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Effects of Different Concentrations of Selenium on Nutrient Uptake of Wild Vegetable *Nasturtium officinale*

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Abstract: A pot experiment was carried out to study the effects of different concentrations of selenium on nutrient uptake of wild vegetable *Nasturtium officinale*. The total nitrogen (N), total phosphorus (P) and total potassium (K) contents in stems, leaves and shoots of *N. officinale* were determined. With the increase of Se concentrations in soil, the total N, P, K contents in shoots of *N. officinale* had the increase trend. So, the treatments of Se promoted the N, P, K absorption of *N. officinale*. These results indicate that adding Se in soil could promote the nutrient absorption of *N. officinale*, which might promote the growth of *N. officinale*.

Introduction

Selenium (Se) is an important trace element in the body's function and plays an extremely important role [1]. For the human body, Se has anti-cancer, to resist a variety of diseases (such as prevention of cardiovascular and cerebrovascular diseases, liver disease, Keshan disease), anti-aging, detoxification, detoxification, enhance immune function and other functions [2-4]. There are different levels of lack of Se in 70% of the region of China, and different levels of Se intake in 72% of the population [5]. Se can not be synthesized in the body and must be ingested from food. The Se content in seafood and liver is higher, but in meat and cereals is lower, and in fruits and vegetables is very low [2, 6]. Long-term consumption of high content of Se fish, meat will bring a burden on human digestion, but also to some families to bring some economic pressure, and excessive Se can also cause Se poisoning [3]. Therefore, cheap, fresh and delicious Se-rich vegetables become an important way to supplement the body of Se [7]. The study on the enrichment characteristics of Se in vegetables has been reported, but the higher Se content of vegetables less [7-9], further screening of high Se content of vegetables on the human body to add Se is of great significance.

Wild vegetable is one of vegetables with high nutritional value and health value, and have become popular food at home and abroad [10]. In recent years, the development and utilization of wild vegetable resources and deep processing technology has gradually been the attention of scholars and attention [11]. *Nasturtium officinale* R. Br. is a perennial cruciferous emergent plant of wild vegetable that is widely distributed in Europe, Asia and North America, and it grows rapidly in nutrient-rich water and is propagated easily from cuttings [12]. In this study, the effects of different concentrations of selenium on nutrient uptake of *N. officinale* were studied. The aim of this study was to screen out the best concentration of Se which could promote the nutrient absorption of *N. officinale*.

Materials and Methods

Materials. The Inceptisol soil samples (purple soil in the Genetic Soil Classification of China) were collected from the Chengdu campus farm of Sichuan Agricultural University (30° 42′N, 103° 51′E) in April 2017. The basic properties of the soil were pH 6.94, organic matter 17.54 g/kg, total nitrogen 3.63 g/kg, total phosphorus 0.38 g/kg, total potassium 17.54 g/kg, alkali soluble nitrogen 195.00 mg/kg, available phosphorus 6.25 mg/kg and available potassium 191.13 mg/kg [13]. The seedlings of *N. officinale* were collected from a ditch in the Ya'an campus farm in December 2016.

Experimental Design. The soil samples were air dried and sieved to 5 mm in October 2016, then 3.0 kg of the air-dried soil was weighed into polyethylene pots (15 cm tall, 18 cm diameter), and Se was added to the soils as Na_2SeO_3 at 0, 5, 10, 25, 50, 75 and 100 mg/kg. The soil was maintained in the submerged state, and then the soil in each pot was mixed. The soils were soaked in the Se solution for 4 weeks, and then the soil in each pot was mixed thoroughly. Three uniform *N. officinale* seedlings (10 cm in length) were transplanted into each pot in December 2016. Each treatment was repeated three times making a total of 21 pots, and put in a completely randomized design with 10 cm spacing between pots. The water depth was 1 cm higher than the soil surface in the first two weeks of the experiment, and 5 cm above the soil surface from two weeks until the time that the *N. officinale* seedlings were harvested.

After 60 days, the *N. officinale* were dug up and divided into stem and leaf, then washed with tap water firstly, followed by deionized water. After that, the organs of all plants were dried at 80 °C until constant weight, ground to < 0.149 mm, and sealed into plastic bags for the determination of total nitrogen (N), total phosphorus (P) and total potassium (K) contents [14].

Statistical Analyses. Statistical analyses were conducted using SPSS 13.0 statistical software (IBM, Chicago, IL, USA). Data were analyzed by one-way analysis of variance with least significant difference (LSD) at the p = 0.05 confidence level.

Results and Discussion

Total N Contents in *N. officinale*. With the increase of Se concentrations in soil, the total N contents in stems, leaves and shoots of *N. officinale* had the increase trend, and the treatments of Se promoted the N absorption of *N. officinale* (Table 1). The total N content in stems of *N. officinale* was ranked as: 100 mg/kg > 10 mg/kg > 50 mg/kg > 75 mg/kg > 5 mg/kg > 25 mg/kg > 0 mg/kg, in leaves of *N. officinale* was 100 mg/kg > 50 mg/kg > 75 mg/kg > 5 mg/kg > 10 mg/kg > 25 mg/kg > 0 mg/kg, and in shoots of *N. officinale* was 100 mg/kg > 75 mg/kg > 50 mg/kg > 10 mg/kg > 5 mg/kg > 25 mg/kg > 0 mg/kg. When the soil Se concentrations were 5, 10, 25, 50, 75 and 100 mg/kg, compared with the control, the total N content in stems of *N. officinale* significantly ($p < 0.05$) increased by 19.75%, 24.15%, 16.15%, 21.63%, 20.91% and 35.90%, respectively, in leaves of *N. officinale* significantly ($p < 0.05$) increased by 8.82%, 8.54%, 8.45%, 17.86%, 17.42% and 37.63%, respectively, and in shoots of *N. officinale* significantly ($p < 0.05$) increased by 11.72%, 13.81%, 10.40%, 14.80%, 15.61% and 36.38%, respectively.

Table 1 Total N contents in *N. officinale* under Se stress

Treatments	Stems (mg/g)	Leaves (mg/g)	Shoots (mg/g)
0	13.87±0.73c	31.97±1.31d	22.02±0.97c
5	16.61±0.90b	34.79±1.37c	24.60±1.09b
10	17.22±0.80b	34.70±2.32c	25.06±1.36b
25	16.11±0.85b	34.67±2.18c	24.31±1.27b
50	16.87±0.84b	37.68±2.13b	25.28±1.39b
75	16.77±1.28b	37.54±2.64b	25.47±1.75b
100	18.85±1.03a	44.00±2.85a	30.03±1.79a

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

Total P Contents in *N. officinale*. With the increase of Se concentrations in soil, the total P contents in stems and shoots of *N. officinale* had the increase trend, and the treatments of Se promoted the P absorption of *N. officinale* (Table 2). However, the total P contents in leaves of *N. officinale* had no increase trend with the increase of soil Se concentrations. The total P content in stems of *N. officinale* was ranked as: 50 mg/kg > 5 mg/kg > 75 mg/kg > 25 mg/kg > 10 mg/kg > 100 mg/kg > 0 mg/kg, in leaves of *N. officinale* was 100 mg/kg > 5 mg/kg > 0 mg/kg > 75 mg/kg > 50 mg/kg > 25

mg/kg > 10 mg/kg, and in shoots of *N. officinale* was 5 mg/kg > 50 mg/kg > 100 mg/kg > 75 mg/kg > 25 mg/kg > 10 mg/kg > 0 mg/kg. When the soil Se concentrations were 5, 10, 25, 50, 75 and 100 mg/kg, compared with the control, the total P content in stems of *N. officinale* significantly ($p < 0.05$) increased by 41.27%, 27.87%, 30.16%, 46.91%, 30.69% and 22.57%, respectively, respectively, and in shoots of *N. officinale* significantly ($p < 0.05$) increased by 25.75%, 9.21%, 11.09%, 24.62%, 19.36% and 21.80%, respectively. When the soil Se concentrations were 5 and 100 mg/kg, the total P contents in leaves of *N. officinale* increased by 2.45% ($p > 0.05$) and 20.25% ($p < 0.05$), respectively, compared with the control. When the soil Se concentrations were 10, 25, 50 and 75 mg/kg, the total P contents in leaves of *N. officinale* decreased by 17.28% ($p < 0.05$), 16.97% ($p < 0.05$), 15.54% ($p < 0.05$) and 0.20% ($p > 0.05$), espectively, compared with the control.

Table 2 Total P contents in *N. officinale* under Se stress

Treatments	Stems (mg/g)	Leaves (mg/g)	Shoots (mg/g)
0	5.67±0.38c	4.89±0.27b	5.32±0.33c
5	8.01±0.44a	5.01±0.31b	6.69±0.38a
10	7.25±0.32b	4.04±0.22c	5.81±0.26b
25	7.38±0.42b	4.06±0.24c	5.91±0.33b
50	8.33±0.44a	4.13±0.26c	6.63±0.36a
75	7.41±0.50b	4.88±0.35b	6.35±0.43a
100	6.95±0.44b	5.88±0.36a	6.48±0.40a

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

Total K Contents in *N. officinale*. With the increase of Se concentrations in soil, the total K contents in stems, leaves and shoots of *N. officinale* had the increase trend, and the treatments of Se promoted the K absorption of *N. officinale* (Table 3). The total K content in stems of *N. officinale* was ranked as: 100 mg/kg > 50 mg/kg > 75 mg/kg > 5 mg/kg > 25 mg/kg > 10 mg/kg > 0 mg/kg, in leaves of *N. officinale* was 100 mg/kg > 75 mg/kg > 5 mg/kg > 25 mg/kg > 10 mg/kg > 50 mg/kg > 0 mg/kg, and in shoots of *N. officinale* was 100 mg/kg > 75 mg/kg > 50 mg/kg > 5 mg/kg > 25 mg/kg > 10 mg/kg > 0 mg/kg. When the soil Se concentrations were 5, 10, 25, 50, 75 and 100 mg/kg, compared with the control, the total K content in stems of *N. officinale* significantly ($p < 0.05$) increased by 18.25%, 16.74%, 17.68%, 37.52%, 28.57% and 28.80%, respectively, in leaves of *N. officinale* significantly ($p < 0.05$) increased by 18.86%, 16.41%, 18.09%, 9.51%, 36.98% and 47.32%, respectively, and in shoots of *N. officinale* significantly ($p < 0.05$) increased by 18.70%, 16.66%, 17.99%, 27.98%, 32.42% and 36.51%, respectively.

Table 3 Total K contents in *N. officinale* under Se stress

Treatments	Stems (mg/g)	Leaves (mg/g)	Shoots (mg/g)
0	43.50±1.89d	37.53±1.43e	40.81±1.67d
5	51.44±2.51c	44.61±2.03c	48.44±1.85c
10	50.78±2.52c	43.69±1.85c	47.61±1.94c
25	51.19±2.83c	44.32±2.24c	48.15±2.11c
50	59.82±3.57a	41.10±2.22d	52.23±2.44b
75	55.93±2.96b	51.41±2.69b	54.04±2.53ab
100	56.03±3.64b	55.29±2.68a	55.71±2.71a

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

Conclusions

With the increase of Se concentrations in soil, the total N, P, K contents in shoots of *N. officinale* had the increase trend. So, the treatments of Se promoted the N, P, K absorption of *N. officinale.* These results indicate that adding Se in soil could promote the nutrient absorption of *N. officinale*, which might promote the growth of *N. officinale.*

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