ROOFTOP FARMING WITH SWEET POTATO FOR REDUCING URBAN HEAT ISLAND EFFECTS AND PRODUCING FOOD AND FUEL MATERIALS

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Abstract

Sweet potato was cultured with a lightweight hydroponic system on a rooftop as a cooling equipment for reducing urban heat island effects and also as urban agriculture in a summer season in Osaka, Japan. In the result, The difference in surface temperatures between concrete plates exposed to sun light and under the vegetation coverage were increased with increasing solar radiation flux and reached 13^{o}C. The tuberous roots yield was 3,2 kg m^{-2} in this method. Sweet potato culture in rooftop farming will be a promising practice for environmental conservation in urban areas.

Key words: hydroponics, rooftop farming, sweet potato, urban agriculture, urban heat island

1. INTRODUCTION

A rooftop farming system was developed as a cooling equipment for reducing urban heat island effects and also as urban agriculture that will be practice of crop production and thus supply of food and fuel materials such as bioethanol. Sweet potato can grow under a stressful condition even on rooftops and has relatively high abilities of transpiratory latent heat loss and photosynthetic carbon fixation compared with other plant species. In this study, sweet potato was cultured with a lightweight hydroponic system on a rooftop and performances of the plants to reduce excess temperature rise and to yield tuberous roots were examined in a summer season in Osaka, Japan. Sweet potato was cultured hydroponically on a roof in this study. Hydroponic techniques for sweet potato production have been developed by Uewada (1990), Mortley et al. (1991), Uewada et al. (1992) and Hill et al. (1992). We have been developing a new hydroponic method for culturing sweet potato with a fibrous rooting substrate in order to ensure high yield with a simple system compared with previous studies.

In this study, sweet potato plants were cultured in a newly developed hydroponic system. Cooling performance of the sweet potato vegetation and the yield and growth performance of plants were investigated.

2. MATERIALS AND METHODS

Culture containers containing rooting substrates were used to culture sweetpotato (*Ipomoea batatas* (L.) Lam. Var. Kokei-14) hydroponically (Fig. 1a). The rooting substrates made with rockwool slabs were inclined in the container and absorbed nutrient solution from the lower end by capillary action (Fig. 1b). Sweetpotato were planted using stem cuttings, which were inserted into the rooting substrate. Cuttings were 0.25-0.28 m long and had 9-11 nodes with 7-9 leaves each. Tuberous roots of sweetpotato were developed in the aerial space between the rockwool slab and the nutrient solution filled at the bottom of the culture container. The nutrient solution used was modified Hoagland solution. Water depth was kept at 0.05 m throughout the experimental period. 16 plants were cultured at a planting density of 2 plants m^{-2} on a rooftop for 150 days from June to November as shown in Fig. 2.

Thermal images of the surfaces of the vegetation canopy and concrete plates were captured using infrared thermography (TH9100, NEC-San-ei Co., Japan). Air temperature and solar radiation flux were also measured. Mean daily integrated solar radiation was 13.2 MJ m^{-2} during the culture period.

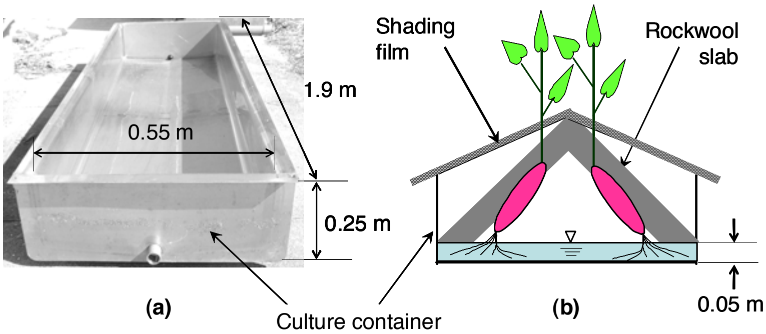

Fig. 1. A photograph of the culture container (a) and a diagram showing a cross section of the hydroponic system with the inclined rookwool slabs (b) used in the experiment.

3. RESULTS AND DISCUSSION

Lower temperatures were observed at the sweet potato vegetation canopy than at concrete plates in the thermal image (Fig. 3). Temperatures at the concrete surface under the vegetation coverage were mostly the same as the temperature at the vegetation canopy surface (Fig. 4). The difference between the air temperature and the surface temperature of the concrete plates exposed to sunlight was increased with increasing solar radiation flux. Differences between the air temperature and surface temperatures of the vegetation canopy and the concrete plates under the vegetation coverage were decreased with increasing solar radiation flux. The difference in surface temperatures between concrete plates exposed to sun light and under the vegetation coverage were, therefore, increased with increasing solar radiation flux and reached 13°C.

The final harvest produced large yields of tuberous roots in the hydroponic system (Fig. 5). The yield of tuberous roots of sweet potato cultured for 150 days was 1.6 kg/plant (Table 1) and 3.2 kg m^{-2}, showing 1.4 times greater yield than the average yield of this variety in the conventional soil culture.

In conclusion, sweet potato production was performed successfully in the hydroponic system on the rooftop. It was confirmed that sweet potato vegetation showed a suitable performance for cooling. Although the rockwool substrate was used for several times, reuse of the rockwool material is restricted because of its fragile property. In order to reuse the substrate for numerous cycles, we need to develop stable substrates or culture methods without solid substrates for rooting, which can keep water and air optimum in the same manner as the rockwool substrate. Sweet potato culture in rooftop farming will be a promising practice for environmental conservation in urban areas.

Fig. 2. A photograph of the vegetation of sweet potato cultured in a hydroponic system on the rooftop. (26 September, 2005)

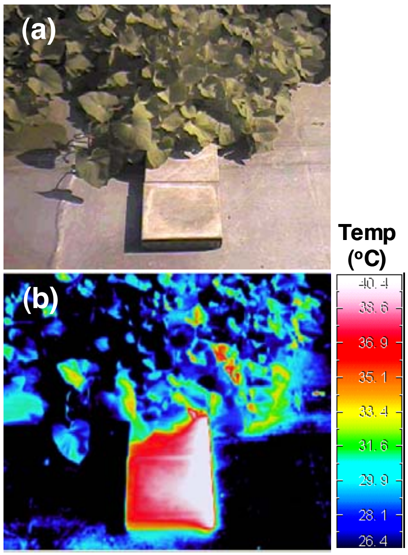

Fig. 3. Visible (a) and thermal (b) images including the sweet potato vegetation canopy and the concrete plates without the vegetation coverage.

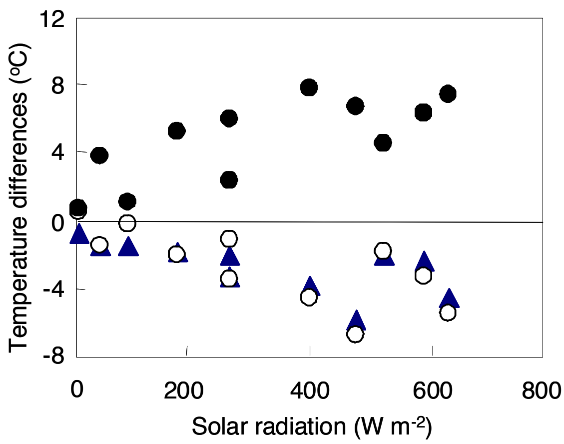

Fig. 4. Effects of solar radiation on temperature differences between the air temperature and surface temperatures of the concrete plates exposed to sun light (●), the sweet potato vegetation canopy (○), and the concrete plates under the vegetation coverage (▲).

Fig. 5. Tuberous roots of sweet potato variety 'Kokei-14' cultured for 150 days in the hydroponic system.

Table 1. Shoot and tuberous root weights, shoot length and leaf area index (LAI) of sweet potato plants cultured for 150 days in the hydroponic system.

Fresh weight (g/plant)			Dry weight (g/plant)			Main stem length (m/plant)	LAI (m^2 m^{-2})
Shoot	tuberous roots	Total	Shoot	tuberous roots	Total		
1311±63	1591±196	2922±247	262±14	445±56	737±69	2.6±0.4	2.8

Mean ± standard error (n=5)

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