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Roof-top-greenhouses, City Landscape and Urban Agriculture

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Abstract

Urban agriculture, the spawn of the local food movement, has become a popular and increasingly viable global trend in last few years. In 2011, New York City passed two bills to support the construction of rooftop greenhouses and free up land for urban farming use, and require municipal businesses to purchase locally grown food.With more such legislations, city landscapes start changing. Infrastructure of local food markets even municipal economy will be reshaped up. Farming is getting decidedly futuristic and increasingly urban.Urban farming will create thousands of new jobs. The rooftop Greenhouses will become the next frontier of urban farming.

Rooftop greenhouses can revolutionize the supermarket and food supply chains. It can harness waste heat from refrigeration systems to support a greenhouse operation, grow local produce, reduce transportation costs and its carbon prints, improvescity landscape and environment. With the world population growing and arable land becoming less available, the need for urban farming and agriculture will increase over the next decades.

Development of new hydroponic and aeroponic technologies at Greenhouse Research and Production Complex (GRPC) in Alberta, Canada makes the rooftop greenhouses more feasible. Several crop types have been tested for better fit to grow in rooftop greenhouses. A number of challenges are still facing by the greenhouse builders and operators. The factors to be considered include the extra costs, city building codes, roofing material for extra weight support, proper drainage system to prevent potential roof water leakage, and future roof surface damage from traffic.

Keywords: Rooftop greenhouse, urban farming, city landscape, agriculture.

1. Introduction

Urbanization started with the industrial revolution in early of 18^{th} century. With the world population growing, arable land has reduced significantly across the world. In large cities, there are less outdoor green spaces, e.g., parks, gardens, and lawns, and number of indoor plants. City dwellers are often frustrated with poor air quality and tedious living environment. While on the tops of city building roofs, there are spaces and areas available (Harrison, 2011).

Urban agriculture, the spawn of the local food movement, has become a popular and increasingly viable global trend.In 2011, New York City Council passed two bills to support the construction of rooftop greenhouses and urban farming. In April of 2011, one of the first rooftop hydroponic greenhouses owned by Lufa Farms came into operation in Montreal, Canada (Dumont, 2011). There are more and more rooftop greenhouses built in New York, Vancouver, London, and many other cities around the world. In some city code, the buildings with a rooftop greenhouse will not be considered an additional story. Greenhouses will be exempt from height limits if less than one-third of the total rooftop areas. Some municipalities maintain a database of unused spaces in order to transform them for urban farm use. Some municipalities require or recommend city facilities likejails and health centers to purchase locally grown food. With more such legislations, city landscapes start changing. Infrastructure of local food markets even municipal economy will be reshaped up.

Development of new hydroponic and aeroponic technologies at Greenhouse Research and Production Complex (GRPC) in Alberta, Canada makes the rooftop greenhouses more feasible. Several crop types have been tested for better fit to grow in rooftop greenhouses.

2. Materials and Mathods

2.1 Comparison between hydroponic and aeroponic lettuce production systems

A floating raftHydroponic lettuce system was built on the top of movable beaches with dimension of 610cm length x 150cm width x 18 cm depth, 9.15 m^2 growing area (Figure 1). After seeds germination, young lettuce plants were transplanted to the Styrofoam rafts with 28 holes and dimension of 122 cm length x 61 cm width.

A pyramid aeroponic lettuce system was built by using the same Styrofoam on the top of movable benches with the same bench length 610 cm x hypotenuse length 115cm x 2, 14 m2 growing area. Compared to the flat hydroponic growing area, the pyramid aeroponic growing area is increased 4.85 m^2 larger (Figure 1).

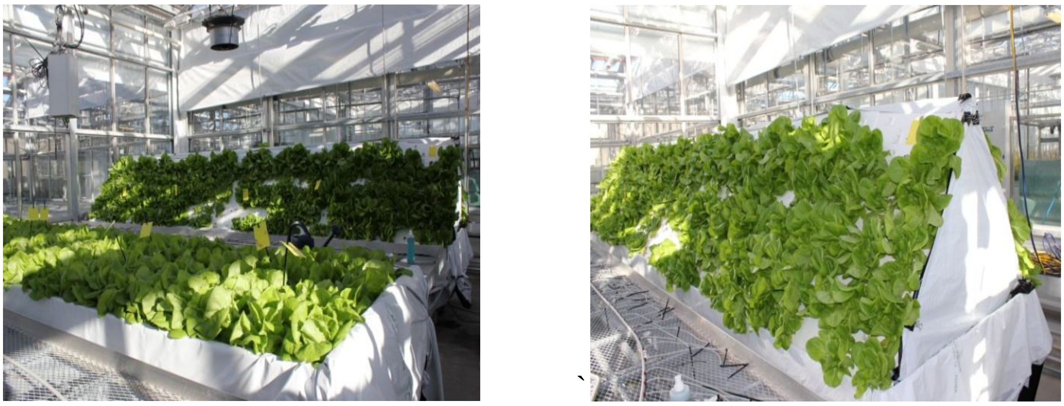

Figure 1: Comparison between floating raft hydroponic lettuce system (13.5 cm water depth) and pyramid aeroponic lettuce system.

2.2. A seed potato aeroponic system

The seed potato aeroponic system was built with the hanging gutters Vital Farms, The Netherlands. It consist three compartments of an enclosed root zoon where the mist is supplied, a tuber zoon for harvest, and the planting area above the gutter. It has been tested for producing seed potatoes by Michele Konschuh, a potato research scientist at Alberta Agriculture and Rural Development (Figure 2).

Figure 2: Seed potato aeroponic system (Courtesy of Michele Konschuh, Brooks, Alberta, Canada).

2.3. Comparison between coco coir and biochar as the growth medium in conventional hydroponic vegetable production systems

Biochar was prepared at Alberta Innovates Future Technologies, Vegreville, Alberta, and tested on tomato, pepper and cucumber crops at Greenhouse Research and Production Complex (GRPC), Brooks, Alberta, Canada (Figure 3). The coco coir was used as the standard commercial growth medium for the controls. Mini cucumber variety is Picowell (RijkZwaan). The seeds were sown on November 26th, and three-week-old seedlings were transplanted in December 17, 2012. Experiments were performed with four replications in three crop cycles. Means were separated using the LSD test.

Figure 3: Biochar and coco coir slabs after the end of tomato and pepper crops (left). Hydroponic cucumber trials under the HPS lighting (right).

3. Results and Discussion

3.1. Comparison betweenhydroponic and aeroponic lettuce production systems

Compared to the flat hydroponic growing area of ?msq, the pyramid aeroponic growing area is increased to ? msq, while with less weight and more sophisticate. The increased growing area is expected to give higher yield, while the lighter system is expected to reduce the extra weight for a building structure to support. In an aeroponic system, water and nutrients are supplied for plants through mist surrounding their rhizosphere. A uniform mist for covering the root surface is required. Low pressure, plugged nozzles or a pump failure can cause the root dried up and even plant loss which were encounter in the trials (Figure 1).

In the seed potato aeroponic system, the nozzles and line pressure functioned better. While the frequency of the misting supply and the feed formulas are still further tested, according to the observations of Michele Konschuh. The tuber yield is still lower than expected.

3.2 Comparison between coco coir and biochar as the growth medium in conventional hydroponic vegetable production systems

Considered less turnover of the growth media, a new growth medium, biochar, was tested in our greenhouse cucumber. The yield is not significantly different between the cucumber crops in the biochar and coco coir (Table 1).After three crop cycles, the coco coir slabs were removed and replaced with new coco coir slabs because the substrate decomposition and water holding capacity changed. While the biochar performs well, has higher resistance to decomposition, and is more consistent with water holding capacity and other physiochemical properties. Less turnovers of the growth media in the rooftop greenhouses can reduce the labour and material costs and rooftop traffic.

Table 1: The yield of cucumber crops in coco coir and biochar media.

Trial No.	Cucumber Yield (kg)	
	Coco coir	Biochar
1	2.64	2.43
2	2.24	2.64
Means*	2.44 a	2.54 a

*Numbers followed by the same letter are not significantly (P = 0.05) different.

Rooftop greenhouses have many advantages in urban farming. It can recycled the waste heat from the buildings underneath, significantly reduce the transportation costs and carbon prints because it is closed to the supermarket and food supply chains. The green spaces and plants can improve city landscape and environment. With growing world population and decreasing of arable land, urban agriculturehas become a popular and increasingly viable global trend in last few years. The need for urban farming and agriculture will increase over the next decades. Farming is getting decidedly futuristic and increasingly urban.Urban farming will create thousands of new jobs. The rooftop Greenhouses will become the next frontier of urban farming (Dumont, 2011).

To build greenhouses on rooftops, however, we are still facing many challenges. Usually the construction costs for a rooftop greenhouse are higher than the same size of a greenhouse on the ground. For construction of a greenhouse on existing buildings, extra weight of the greenhouse to be added on the roofs has to be considered and calculated carefully.The extra height of the greenhouse to the top of the building roof should be allowed by the city building codes.The waterproof roofing material should be selected andproper drainage system can be designed to prevent potential roof water leakageand future roof surface damage from traffic (Dumont, 2011).

Although the environmental and social benefits can be clearly demonstrated for urban farming and rooftop greenhouses, the economic benefits have not been a reality. The economic returns and the actual profit margin are heavily dependent upon the system design and andgreenhouse operation costs. Studies of different crop systems and growth media will help the rooftop greenhouse design and development. Further exploring of the feasibility of our tested crop systems and technologies in the in-situ rooftop greenhouses is needed in near future.

References

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