Effects of Different Concentrations of Selenium on Growth of *Capsella bursa-pastoris*

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Abstract: A pot experiment was conducted to study the effect of selenium at concentrations of 0, 5, 10, 25, 50, 75 and 100 mg/kg on the growth of *Capsella bursa-pastoris*. The biomass, photosynthetic pigment content and antioxidant enzyme activity were measured. The results showed that 5, 10, 10, 25 mg/kg selenium can promote the growth and development of *C. bursa-pastoris*. 50, 75 and 100 mg/kg selenium inhibited it. Chlorophyll decreased significantly only when the concentration was 75 mg/kg, while carotenoid decreased significantly when the concentration was 75 mg/kg and 100 mg/kg. With the increase of selenium concentration, the activity of superoxide dismutase (SOD) increased first and then decreased. All the activity of peroxidase (POD) was lower than that of the control, and all the activity of catalase (CAT) was higher than that of the control.

1. Introduction

Selenium is an essential trace element in human body. Severe selenium deficiency will cause selenium deficiency symptoms such as Keshan disease and bone disease [1]. Selenium supplementation can increase the number of natural killer cells, protect cardiac muscle and cardiovascular system, promote brain development, prevent cancer [2], and even reduce HIV and other virus infections [3]. *Capsella bursa-pastoris* is an annual or biennial herb of *Capsella of Cruciferae*, which is distributed in temperate regions of the world. It is common wild and also cultivated artificially [4]. In the experiment of enriching heavy metals with *C. bursa-pastoris*, it was found that it can resist certain heavy metal toxicity, and its underground parts can enrich a large amount of cadmium elements. It is a cadmium hyperaccumulator [5]. *C. bursa-pastoris* has a high nutritional content. Compared with other fruits and vegetables, it has the highest protein content, vitamin C content is four times higher than tomato, calcium content exceeds milk, chocolate and soybean, iron content is seven times as high as tomato and nine times as high as carrot. Carotene is also higher than carrot, which contains a variety of organic acids, flavonoids, choline, acetylcholine, tyramine, brucine, etc. It has a unique health care function [6]. Selenite is in an organic state in plants after being extracted by plants [7]. The transport of selenite is generally believed to convert the absorbed selenite into $se6^{+}$ and organic selenium compounds (selenomethionine and its oxides, selenomethylcysteine, etc.) at the roots, then transport selenate and a small portion of selenate to plant leaves, where selenate is converted into selenite, then into organic selenium, and finally transported to different organs of plants [8].

2. Materials and Methods

Materials Collection. *C. bursa-pastoris* seeds were collected in farmland near Chengdu campus of Sichuan Agricultural University. Sodium selenite is a common laboratory reagent and is purchased from Chengdu Kelong chemical reagent factory. The soil is fluvo-aquic soil from farmland near Chengdu campus of Sichuan Agricultural University (selenium is not detected), which is spread out for drying for one week and then passed through a 5 mm sieve.

Experimental Design. The experiment was carried out in Chengdu campus of Sichuan Agricultural University. 3 kg of soil was weighed and put into a 21 cm × 20 cm (height × diameter) basin. 0, 5, 10, 25, 50, 75 and 100 mg/kg of sodium selenite solution were added respectively to fully mix with the soil, keep the soil moist, mix again after natural standing and balancing for 4 weeks, and mix the soil thoroughly and evenly from time to time. Selecting *C. bursa-pastoris* seeds with full grains, sterilizing in 10 % hydrogen peroxide solution for 10 min, then washing with ultrapure water, uniformly placing in a culture dish with filter paper, maintaining sufficient water, and accelerating germination in a 20 deg c artificial incubator. Sowing in a 32-hole tray after exposure to white light to raise seedlings, when growing to 3-5 real leaves, selecting *C. bursa-pastoris* seedlings with the same growth rate to transplant into prepared pots with different selenium concentration treated soil, 4 plants in each pot, repeating each treatment 5 times. After *C. bursa-pastoris* grows in soil with different selenium concentrations for 30 d, various indexes are harvested and determined. The dry weights of roots, stems and leaves were determined by conventional methods. Chlorophyll content in leaves was determined by ethanol-acetone mixed extraction method [9]. Potassium permanganate titration method was used to determine the activity of Catalase (CAT) [10]. Peroxidase (POD) activity was determined by guaiacol method [11]. Nitrogen Blue Tetrazolium (NBT) photoreduction method was used to determine the activity of superoxide dismutase (SOD) [12].

Statistical Analyses. Use software of EXCEL 2010 to sort out the test data and use SPSS 18.0 for statistical analysis. The obtained data were analyzed by univariate analysis of variance (ANOVA) with $p < 0.05$ as the standard and Duncan method was used to test the significance of the difference.

3. Results and Discussion

Effects of Selenium on the Biomass of *Capsella bursa-pastoris.* When the concentrations were 5, 10 and 25 mg/kg, the biomass of shoots and roots of *C. bursa-pastoris* was higher than that of the control. The stem and leaf reached the highest when the selenium concentration was 5 mg/kg, increasing 165.30 % and 190.00 % respectively compared with the control. The root reached the highest when the concentration was 10 mg/kg, increasing 8.70 % compared with the control. When the concentrations were 50, 75 and 100 mg/kg, the biomass was lower than that of the control. The biomass of stem and leaf was the lowest when the concentration was 75 mg/kg, which decreased 71.42 % and 66.67 % respectively compared with the control. The biomass of root was the lowest when the concentration was 100 mg/kg, which decreased 26.09 % compared with the control.

Table 1 Effects of selenium on the biomass of *Capsella bursa-pastoris*

Treatments (mg/kg)	Steams (g/plant)	Leaves (g/plant)	Shoots (g/plant)	Roots (g/plant)
0	0.098±0.005c	0.060±0.012c	0.158±0.006c	0.023±0.001ab
5	0.316±0.028a	0.174±0.010a	0.490±0.027a	0.024±0.001a
10	0.260±0.020b	0.173±0.001a	0.433±0.019b	0.025±0.002a
25	0.089±0.005cd	0.093±0.009b	0.182±0.014c	0.023±0.003ab
50	0.050±0.003de	0.050±0.009c	0.100±0.006d	0.020±0.004abc
75	0.028±0.003e	0.020±0.001d	0.048±0.003e	0.017±0.001bc
100	0.029±0.003e	0.031±0.002d	0.060±0.001e	0.014±0.002c

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

Effects of Selenium on Chlorophyll Content of *Capsella bursa-pastoris.* Chlorophyll a only decreased by 42.39 % at 75 mg/kg compared with the control, and there was no significant difference in other concentrations. Chlorophyll b decreased by 51.30 % at 75 mg/kg and increased by 57.31 % at

100 mg/kg compared with the control. There was no significant difference in other concentrations. When the total chlorophyll content was 75 mg/kg, it was significantly reduced by 44.62 % compared with the control, and there was no significant difference in other concentrations. Carotenoids decreased 57.53 % and 66.80 % at 75 mg/kg and 100 mg/kg respectively compared with the control. With the increase of selenium concentration, chlorophyll reached its lowest value at 75 mg/kg and rebounded at 100 mg/kg, which may be related to the special physiological structure of *C. bursa-pastoris*.

Table 2 Effects of selenium on photosynthetic pigment content of *Capsella bursa-pastoris*

Treatments (mg/kg)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll (mg/g)	Chlorophyll a/b	Carotenoids (mg/g)
0	1.819±0.044a	0.616±0.049b	2.434±0.194a	2.974	6.332±0.370a
5	1.894±0.052a	0.594±0.006b	2.488±0.058a	3.186	5.659±0.096a
10	2.082±0.167a	0.692±0.054b	2.774±0.104a	3.009	6.390±0.119a
25	2.010±0.105a	0.702±0.068b	2.712±0.193a	2.867	6.347±0.340a
50	1.851±0.116a	0.656±0.032b	2.507±0.208a	2.836	5.007±0.235a
75	1.048±0.050b	0.300±0.025c	1.348±0.095b	3.599	2.689±0.179b
100	2.060±0.181a	0.969±0.089a	3.029±0.092a	2.144	2.102±0.095b

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

Effects of Selenium on Antioxidant Enzyme Activities of *Capsella bursa-pastoris*. In the effect of soil selenium concentration on SOD activity, except for the concentration of 100 mg/kg, other concentrations were higher than that of the control, reaching the maximum when the concentration was 25 mg/kg, which was 33.27 % higher than that of the control; POD activity was lower than that of the control, reaching the lowest value in 5 mg/kg, which was 73.46 % lower than that of the control. CAT activity was higher than that of the control, reaching the maximum at 50 mg/kg, which was 78.06 % higher than that of the control.

Table 3 Effects of selenium on antioxidant enzyme activities of *Capsella bursa-pastoris*

Treatments (mg/kg)	SOD activity (U/g)	POD activity (U/g/min)	CAT activity (U/g/min)
0	398.52±6.28d	6595.56±186.05a	17.00±1.80c
5	391.11±14.66d	1750.67±9.43d	25.20±0.75ab
10	520.00±4.19a	2650.67±52.80cd	20.80±0.57bc
25	531.11±1.05a	3650.67±337.47bc	24.53±2.26ab
50	428.89±1.05c	4262.67±231.93b	30.27±2.83a
75	497.04±9.43b	6101.33±245.13a	25.67±1.56ab
100	378.52±13.62d	5900.00±304.91a	24.33±1.41ab

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

4. Conclusions

Results show that 5, 10, 10, 25 mg/kg selenium soil can promote the growth and development of *C. bursa-pastoris*, while 50, 75, and 100 mg/kg selenium soil can inhibit it, indicating that low concentration can promote the growth of *C. bursa-pastoris* and high concentration inhibit. Chlorophyll decreased significantly only when the concentration was 75 mg/kg, while carotenoids decreased significantly when the concentration was 75 mg/kg and 100 mg/kg, indicating that high concentration of selenium was not good for photosynthesis. With the increase of selenium concentration, SOD activity first increased and then decreased. POD activity was lower than that of the control, reaching the lowest at 5 mg/kg, and CAT activity was higher than that of the control. Considering all these factors, selenium concentration of 5 mg/kg is the most suitable for the growth of *C. bursa-pastoris*.

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