Selenium Accumulation Characteristics of Tomato Seedlings

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Keywords: Selenium; Tomato seedlings; Growth characteristics

Abstract. A pot experiment was conducted to study the selenium accumulation characteristics of tomato seedlings under different concentrations of selenium. Four treatments were used in the experiment: soil was constructed by adding 0, 5, 10, 25 mg/kg exogenous selenium. The fresh weight and selenium contents in roots, stems and leaves of tomato seedlings were determined. The results showed that the selenium contents of tomato seedling organs increased with the increase of soil selenium concentration. The biomass of roots, stems and leaves of tomato seedlings increased firstly and then decreased with the increase of soil selenium concentration, and reached the maximum value when the soil selenium concentration was 5 mg/kg, which was 94.59%, 33.16% and 40.09% higher than the control, respectively. However, the biomass decreased significantly when the soil selenium concentration reached 25 mg/kg, which was 52.51%, 67.42%, 70.14% lower than the control. Therefore, low concentration selenium could increase the biomass and promote the growth of tomato seedlings. However, the high concentration of selenium could reduce the biomass of tomato seedlings, inhibit the growth of tomato seedlings, and produce toxic effects in severe cases. The concentration of 5 mg/kg Se was the best.

1. Introduction

Tomato is one of the most widely cultivated vegetables in the world, and plays a very important role in the vegetable market. Selenium is one of the most widely distributed elements on earth, with an average content of 0.09 mg/kg in most soils [1]. Selenium is essential micronutrient [2] and beneficial micronutrient [3] for plant growth. Studies have shown that if the daily selenium intake is insufficient, will lead to the occurrence of bone disease, Keshan disease, cardiovascular and cerebrovascular diseases and other diseases [4]. Selenium has anticancer, anti-aging, antitumor, and immunity enhancing effects, known as the "protective agent of life" [5]. Nowadays, with the improvement of living standard, people pay more and more attention to their own life and health, and people pay more and more attention to selenium supplement. Soil selenium is the main source of selenium absorption by plants. Plants absorb inorganic selenium in soil and then convert it into organic selenium needed by human body. Therefore, it is a safe and effective way to supplement selenium needed by human body by eating plants with higher selenium content. The results also showed that selenium played an important role in plant growth and development: Low concentration selenium can improve the antioxidant capacity of plants [6], promote chlorophyll metabolism [7], promote plant growth, improve yield, quality and dry matter content [8]. But because selenium can accumulate in plants and soil, high concentrations of selenium can produce toxic effects on crops [9]. Therefore, in this experiment, tomato seedlings were used as materials to study the accumulation characteristics of selenium by adding different concentrations of selenium into soil through pot experiments.

2. Materials and Methods

Materials. The experiments were conducted at Sichuan Agricultural University (30° 42′ N, 103° 51′ E), Wenjiang, Chengdu, Sichuan, China. Tomato seeds were provided by fruit and vegetable research institute of Chengdu campus of Sichuan agricultural university. The breeds were multi-generation inbred lines with stable homozygous characters. Selenium was purchased from Chengdu kelong chemical reagent factory. All chemicals used in experiments were analytical pure.

Experimental Design. The experiment was conducted in Sichuan agricultural university (Chengdu campus) from April to July, 2017. In April 2017, the soil was air-dried, crushed, evenly mixed, screened by a 5 mm sieve, weighed 6.0 kg respectively and placed in a plastic basin of 18 cm×26 cm (height × diameter), added with analytical pure $Na_2O_3Se \cdot 5H_2O$ solution, and the selenium concentration was 0, 5, 10, 25 mg/kg, and fully mixed with the soil, and naturally placed for balance for 4 weeks before mixing again for later use. When the three leaves of tomato seedlings were unfolded, the tomato seedlings with uniform growth were selected, three plants were planted in each pot with 4 treatments, and each treatment was repeated 3 times, randomly placed, and routinely administered. The determination of the indicators was after planting 30 days.

Statistical Analyses. Statistical analysis was carried out by using SPSS 20.0 statistical software. The data were analyzed by one-way ANOVA, with the least significant difference at the 5% confidence level.

3. Results and Discussion

Biomass of Tomato Seedlings. The fresh weight of roots, stems and leaves of tomato seedlings increased firstly and then decreased with the increase of soil selenium concentration (Table 1), and reached the maximum value when the soil selenium concentration was 5 mg/kg, which was significantly higher than that of the control 94.59% ($p < 0.05$), 33.16% ($p < 0.05$), 40.09% ($p < 0.05$), respectively. There was no significant difference between the control and the soil selenium concentration of 10 mg/kg. The fresh weight of roots, stems and leaves of tomato seedlings was significantly lower than that of control 52.51% ($p < 0.05$), 67.42% ($p < 0.05$), 70.14% ($p < 0.05$) when soil selenium concentration was 25 mg/kg. The root/shoot ratio of tomato seedling was 43.54% higher than that of control at 5 mg/kg se concentration in soil. At 10 mg/kg, the root/shoot ratio was lower than that of the control. The results showed that low concentration of selenium could increase the biomass accumulation of tomato seedlings, while high concentration of selenium could decrease the biomass of tomato seedlings.

Moisture Content of Tomato Seeding. In order to understand the effect of exogenous selenium on dry matter content of tomato seedlings, the water content of tomato seedlings was determined (Table 2). The water content of roots, stems and leaves of tomato seedlings reached the minimum value when the soil selenium concentration was 5 mg/kg, and was lower than 1.14% ($p < 0.05$), 5.83% ($p < 0.05$) and 1.29% ($p < 0.05$) of the control respectively. The peak value reached at 10 mg/kg, which was 0.8% ($p < 0.05$), 0.47% ($p < 0.05$) and 1.53% ($p < 0.05$) higher than the control. Therefore, low concentration selenium could increase dry matter accumulation in tomato seedlings.

Selenium Content of Tomato Seeding. In order to investigate the distribution of selenium in different organs of tomato seedlings, the selenium contents in different organs was analyzed. The selenium content in different organs of tomato seedlings was significantly different (Table 3). The content of selenium in roots, stems and leaves of tomato seedlings increased with the increase of soil selenium concentration, and reached the maximum at 25 mg/kg soil selenium concentration, which was significantly different from the control and higher than the control 4372.90% ($p < 0.05$), 3279.14% ($p < 0.05$), 4854.57% ($p < 0.05$), respectively. When soil selenium concentration was 10 mg/kg, the selenium content in the leaves was not significantly level with the control, and selenium content in roots, stems and leaves was 1928.35% ($p < 0.05$), 1862.50% ($p < 0.05$) and 1431.23% ($p < 0.05$) higher than that of the control, respectively. The selenium contents in roots, stems and leaves of tomato seedlings were 954.00% ($p < 0.05$), 1100.37% ($p < 0.05$) and 948.35% ($p < 0.05$) higher than those of the control respectively when the soil selenium concentration was 5 mg/kg. At the same time, the trend of selenium content in tomato organs under different soil selenium concentrations was root > leaf > stem.

Table 1 Fresh weight of tomato seedlings

Se concentration (mg/kg)	Root (g/plant)	Stem (g/plant)	Leaf (g/plant)	root/shoot ratio
0	3.510±0.255b	15.400±0.857b	8.473±0.486b	0.147
5	6.830±0.969a	20.507±1.013a	11.870±1.082a	0.211
10	3.673±0.131b	16.310±0.460b	9.317±0.353b	0.143
25	1.667±0.074c	5.017±0.346c	2.530±0.227c	0.221

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

Table 2 Moisture content of tomato seedlings

Se concentration (mg/kg)	Roots (%)	Stems (%)	Leaves (%)
0	0.875±0.006a	0.858±0.005a	0.851±0.004ab
5	0.865±0.004a	0.808±0.003b	0.840±0.003bc
10	0.882±0.008a	0.862±0.007a	0.864±0.004a
25	0.866±0.007a	0.845±0.005a	0.825±0.005c

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

4. Conclusions

It is an important and effective measure to increase selenium content in crop organs by applying exogenous selenium to soil. The results showed that the growth of roots, stems and leaves of tomato seedlings could be promoted by adding a certain concentration of exogenous selenium, and the biomass and dry matter content of tomato seedlings could be increased. However, the high concentration of selenium could inhibit the growth of tomato seedlings and reduce their biomass seriously. Therefore, although selenium accumulation in crops increases with the increase of exogenous selenium concentration, but when selenium content is high, the crops to selenium absorption into a crazy absorption state, at this time selenium toxicity to crops will be more and more obvious, resulting in crop biomass but with the increase of exogenous selenium concentration and reduce, serious will also make its crop death. And 5 mg/kg Se was the best treatment.

Table 3 Selenium accumulation in tomato seedlings

Se concentration (mg/kg)	Root (mg/kg)	Stem (mg/kg)	Leaf (mg/kg)
0	4.768±0.337c	0.663±0.028d	1.835±0.089b
5	50.254±2.614bc	7.954±0.507c	19.237±1.005b
10	96.710±3.986b	13.004±0.773b	28.099±1.252b
25	213.264±9.753a	22.391±1.892a	90.918±2.791a

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

Acknowledgements

This work was financially supported by the Application Infrastructure Project of Science and Technology Department of Sichuan Province (2016JY0258).

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