, Inc., but it might be too early. The Leaf Area Index (LAI) is an important factor for reducing the cooling load (Takakura et al., 2000). Not only the thermal effect of top greenery for cooling loads, but also food production capabilities are important.

Agricultural land in Metropolitan Tokyo has been cut by more than 1, 400 ha during the last 10 years. The farming population is dwindling and aging rapidly (Evolution of urban agriculture, 2010). Food production in densely populated urban areas can improve local food production and reduce food mileage while contributing to energy saving (Wolveerson, 2012).

Vertical farming is a current topic in urban agriculture and several proposals with fancy pictures are on website. There are three types; a residence with vegetation, a
showcase of exhibition and farming. The first two should be separated from the other because cultivation period is relatively short and yield is not a problem. However, farming is different. Before pursuing vertical farming, we should try to use available lands in urban areas in a horizontal way to the greatest extent possible to harvest the sun efficiently.

Humans live in a vertical mode in urban areas because they need weak light intensity to be comfortable. Solar radiation is too strong for human beings to work outside. However, for most plants, solar radiation is necessary for growth and development. Light penetrates exponentially in a vertical plant canopy. The sun can replace vast amounts of energy necessary for artificial lighting. Tower greenhouses in Vienna, Austria, a similar tower greenhouse in Hannover University and similar tower greenhouse in Japan are monuments demonstrating this fact (Sugi et al., 1968; Takakura, 2011). Vertical farming using artificial light is another story. It should be scrutinized from economical point of view.

REFERENCES


Hanging Garden of Babylon, 2012: http://ja.wikipedia.org/wiki/%E3%83%90%E3%83%93%E3%83%A9%E3%83%83%E3%83%AD%E3%83%B3%E3%83%B1%E7%A9%BA%E4%B8%AD%E5%BA%AD%E5%9C%92.


Wolverson R (2012). Local food grows up. Time, October 15, business pp.1, 2, 4, 6, 8.