Effects of abscisic acid on total phosphorus content in *Perilla frutescens* seedlings under cadmium stress

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Abstract. In the experiment, the leaves of *Perilla frutescens* were foliage sprayed with different concentrations (0, 1, 5, 10, 20 μmol·L⁻¹) of abscisic acid (ABA) under cadmium stress (10 mg·kg⁻¹). The results showed that compared with the total phosphorus content in root, stem, leaf and shoot, when the ABA concentration was 5 μmol·L⁻¹, the total phosphorus content in corresponding organs increased by 112.07%, 17.74%, 13.89% and 15.01%. In conclusion, appropriate concentration of ABA could increase the total phosphorus content of various organs of *P. frutescens* under cadmium stress, and the concentration of 5 μmol·L⁻¹ was the most suitable.

1. Introduction

Phosphorus is one of the most important mineral element affecting plant growth and metabolism. It plays an important role in photosynthesis, respiration and the regulation of a series of enzymes [1]. Study has shown that when the phosphorus content in plants is at a low level, the total leaf area, leaf growth rate and leaf number of the plants are significantly decreased, thereby reducing the assimilation area and severely limiting the total carbon fixation of photosynthesis [2]. Abscisic acid (ABA), as a “stress hormone”, ABA can change the physiological processes of plants under various environmental stresses such as drought, salt and heavy metal stress, and regulate the physiological activities of shoot to adapt to various stresses [3-5]. Study has showed that the endogenous ABA content increase in plant under P-deficiency stress, it might enhance transportation of phosphorus and water, and reduce membrane lipid peroxidation [6]. So, we suspect that if exogenous ABA can affect the phosphorus content in plant under stress. Therefore, in the study, spraying exogenous ABA to *Perilla frutescens* under cadmium stress, and then the total phosphorus content of different organs of *P. frutescens* was determined, to verify if ABA has effects on the total phosphorus content of *P. frutescens* seedlings under cadmium stress.

2. Materials and methods

2.1. Materials
Seeds of *P. frutescens* were collected from uncontaminated soil on a farm at the Chengdu Campus of Sichuan Agricultural University (30°71ʹN, 103°87ʹE) in October 2017, air dried and stored at 4°C.

### 2.2. Experimental design

The experiment was conducted in the greenhouse of Chengdu Campus farm from March to July 2018. In March 2018, after the soil was air dried, crushed, mixed and sieved (6.72 mm), 3.0 kg soil was accurately weighed into each plastic pot (23 cm height × 30 cm diameter). A CdCl₂·2.5H₂O solution was added to the soil to achieve a final cadmium concentration of 10 mg·kg⁻¹ [7-8], and the soil moisture was maintained at 80% of field capacity for 8 weeks. After this period, the soil was crushed and mixed thoroughly. Four uniform *P. frutescens* seedlings (with three pairs of expanded true leaves) were transplanted into each pot in May 2018, then sprayed ABA solution that concentration was 0, 1, 5, 10 and 20 μmol·L⁻¹ onto the foliage of seedlings, respectively (25 mL per pot). Each treatment was repeated four times and watered every day to maintain the soil moisture at 80% of field capacity until the plants were harvested.

Two months after the plants were transplanted (July 2018), the plants were harvested and washed with tap water, then followed by deionized water for three times. After that, the plants were divided into three parts of root, stem and leaf, respectively. Finally, deactivation of enzymes in 110 °C for 15 min, and then dry at 80 °C to constant weight. After weighing, the dry sample was ground and passed through a 100 mesh sieve for chemical analysis. Weighed 0.2 g of dry sample and digested it with H₂SO₄-H₂O₂. Then used the solution leafed after digestion to determine the total phosphorus content in various tissues by Mo-Sb Anti-spectrophotometer method [9].

### 2.3. Statistical analyses

Statistical analyses were conducted using statistical software of SPSS 17.0. Data were analyzed by one-way ANOVA with least significant difference at 5% confidence level.

### 3. Results and discussion

#### 3.1. Total phosphorus content in root of *P. frutescens*

After foliar spray with ABA solution, the phosphorus content in root of *P. frutescens* increased significantly (Figure 1). Among the treatments of ABA, when the concentration of ABA was 1-5 μmol·L⁻¹, the total phosphorus content of root increased with the increase of ABA concentration; And when the concentration of ABA was 10-20 μmol·L⁻¹, the total phosphorus content decreased with the increase of ABA concentration, but it was still significantly higher than that when the ABA concentration was 0 μmol·L⁻¹. The ABA concentration ranged from 1-20 μmol·L⁻¹, and the corresponding total phosphorus content in the root increased by 55.87% (*p* < 0.05), 112.07% (*p* < 0.05), 89.16% (*p* < 0.05) and 80.11% (*p* < 0.05), respectively, compared with the total phosphorus content when the ABA concentration was 0 μmol·L⁻¹.

#### 3.2. Total phosphorus content in stem of *P. frutescens*

The total phosphorus content in stem increased with the increase of ABA concentration, reached the peak when the ABA concentration was 5 μmol·L⁻¹, and then decreased (Figure 2). When the ABA concentration was 5 μmol·L⁻¹, the total phosphorus content in stem was 17.74% (*p* < 0.05) higher than that when the ABA concentration was 0 μmol·L⁻¹. There was no significant difference in total phosphorus content in the remaining ABA treatments.
3.3. Total phosphorus content in leaf of *P. frutescens*

For the total phosphorus content in leaf, it decreased when the ABA concentration was 1 and 20 μmol·L⁻¹, and increased when ABA concentration was 5 and 10 μmol·L⁻¹ (Figure 3). Compared with the total phosphorus content in leaf when the ABA concentration was 0 μmol·L⁻¹, the total phosphorus content in leaf decreased by 19.50% \((p < 0.05)\) and 7.57% \((p < 0.05)\), respectively, when the ABA concentration was 1 and 20 μmol·L⁻¹. And the total phosphorus content in leaf increased by 13.89% \((p < 0.05)\) and 8.87% \((p < 0.05)\), respectively, when the ABA concentration was 5 and 10 μmol·L⁻¹.

3.4. Total phosphorus content in shoot of *P. frutescens*

The change in the total phosphorus content in shoot of *P. frutescens* was similar to that in leaf, when the ABA concentration was 1 and 20 μmol·L⁻¹, the total phosphorus content decreased, and when the ABA concentration was 5 and 10 μmol·L⁻¹, it increased (Figure 4). Compared with the total phosphorus content in shoot when the ABA concentration was 0 μmol·L⁻¹, the total phosphorus content in shoot decreased by 10.75% \((p < 0.05)\) and 4.15% \((p < 0.05)\), respectively, when the ABA concentration was 1 and 20 μmol·L⁻¹. And the total phosphorus content in shoot increased by 15.01% \((p < 0.05)\) and 6.47% \((p < 0.05)\), respectively, when the ABA concentration was 5 and 10 μmol·L⁻¹.
4. Conclusions

In the experiment, after foliar spray with ABA solution, the total phosphorus content in root of *P. frutescens* under cadmium stress increased, and had no effects on that in stem except for ABA with a concentration of 5 μmol·L⁻¹. In terms of total phosphorus content in the leaf and shoot of *P. frutescens*, ABA at concentrations of 1 and 20 μmol·L⁻¹ significantly decreased it of the two tissues, while ABA at concentrations of 5 and 10 μmol·L⁻¹ increased it. Compared with the total phosphorus content in root, stem, leaf and shoot, the total phosphorus content for all the tissues above were highest when the ABA concentration was 5 μmol·L⁻¹, increased by 112.07% (p < 0.05), 17.74% (p < 0.05), 13.89% (p < 0.05) and 15.01% (p < 0.05). In conclusion, appropriate concentration of ABA could increase the total phosphorus content of various organs of *P. frutescens* under cadmium stress, and the concentration of 5 μmol·L⁻¹ was the most suitable.

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