Effects of Selenium on Physiological Property and Selenium Accumulation of *Lactuca sativa*

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Abstract. The Effects of six selenium concentrations (0, 5, 10, 25, 50, 75, and 100 mg/kg) on physiological property and selenium accumulation of *Lactuca sativa* were conducted by a pot experiment. 5 mg/kg of Se concentration can promote *L. sativa* biomass increased. Above 5 mg/kg, Se can restrain *L. sativa* growth. *L. sativa* can enrich plenty Se in high Se soil and the roots Se content distribution is higher than shoots. With the Se concentration increased, the Se content of roots and shoots increased. When Se concentration was 10-100 mg/kg, the Se content in roots was 1.34, 4.49, 5.44, 11.20 and 17.42 times higher than that of 5 mg/kg, respectively, the Se content in shoots was 1.91, 4.14, 5.13, 6.14 and 8.69 times higher than that of 5 mg/kg, respectively, the Se accumulation in roots was 1.15, 3.70, 3.58, 4.36 and 4.50 times higher than that of 5 mg/kg, respectively, the Se accumulation in shoots were 1.31, 1.56, 1.61, 1.63 and 1.94 times higher than that of 5 mg/kg, respectively. Both the Se content and Se accumulation of *L. sativa* reached maximum at 100 mg/kg of Se concentration. Therefore, exerting 100 mg/kg of Se concentration, the Se enrichment of *L. sativa* is the best.

1.Introduction

Selenium (Se) is a trace element beneficial to human health. Se deficiency will cause keshan disease, hypertension, cancer and many other diseases. However, Se geographical distribution is uneven [1]. Studies have shown that exerting modest Se is propitious to plants growth and strengthens their resistance to hostile environment [2]. the Se enrichment characteristics have distinctions in different plant, which has been proved in *Fagopyrum esculentum* Moench [3] and Flue-cured Tobacco [4]. Selenite can be transformed into organic selenium [5], and it is easy to form Insoluble iron-aluminum oxide in soil [6]. So it is beneficial to maintain soil selenium and to reduce the toxicity to plants. Rather, selenate has much toxic effect on plants. Thus, selenite application effect is better than selenate. Therefore, the experiment used sodium selenite admixing soil to study the effects of different Se concentrations on Physiological Property and Selenium Accumulation of *Lactuca sativa*, in order to find out the appropriate exogenous Se concentration.

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2.Materials and methods

2.1 Materials collection

L. sativa seeds were purchased from Guangdong Konong vegetable seed Industry Company Limited. Sodium selenite purchased from Chengdu Kelong Chemical Reagent Factory. The soil was taken from farmland around Sichuan agricultural university (Chengdu campus). It was sandy loam soil and selenium was not detected.

2.2 Experiment design

The soil samples were air-dried, crushed, passed through 5mm mesh, later, weighted 3.0 kg and placed into each 21 cm × 20 cm (high × diameter) plastic pot. Pure sodium selenite solution was added to the soil by concentrations of 0, 5, 10, 25, 50, 75, and 100 mg/kg, respectively, and fully mixed with the soil. Keep the soil moist and place it for 30 days. Seeds of *L. sativa* were sterilized for 10 min with 10% hydrogen peroxide solution, rinsed with ultrapure water, placed uniformly into a pallet (covering 1:1 vermiculite and pearlstone) for germination. Later, seedlings planted into a 50-hole tray. When unfolded 2-3 real-leaf, uniform growth seedlings were selected and transplanted into prepared pots. Three seedlings planted into per pot. Each treatment was repeated five times. After 40 days cultivated, seedlings were harvested and the biomass was determined by conventional methods. The roots and shoots were collected and dried into powder at 60℃. 0.6g powder was weigh and put into 100ml triangular bottle. Then, it was moisturized with deionized water and added 10ml 9:1 mixed HNO_3-$HClO_4$ acid, and placed on overnight. Morrow day, the solution was heated. When solution became clear and accompanied by thick white smoke, adding 5ml 1:1 high grade pure hydrochloric acid. When the solution cools to room temperature, transferred it into 50ml capacity bottle and using atomic fluorescence spectrometry to determine Se content [7].

2.3 Statistical analyses

Statistical analyses were conducted by SPSS 20.0 statistical software. Transfer Factors =shoots content / roots content. Se extraction = plant Se concentration × plant biomass.

3.Results and discussion

3.1 Biomass of L. sativa

With the Se concentrations increased, the dry weight of roots and shoots increased first and then decreased, and reached the maximum at 5 mg/kg of Se concentration, which significantly raised than that of their severally control 16.95% and 45.41%. Above 5 mg/kg, the dry weight of roots and shoots all lower than control, and reached the minimum at 100 mg/kg of Se concentration, which in contrast to control significantly decreased 69.49% and 68.12%. Besides, at 10 mg/kg of Se concentration, root/shoot ratio reached minimum 0.21.

Table 1. Biomass of L. sativa.

Treatments (mg/kg)	Root dry weight (g/plant)	Shoot dry weight (g/plant)	root/shoot ratio
0	0.59±0.05ab	2.29±0.10b	0.26
5	0.69±0.06a	3.33±0.32a	0.21
10	0.60±0.01a	2.26±0.18b	0.22
25	0.57±0.04ab	1.22±0.12c	0.47
50	0.46±0.04b	1.03±0.02cd	0.44
75	0.27±0.02c	0.86±0.08cd	0.32
100	0.18±0.01c	0.73±0.01d	0.25

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

3.2 Se concentrations of L. sativa

The content of Se in roots and shoots increased with the increased of Se concentration, and both reached peak at 100 mg/kg of Se concentration. When Se concentration was 10-100 mg/kg, the Se content in roots was 1.34, 4.49, 5.44, 11.20 and 17.42 times higher than that of 5 mg/kg, respectively. The Se content in shoots was 1.91, 4.14, 5.13, 6.14 and 8.69 times higher than that of 5 mg/kg, respectively. Transfer Factor maximum was 0.51 (10 mg/kg). In all Se concentration, the Se content of roots all higher than shoots.

Table 2. Se contents of L. sativa.

Treatments (mg/kg)	Se concentration in root (μg/g)	Se concentration in shoot (μg/g)	Transfer Factor
0	0.00±0.00f	0.00±0.00c	0.00
5	3.28±0.30e	1.18±0.10c	0.36
10	4.38±0.42e	2.25±0.12c	0.51
25	14.74±1.45d	4.89±0.46b	0.33
50	17.84±1.00c	6.05±0.58b	0.34
75	36.75±1.48b	7.25±0.70b	0.20
100	57.13±1.81a	10.25±0.97a	0.18

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

3.3 Se accumulations of L. sativa

Different from Se content, the Se accumulation of roots variation trend was increase first and then decrease, the shoots showed an increase trend. But both Se accumulation reached peak at 100 mg/kg of Se concentration. When Se concentration was 10-100 mg/kg, the Se accumulation in roots was 1.15, 3.70, 3.58, 4.36 and 4.50 times higher than that of 5 mg/kg, respectively. The Se accumulation in shoots was 1.31, 1.56, 1.61, 1.63 and 1.94 times higher than that of 5 mg/kg, respectively, and only 100 mg/kg reached significant level. Except 5, 10 mg/kg of Se concentration, the accumulation of roots all higher than shoots.

Table 3. Se accumulation of *L. sativa.*

Treatments (mg/kg)	Se accumulation in root (μg/plant)	Se accumulation in shoot (μg/plant)
0	0.00±0.00b	0.00±0.00c
5	2.28±0.22b	3.85±0.36b
10	2.62±0.25a	5.06±0.12ab
25	8.44±0.81a	6.00±0.44ab
50	8.16±0.78a	6.19±0.51ab
75	9.95±0.99a	6.29±0.60ab
100	10.26±1.00a	7.47±0.73a

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

4.Conclusions

5 mg/kg of Se concentration can promote *L. sativa* biomass increased, compared with control, root and

shoot biomass increased 16.95% and 45.41%. Above 5 mg/kg, Se can restrain *L. sativa* growth. Compared with control, root and shoot biomass significantly decreased 69.49% and 68.12%. For root/shoot ratio, it reached minimum at 10 mg/kg of Se concentration. It means that with the Se concentration increased, *L. sativa* adapts high Se stress by increasing root proportion. Under Se concentration gradient treatment, the roots and shoots Se content of *L. sativa* showed a trend of increase progressively. It means *L. sativa* can enrich plenty Se in high Se soil. For Transfer Factor, it reached maximum at 10 mg/kg of Se concentration, which illustrated that the ability of transfer Se from roots to shoots of *L. sativa* was best in this concentration. At 100 mg/kg of Se concentration, the Se accumulation of roots and shoots reached maximum, which were 4.50 and 1.94 times higher than that of 5 mg/kg. Therefore, exerting 100 mg/kg of Se concentration, the effect of Se enrichment is the best.

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