Study on Selenium Accumulation Characteristics of *Pterocypsela laciniata*

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**Abstract.** Pot experiments were conducted to investigate the selenium accumulation characteristics of *Pterocypsela laciniata* under different selenium concentrations. The results showed that with the increase of Se concentration in soil, the biomass of root, stem, leaf and shoot of *P. laciniata* decreased, but the Se content of root, stem, leaf and aboveground part increased, and all reached the maximum when Se concentration was 100 mg/kg. When the concentration of Se in soil was 5 mg/kg and 10 mg/kg, the root and shoot of *P. laciniata* had the strongest ability to enrich Se in soil, respectively. When the concentration of selenium was 10 mg/kg, the accumulation of selenium in root and shoot of *P. laciniata* reached 123.06 µg/plant and 67.63 µg/plant respectively. Therefore, *P. laciniata* has strong selenium accumulation ability.

**1. Introduction**

Selenium is one of the essential trace elements in human body. Excessive or low selenium content will lead to human diseases [1]. Long-term selenium deficiency in human body can cause various diseases, such as heart disease, Keshan disease, Kaschin-Beck disease, etc [2]. Selenium is of great significance in preventing and treating diseases, promoting health and preventing aging. The results showed that biological selenium was the most safe and effective way to supplement selenium. The nutritional and medicinal value of selenium was closely related to the chemical forms of selenium [3]. In the aspect of human absorption and utilization of selenium, organic selenium is greater than inorganic selenium, and plant selenium is higher than animal selenium. It is of great significance to study selenium enriched food. Agricultural products are the main source of food for human beings. Obtaining selenium enriched agricultural products through agricultural bioaugmentation is an effective way to supplement selenium for human beings [4]. Vegetables grow rapidly, have high utilization rate and are easy to eat. Compared with fruits and grain crops, vegetable plants have higher selenium content. The results showed that there were some differences in Se uptake by different kinds of vegetables. Generally speaking, the Se enrichment ability of leafy vegetables such as cabbage, lettuce and spinach was higher than that of cucumber, tomato and chili. The results showed that the average Se accumulation content (fresh weight) of leek was 0.043 mg/kg, and that of bitter gourd was only 0.0133 mg/kg, the former was more than three times as much as the latter [6], and the Se content of selenium-enriched sprouts was 10 times as much as that of conventional sprouts [5-6]. Therefore, selenium-rich vegetables can be obtained by applying exogenous selenium to vegetables to achieve the purpose of development and utilization.
P. laciniata is a perennial herb of Pterocypsela. It not only has good flavor, delicate texture and high nutritional value, but also plays an important role in anti-tumor, anti-oxidation, anti-cardiovascular and cerebrovascular diseases. It can be used as a vegetable cultivation, in the vegetable off-season to provide people with nutrient-rich stems and leaves, but also as people's health care products. In this experiment, P. laciniata was used as the experimental material to study the enrichment characteristics of selenium by P. laciniata, and to provide a reference for the development of selenium-rich vegetables.

2. Materials and method

2.1. Materials

Seeds of P. laciniata were collected near Chengdu Campus of Sichuan Agricultural University. After seedling in the laboratory, seedlings with good and consistent growth were selected and transplanted into pots at the end of March 2018. The test soil was taken from farmland soil near Chengdu Campus of Sichuan Agricultural University.

2.2. Experimental design

The experiment was conducted in Chengdu Campus of Sichuan Agricultural University. After the soil was dried, crushed and screened by 5 mm, 3.0 kg soil was put into the plastic basin of 15 cm × 18 cm (high × diameter). Selenium is added to the soil in the form of Na2SeO3 solution and fully mixed. Keep the soil moist, place 60 days, mix the soil regularly and make the soil mix well. The selenium concentration in soil was 0, 5, 10, 25, 50, 75 and 100 mg/kg respectively. P. laciniata seeds near Chengdu Campus of Sichuan Agricultural University were selected. After P. laciniata seedlings cultivation in laboratory, seedlings with good and consistent growth were transplanted into pots. Four seedlings were planted in pots, and four seedlings were scattered in pots. Each treatment was planted in two pots with a basin spacing of 10 cm. During the whole growth process of P. laciniata, water was kept daily to maintain the field capacity of about 80% of the soil in the basin and to remove other weeds and pests in time. After P. laciniata planting for 50 days, the whole plant was harvested, and the roots, stems and leaves were cleaned with tap water, and then rinsed with deionized water three times. The plants were blanched at 110 °C for 15 minutes, dried at 75 °C for constant weight, weighed, crushed and screened over 100 meshes. 1.000 g sample was weighed, added with HNO3-HClO4 (volume ratio 4:1) and placed for 12 hours, then digested until the solution was transparent, reduced by hydrochloric acid, filtered, fixed volume to 50 ml. Selenium content was determined by atomic fluorescence spectrometry.

3. Statistical analyses

Statistical analyses were conducted with statistical software of SPSS 17.0. Data were analysed by one-way ANOVA with least significant difference at 5% confidence level. Bioconcentration factor (BCF) = selenium content in root (shoot) / soil selenium content [7], Translocation factor (TF) = Selenium content in shoot of plant / Se content in root [8], TAF = (Se content in shoot × shoot biomass) / (Se content in root × root biomass).

4. Results and analysis

4.1. Effects of different selenium concentrations on biomass of P. laciniata

With the increase of soil Se concentration, the biomass of root, stem, leaf and shoot decreased (Table 1). Compared with the control, the root biomass decreased by 30.75%, 49.46%, 82.25%, 85.47%, 91.46% and 97.57% respectively, and the shoot biomass decreased by 41.39%, 57.62%, 85.96%, 87.33%, 91.17% and 93.98% respectively, when the selenium concentration was 5, 10, 25, 50, 75, 100 mg/kg. When the concentration of selenium was 25 mg/kg, the biomass of root and shoot increased sharply, and it indicated that high concentration of selenium in soil had an obvious inhibitory effect on
the growth of P. laciniata. With the increase of soil Se concentration, root-shoot ratio increased first and then decreased, the maximum value was 0.537, and the minimum value was 0.171. The root-shoot ratio was higher than that of the control group when the selenium concentration was 5, 10, 25, 50 mg/kg, but when the selenium concentration was 70 and 100 mg/kg, the root-shoot ratio was lower than that of the control group.

### Table 1. Biomass of P. laciniata.

| Treatment (mg/kg) | Root (g/plant) | Stem (g/plant) | Leaf (g/plant) | Shoot (g/plant) | Root/Shoot ratio |
|------------------|----------------|----------------|----------------|-----------------|-----------------|
| 0                | 1.76±0.013a    | 1.84±0.058a    | 2.31±0.006a    | 4.16±0.052a     | 0.425           |
| 5                | 1.22±0.042b    | 0.90±0.027b    | 1.54±0.007b    | 2.44±0.034b     | 0.502           |
| 10               | 0.89±0.017c    | 0.40±0.014c    | 1.36±0.017c    | 1.76±0.031c     | 0.506           |
| 25               | 0.31±0.008d    | 0.17±0.006d    | 0.40±0.003d    | 0.58±0.003d     | 0.537           |
| 50               | 0.25±0.004e    | 0.16±0.007d    | 0.36±0.010e    | 0.52±0.017d     | 0.487           |
| 75               | 0.15±0.008f    | 0.10±0.007e    | 0.26±0.004f    | 0.36±0.011e     | 0.410           |
| 100              | 0.04±0.007g    | 0.09±0.003e    | 0.15±0.006g    | 0.25±0.003f     | 0.171           |

Values are means ± standard errors. Means with the same letter within each column are not significantly different at \( p < 0.05 \).

### 4.2. Effects of different selenium concentrations on selenium content in P. laciniata

With the increase of selenium concentration in soil, the selenium content in roots, stems, leaves and shoots of P. laciniata also increased (Table 2). When the concentration of selenium was 100 mg/kg, the content of selenium in roots, stems, leaves and shoots of P. laciniata was the highest, which were 539.99, 132.70, 157.97 and 148.10 mg/kg, respectively. When the Se concentration was 5 mg/kg, the BCF of root was the highest (15.50). With the increase of Se concentration in soil, the root enrichment coefficient decreased in turn. The BCF of shoot increased first and then decreased with the increase of Se concentration in soil. The maximum value was 3.83 when Se concentration was 10 mg/kg, and the smallest value was 1.48 when Se concentration was 100 mg/kg. This indicated that the enrichment ability of P. laciniata to selenium decreased gradually with the increase of Se concentration in soil. In terms of TF, the TF of P. laciniata were less than 1, and the range was between 0.106-0.302.

### Table 2. Selenium content in P. laciniata.

| Treatment (mg/kg) | Root (mg/kg) | Stem (mg/kg) | Leaf (mg/kg) | Shoot (mg/kg) | BCF of root | BCF of Shoot | TF   |
|------------------|--------------|--------------|--------------|---------------|-------------|--------------|------|
| 0                | 1.23±0.07g   | 0.13±0.028f  | 0.24±0.014f  | 0.19±0.019f   | 0.154       |              |      |
| 5                | 77.48±1.20f  | 7.74±0.085f  | 8.54±0.071f  | 8.24±0.081f   | 15.50       | 1.65         | 0.106|
| 10               | 137.65±1.79c | 32.77±1.754c | 39.91±1.570c | 38.29±1.640c  | 13.77       | 3.83         | 0.278|
| 25               | 248.60±5.44d | 56.67±5.162d | 76.25±2.630d | 70.36±3.231d  | 9.94        | 2.81         | 0.283|
| 50               | 343.61±13.12c| 85.52±5.996c | 108.23±4.243c| 101.13±4.867c | 6.87        | 2.02         | 0.294|
| 75               | 422.45±19.01b| 113.50±6.208b| 133.10±6.463b| 127.72±6.182b | 5.63        | 1.70         | 0.302|
| 100              | 539.99±24.18a| 132.70±7.340a| 157.97±8.188a| 148.10±7.465a | 5.40        | 1.48         | 0.274|

Values are means ± standard errors. Means with the same letter within each column are not significantly different at \( p < 0.05 \).

### 4.3. Effects of different selenium concentrations on selenium accumulation of P. laciniata

Selenium accumulation in roots and shoots of P. laciniata increased firstly and then decreased with the increase of Se concentration in soil (Table 3). When the Se concentration was 10 mg/kg, the Se accumulation in roots and shoots reached the maximum value, 123.06 µg/plant and 67.63 µg/plant, respectively, which were significantly higher than the control \( (P < 0.05) \). As far as the TAF of P. laciniata is concerned, with the increase of Se concentration in soil, the TAF decreased first and then
increased. When Se concentration was 100 mg/kg, TAF reached the maximum value (1.6), and when Se concentration was 5 mg/kg, TAF reached the minimum value (0.21).

### Table 3. Selenium accumulation of P. laciniata.

| Treatment (mg/kg) | Root (µg/plant) | Stem (µg/plant) | Leaf (µg/plant) | Shoot (µg/plant) | TAF |
|------------------|-----------------|-----------------|-----------------|-----------------|-----|
| 0                | 2.18±0.109f     | 0.24±0.060e     | 0.56±0.031g     | 0.80±0.0091f    | 0.37|
| 5                | 94.91±1.815b    | 6.97±0.132d     | 13.16±0.049f    | 20.13±0.083e    | 0.21|
| 10               | 123.06±5.724a   | 13.11±0.238ab   | 54.52±1.467a    | 67.63±1.705a    | 0.55|
| 25               | 78.06±3.819c    | 9.97±1.229c     | 31.19±0.860d    | 41.16±2.089d    | 0.53|
| 50               | 88.31±4.831b    | 14.11±0.385a    | 39.29±0.469b    | 53.40±0.853b    | 0.6 |
| 75               | 63.79±6.455d    | 11.46±1.430bc   | 35.54±2.290c    | 47.00±3.720c    | 0.74|
| 100              | 23.22±2.778e    | 13.01±1.086ab   | 24.17±0.359e    | 37.18±1.445d    | 1.6 |

Values are means ± standard errors. Means with the same letter within each column are not significantly different at $p < 0.05$.

### 5. Conclusions

Selenium content in the roots and shoots of *P. laciniata* increased with the increase of Se concentration in soil. When the concentration of Se in soil was 5 mg/kg and 10 mg/kg, the root and shoot of *P. laciniata* had the strongest ability to enrich Se in soil, respectively. When the concentration of selenium was 10 mg/kg, the accumulation of selenium in roots and shoots of *P. laciniata* reached 123.06 µg/plant and 67.63 µg/plant respectively. Therefore, *P. laciniata* has strong selenium accumulation ability.

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