Cultivation of Ashwagandha and Botan-bofu in the Plant Factory

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Abstract: we tried to get some fundamental data in order to make optimum condition for plant growth of ashwagandha and botan-bofu clear. These plants were grown hydroponically in the plant factory. Optimum germination temperatures were 27.5°C in ashwagandha and 20 °C in botan-bofu. It was estimated that optimum temperature and light saturation point of photosynthesis were 30°C and 1,000 μmol m^{-2} s^{-1} in Ashwagandha and 28°C and 700 μmol m^{-2} s^{-1} in Botan-bofu, respectively. The highest dry weights were gotten in standard and 3/4 strength of nutrient solution in ashwagandha and botan-bofu, respectively.

Keywords: Ashwagandha, Botanboufu, Germination, Nutrient solution, Photosynthetic rate

1. INTRODUCTION

In Japan, vegetable production in the plant factory is given much attention recently because stable production which is not affected by climate or location, high quality, no use of any pesticides, low density of living bacteria on the surface of crops and so on. The number of the plant factory using only artificial lighting as light source is 125 in 2013 and is increasing (Super Hort Project Council, 2013). Its market scale is estimated at 4,200 million yen for facilities and 3,400 million yen for products in 2013, and is expected to reach at 8,800 million yen and 20 billion yen in 2018 (Fuji Keizai Management Co., Ltd., 2013; Yano Research Institute Ltd., 2013).

The most popular crop in the plant factory is just a lettuce now. It is being studied on the method to decrease the cost of vegetable production more by new innovations for facilities or controlling environments. Furthermore, it is also studied on technique for increasing additional value by decreasing toxic content in the lettuce as nitrate and potassium or increasing functional components such as anti-oxidants in the plants. While, new vegetables having functional substances have been sought for plant factory.

We are focusing on two functional vegetables as ashwagandha and botan-bofu for new vegetables in the plant factory now. Ashwagandha is one of the Indian medicine plants. It is used for Ayurveda, which is Indian traditional home medicine. Ashwagandha contains withanolides, especially withafelin A and withanone. Not only alcohol extract but also water extract from ashwagandha leaves have been demonstrated to be cytotoxic to human cancer cells (Kaur *et al*., 2004; Shar *et al*., 2009; Wadha *et al*., 2013). Botan-bofu grows naturally at southern Kyushu region to Okinawa islands area in Japan. It has three varieties. A var. *latifolium* has been reported that it has anti-atherosclerotic and vasorelaxant effect and its functional ingredient is isosamidin (Onogi *et al*., 20089; Onogi, 2009). In this study we tried to get some fundamental data in order to make optimum condition for plant growth in these plants clear.

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2. MATERIALS AND METHODS

Seeds of Ashwagandha (*Withania somnifera* (L.) Dunal) and Botan-boufu (*Peucedanum japonicum* Thunb. var. *latifolium*) were sown in the plastic tray filled with vermiculite and put in 20 to 35°C constant.

Four weeks in ashwagandha and five weeks in botan-bofu after seeding, the seedlings were transferred into a growth chamber and grown hydroponically. A half-strength Enshi-shoho nutrient solution was used for seedlings. Fluorescent lamps were used as light source. Day length was 16 h. Photosynthetic photon flux density (PPFD) was about 160 μmol m^{-2} s^{-1} on the surface of planting panel. Air temperatures were set to 27/22°C (light/dark). CO_2 concentration was set to 700 μmol mol^{-1}. Two weeks in ashwagandha and three weeks in botan-bofu after transplanting in hydroponic system, nutrient treatments were started. The plants were grown in 1/2, 3/4, 1 and 5/4 strength of Enshi-shoho nutrient solution. Two weeks after treatments, three plants from each treatment were harvested and fresh and dry weiths were measured.

The plants grown in a standard-strength Enshi-shoho nutrient solution were used for measuring photosynthetic rates. Potable photosynthesis system (LI-6400, Li-cor) was used for measuring the photosynthetic rates. For light-photosynthesis curve, CO_2 concentration, relative humidity, leaf temperature was set to 1,000 μmol mol^{-1}, 70% and 28°C, respectively and PPFD was changed 0 to 3,500 μmol m^{-2} s^{-1}. For temperature-photosynthesis curve, PPFD, CO_2 concentration and relative humidity was set to 300 μmol m^{-2} s^{-1}, 1,000 μmol mol^{-1} and 70%, respectively and leaf temperature was changed 20 to 35 or 32°C.

3. RESULTS AND DISCUSSION

3.1 Germination temperature

Ashuwagandha seeds started germination 6 days after seeding. The germination was faster as the temperature increased (Fig. 1). Final germination rate was little different between the temperatures. In some other experiments, germination rate at 30°C sometimes became lower (data not shown). Therefore, it was thought that optimum germination temperature was 27.5°C. Botan-bofu seeds started germination 10 days after seeding. The seeds germinate little at more than 27.5°C. Comparing between 20 and 25°C, germinating rate was higher at 20°C and it was about 40% (Fig. 2). It was thought that optimum germination temperature is around 20°C. It was thought that pre-selection of fertile seeds was needed because germination rate was low as 40%.

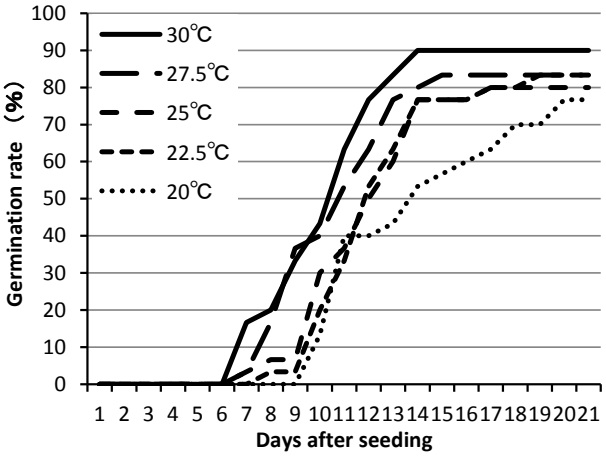

Fig. 1 Effect of temperature on germination of ashwagandha seeds.

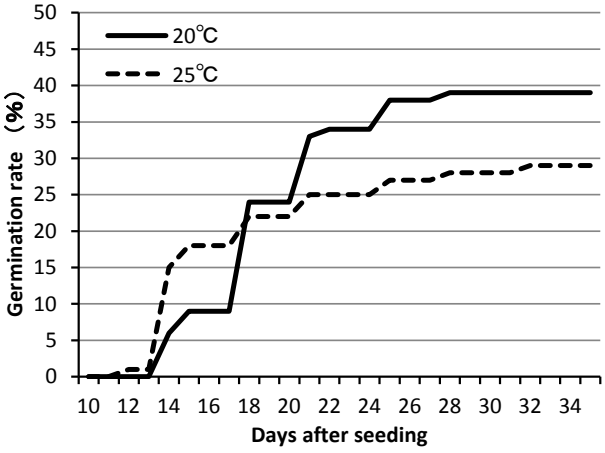

Fig. 1 Effect of temperature on germination of botan-bofu seeds.

3.2 Photosynthesis property

In ashwagandha light compensation point and light saturation point was estimated 60 and 1,000 μmol m^{-2} s^{-1}, respectively (Fig. 3). Generally, PPFD in the plant factory is 100 to 300 μmol m^{-2} s^{-1}. It is thought that ashwagandha needs very high light intensity. Photosynthetic rate increased up to 32°C (Fig. 4). It is estimated that optimum temperature is around 30°C.

In botan-bofu, light saturation point was estimated around 700 μmol m^{-2} s^{-1} (Fig. 5). It was thought that Botan-bofu was also need high light intensity. Photosynthetic rate was not significantly different between 22 and 32°C, and it was the highest at 28°C (Fig. 6). It is estimated that botan-bofu has wide range of optimum temperature. It was thought that botan-bofu have a liking for lower light intensity and temperature, compared with ashwagandha.

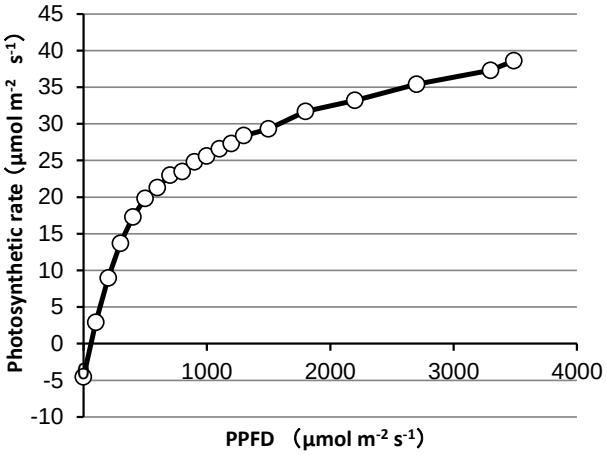

Fig. 3 Light-photosynthesis curve of ashwagandha.

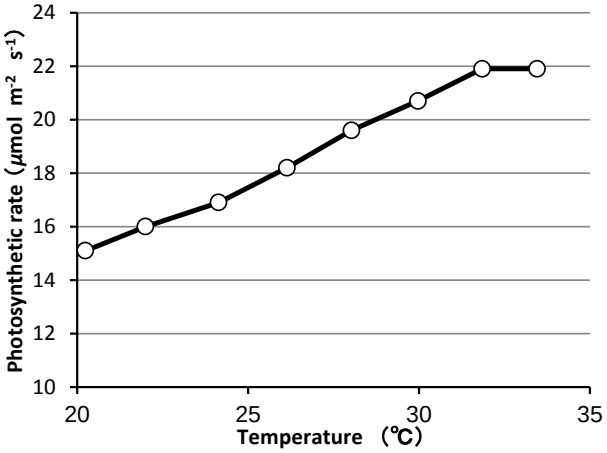

Fig. 4 Temperature-photosynthesis curve of ashwagandha.

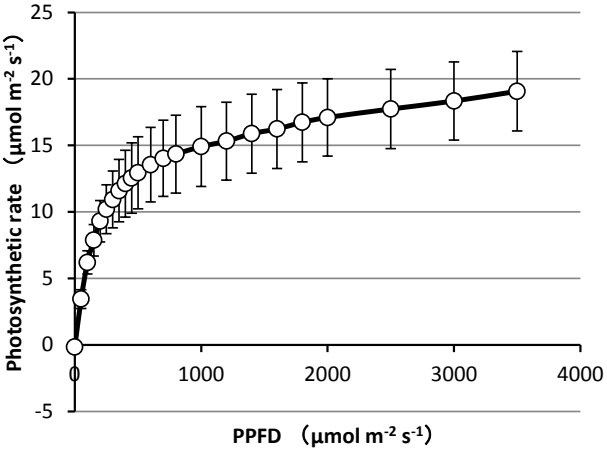

Fig. 5 Light-photosynthesis curve of botan-bofu.

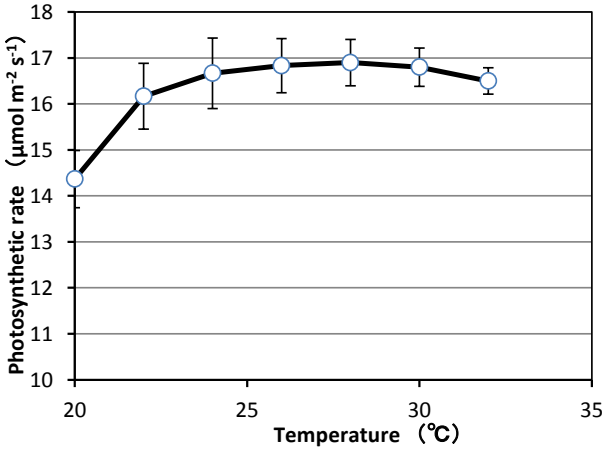

Fig. 6 Temperature-photosynthesis curve of botan-bofu.

3.3 Nutrient concentration

In ashwagadha, fresh and dry weights of shoot were increasing as the nutrient concentration increased (Fig. 7). Fresh and dry weights of root were the highest in standard concentration. It is thought that standard concentration is optimum for ashwagandha.

In botan-bofu, fresh weights of shoot and root were almost equal between 3/4 to 5/4 and low in 1/2 strength nutrient solution (Fig. 8). Dry weight of shoot and root were the highest in 3/4 strength nutrient solution. It is thought that 3/4 strength nutrient solution is optimum for botan-bofu.

3.4 Concluding remarks

In this study we estimated optimum condition of germination, photosynthesis and

concentration of nutrient solution. Now we are conducting the experiments of actual cultivation under various environmental conditions in order to establish the optimum condition.

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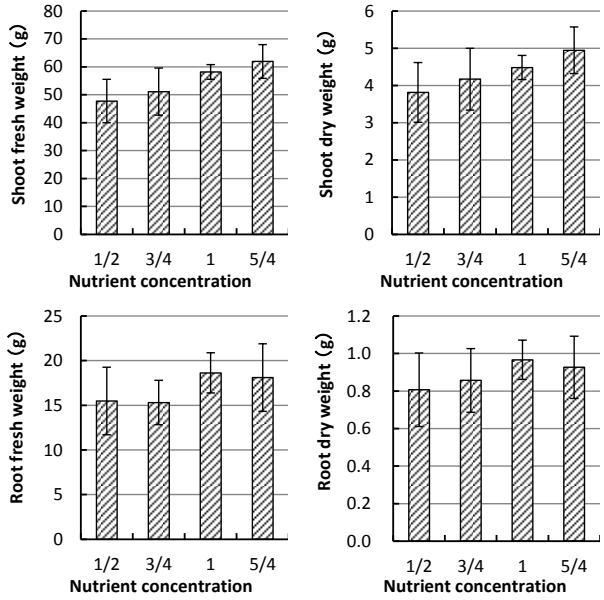

Fig. 7 Effects of concentration of the nutrient solution on the plant growth of ashwagandha.

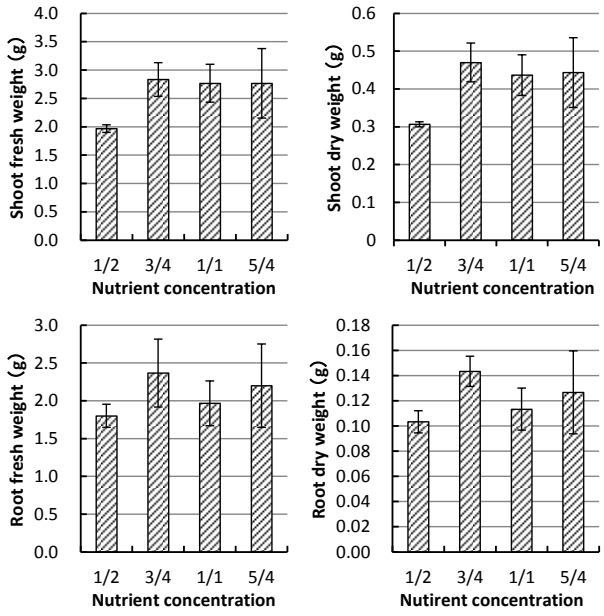

Fig. 8 Effects of concentration of the nutrient solution on the plant growth of botan-bofu.

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