Effects of Abscisic Acid on Soluble Sugar Accumulation of Cyphomandra betacea Seedlings under Cadmium Stress

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Abstract. In this study, the effects of different concentrations (0, 1, 5, 10, and 20 μmol/L) of abscisic acid (ABA) on soluble sugar accumulation in Cyphomandra betacea seedlings under cadmium stress were studied. The results showed that spraying 10 and 20 μmol/L ABA could effectively increase the content of soluble sugar in roots, stems, leaves and aerial parts of C. betacea seedlings. Spraying 1 and 5 μmol/L ABA reduced the soluble sugar content in roots, stems, leaves and aerial parts of C. betacea seedlings. Therefore, the use of 20 μmol/L ABA can increase the accumulation of soluble sugar in C. betacea seedlings.

1. Introduction
The National Soil Pollution Status Survey Bulletin released in 2014 shows that the over-standard rate of cultivated land in China was 19.4%, and the over-standard rate of cadmium pollutants reached 7%. Cadmium is one of the main pollutants in China's soil [1]. The pollution of heavy metal cadmium in soil is huge, and it is characterized by high toxicity, stability and difficulty in removal. How to effectively reduce cadmium pollution is a difficult point in current research [2].

Cyphomandra betacea belongs to Solanaceae, cyphomandra. C. betacea is a perennial fruit tree. The plant hormone abscisic acid (ABA) plays an important regulatory role in the growth and development of plants as an important hormone in response to stress in plants [3]. Soluble sugar is a product of photosynthesis, and its content can directly or indirectly reflect photosynthesis yield and product transport efficiency. Studies have shown that increased intracellular soluble sugar content can increase plant water retention, improve plant drought resistance and enhance plant resistance [4]. The study of Xu et al. showed that the soluble sugar content of Chinese cabbage in seedling stage increased after ABA treatment, which improved the cold resistance of Chinese cabbage [5]. Therefore, in this study, different concentrations of ABA were sprayed on C. betacea under cadmium stress to study the effect of ABA on soluble sugar accumulation in C. betacea seedlings, so as to provide reference for improving the resistance of C. betacea to cadmium stress.

2. Materials and methods
In December 2018, the tested soil was air-dried, and the air-dried soil of the 6.72 mm sieve was filled with a 21 cm × 20 cm (diameter × height) plastic pot. The pure CdCl₂·2.5H₂O solution was added to the soil to make the cadmium concentration in the soil 5 mg/kg. Keep the soil moist, place it for 30 days, mix it occasionally, and mix the soil thoroughly.
In January 2019, planted the *C. betacea* seeds in a climate box, transplanted seedlings (2-3 pieces of leaves) into pots, 3 per pot. In February 2019, ABA (0, 1, 5, 10, 20 μmol/L) was sprayed, and each treatment was repeated 3 times. The distance between the basin and the basin was 15 cm, which was completely randomly placed. The position of the basin and the basin was exchanged irregularly throughout the growth process to weaken the effect of the marginal effect. In March 2019, the whole plant was harvested, and the *C. betacea* seedlings were divided into three parts: root, stem and leaf. They were washed with tap water, washed with deionized water for 3 times, then dried at 110 °C for 15 min, dried at 80 °C, and measured for soluble sugar content [6].

Microsoft Excel 2010 was used to organize, analyze and draw the test data. Statistical analyses were conducted using SPSS 17.0 statistical software (IBM, Chicago, IL, USA). The results were statistically analysed by one-way ANOVA with Duncan’s multiple range test at the p=0.05 confidence level.

3. Results and Discussion

3.1. Soluble sugar content in roots of *C. betacea* seedlings

![Figure 1. Soluble sugar content in roots of *C. betacea* seedlings. Means with the same letter within each column are not significantly different at p < 0.05.](image)

As shown in Figure 1, the difference between ABA and control sprayed at 1 μmol/L was not obvious. The soluble sugar content in the roots of *C. betacea* seedlings sprayed with 5 μmol/L ABA was 28.10% lower than that of the control (p < 0.05). After spraying 10 and 20 μmol/L ABA, the soluble sugar content of *C. betacea* seedlings increased significantly, which was 43.18% (p < 0.05) and 70.59% (p < 0.05), respectively. It can be seen that spraying 20 μmol/L ABA compared with the control had the best effect on increasing the soluble sugar content in the roots of *C. betacea* seedlings.

3.2. Soluble sugar content in stems of *C. betacea* seedlings

The effect of different concentrations of ABA on the soluble sugar content of stems of *C. betacea* seedlings is shown in Figure 2. Compared with the control, the soluble sugar content of the stems of *C. betacea* seedlings increased after spraying 10 and 20 μmol/L ABA. When the concentration of ABA increased gradually, the content of soluble sugar in the stems of *C. betacea* seedlings increased gradually, which was 13.73% (p < 0.05) and 23.13% (p < 0.05), respectively. Spraying ABA at a concentration of 20 μmol/L had the best effect on improving the soluble sugar content of *C. betacea* seedling stems.
Figure 2. Soluble sugar content in stems of *C. betacea* seedlings. Means with the same letter within each column are not significantly different at *p* < 0.05.

3.3. Soluble sugar content in leaves of *C. betacea* seedlings

It can be seen from Figure 3 that the soluble sugar content in the leaves of *C. betacea* seedlings was different after different concentrations of ABA treatment. After 5 μmol/L ABA treatment, the soluble sugar content of the leaves of *C. betacea* seedlings was the lowest, which was 12.36% (*p* < 0.05) lower than that of the control. After 20 μmol/L ABA treatment, the soluble sugar content of the leaves of *C. betacea* seedlings was the highest, which was significantly higher than that of the control by 22.41% (*p* < 0.05). Compared with the control, the effect of spraying 1 μmol/L ABA was not significant.

3.4. Soluble sugar content in aerial parts of *C. betacea* seedlings

Under ABA spraying, 1 and 5 μmol/L ABA reduced the soluble sugar content in the aerial parts of *C. betacea* seedlings (Figure 4). Spraying 5 μmol/L ABA reduced the soluble sugar content in the aerial parts of the lowest, which reduced by 29.77% (*p* < 0.05), 10 and 20 μmol/L ABA increase soluble sugar content. At 20 μmol/L, the maximum value was increased by 22.58% (*p* < 0.05), and the difference reached a significant level.

Figure 3. Soluble sugar content in leaves of *C. betacea* seedlings. Means with the same letter within each column are not significantly different at *p* < 0.05.
Figure 4. Soluble sugar content in aerial parts of *C. betacea* seedlings. Means with the same letter within each column are not significantly different at $p < 0.05$.

### 4. Conclusions
Spraying 10 and 20 μmol/L ABA could increase the content of soluble sugar in the roots, stems, leaves and aerial parts of *C. betacea* seedlings, and the best effect was achieved by spraying 20 μmol/L ABA.

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