Advantages of sweetpotato culture in a controlled ecological life support system in space

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Abstract: The long term life support of crew in space is greatly dependent on the amounts of food, atmospheric O_2 and clean water produced by plants. Therefore, the bio-regenerative life support system such as space farming with scheduling of crop production, obtaining high yields with a rapid turnover rate, converting atmospheric CO_2 to O_2 and purifying water should be established with employing suitable plant species and varieties and precisely controlling environmental variables around plants grown at a high density in a limited space. Sweetpotato has been a candidate food crop in space. Sweetpotato culture has many advantages over the culture of other crops, because sweetpotato has a higher growth rate and yield, and greater nutritional values than other crops and the whole plant is mostly edible. Therefore, sweetpotato is a promising crop in space farming and can be utilized for the vegetable crop as well as the root crop allowing little waste.

Key words; Controlled ecological life support system, Space farming, Sweetpotato

1. Introduction

Plant production in space has recently been of greater concern as the possibility of realizing manned space flight over a long duration increases. The feasibility of achieving long-duration manned space missions for other planets will be highly dependent on crops in Controlled Ecological Life Support System (CELSS) including space farming that will play important roles in food production, CO2/O2 conversion and water purification (e.g., Nitta, 1987; Salisbury, 1991; Gitelson, 1992). In space farming, scheduling of crop production and obtaining high yields with a rapid turnover rate are important.

Sweetpotato (*Ipomoea batatas* (L.) Lam.) is one of the most important food crops in the world (Yoshimoto,1998) and will play an important role in solving global issues concerning food, natural resources and the environment (Kozai et al.1996). It will be especially important as a food crop in Asia and African countries where population is expected to increase significantly in the future (Yoshimoto, 1998). 1t is also an important vegetable crop and an important animal feed as well as an industrial material for producing starch, sugar and alcohol (Islam et al. 1997 and 1998).

Sweetpotato is also expected to be one of candidate crops for food in long term space missions. Sweetpotato culture has many advantages over the culture of other crops, i.e., it grows more rapidly, has a high yield, and requires less fertilizer (Kozai et al. 1996). Recirculating hydroponic systems were recommended in space farming to allow efficient crop production and conservation of nutrients and water (Bugbee, 1995; Wheeler et al., 1999). Sweetpotato culture has many advantages over the culture of other crops, because sweetpotato grows rapidly, has a higher yield, and greater nutritional values than other crops.

2. Nutritional values of sweetpotato

Tuberous roots of sweetpotato contain higher values of various vitamins, minerals and protein than other vegetable clops (Woolfe, 1992) and leaves also have potential effects on human health and nutrition (Ishiguro et al., 2005; Islam, 2006). Sweetpotato is beginning to be known as a pollution-free and natural health-food, with high contents of various nutrition components and antioxidant elements such as beta-carotene, ascorbic acid and tocopherol that protect against heart disease and cancer (Ahn et al. 1998). It fixes a higher amount of energy (194 MJ h^{-1} day) through photosynthesis, and its ability to grow quickly under hard conditions has contributed to its role as a food security crop in a number of places (Mok et al. 1998) including future space colonies.

3. Yields of sweetpotato cultured in a hydroponic system

A hydroponic system for producing tuberous roots and fresh edible leaves and stems of sweetpotato was newly developed (Kitaya et al., 2008). The system mainly consisted of culture containers, rockwool fiberous slabs, and a nutrient solution supply subsystem. The rooting

substrates made with rockwool slabs were inclined in a culture container and absorbed nutrient solution from the lower end of the slabs by capillary action. Tuberous roots developed on the lower surface of the rockwool slabs. Three sweetpotato cultivars, 'Elegant summer', 'Kokei-14' and 'Beniazuma', were cultured in the hydroponic system for five months from June to November under the sun light in Osaka, Japan as a fundamental study for establishing the space farming system. Fresh weights of the tuberous roots were 1.6, 1.2 and 0.6 kg/plant for Koukei 14, Elegant summer and Beniazuma, respectively, and dry weights 0.34, 0.45 and 0.23 kg/plant. Dry weights of the top portion (leaves, petioles and stems) were 0.42, 0.29 and 0.61 kg/plant for 'Elegant summer', 'Kokei-14' and 'Beniazuma', respectively. Young stems and leaves as well as tuberous roots of 'Elegant summer', for example, are edible and palatable. Therefore some varieties of sweetpotato would be a promising crop to produce large amounts of food with high nutritional values in the present hydroponic system in space farming.

4. Development of a sweetpotato culture system in CELSS

We have initiated the development of a system for producing sweetpotato plants as a root crop and a leafy vegetable crop, which will be applied to the space farming. We are investigating the ability of clean water production through transpiration as well as food production and CO_2/O_2 conversion through photosynthesis in the sweetpotato production system. The biomass of the whole plant was mostly edible. The proportion of the top (leaves and stems) and tuberous roots was strongly affected by environmental variables even when the total biomass production was mostly the same. The production of biomass and clean water was controllable especially by light, atmospheric CO_2 and rooting medium moisture regimes. Therefore, sweetpotato can be utilized in CELSS for the vegetable crop as well as the root crop allowing little waste and is a promising functional crop for supporting long-duration human activity in space.

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