The selenium accumulation characteristics of grape seedlings

Lei Liu¹, Ting Wang², Liyun Sui², Ji Liu², Lijin Lin³ and Ming’an Liao¹*
¹College of Horticulture, Sichuan Agricultural University, Chengdu, Sichuan, 611130, China
²Chengdu Academy of Agriculture and Forestry Sciences, Chengdu, Sichuan, 611130, China
³Institute of Pomology and Olericulture, Sichuan Agricultural University, Chengdu, Sichuan, 611130, China
*Corresponding author’s e-mail: lman@sicau.edu.cn

Abstract. To study the selenium accumulation characteristics of fruit tree, different selenium concentrations (0.00, 0.05, 0.10, 0.25, 0.50, 1.00, 2.00 mg/L) were used on the grape seedlings, and the selenium accumulation characteristics of grape seedlings were studied by a pot experiment. With the increase of selenium concentration in culture medium, the biomass of grape seedlings had increase trend when the culture medium selenium was no more than 0.05 mg/L, and decreased when the culture medium selenium was exceed 0.05 mg/L. When the culture medium selenium was 0.05 mg/L, the biomass of grape seedlings got the maximum. For selenium content in plants, with the increase of selenium concentration in culture medium, the selenium contents in roots and shoots of grape seedlings increased. Therefore, lower selenium concentration in culture medium could promote the growth of grape seedlings, while higher selenium concentration inhibited, and grape seedlings had strong selenium uptake ability.

1. Introduction
Selenium plays an extremely important role in the function of the human body [1-2]. Selenium can’t be synthesized in the human body, which can maintain the health of the human body through a small amount of selenium; the selenium content in seafood and animal liver is high, but in meat and grain is low, and the selenium content in fruits and vegetables is very low [3-5]. Long-term consumption of fish and meat with high selenium content will burden the human body digestion, and will also bring some economic pressure to some families, and excessive selenium may cause selenium poisoning [5-6]. Therefore, cheap, fresh and delicious selenium-enriched fruits and vegetables have become an important way to supplement selenium in the human body [7]. There have been reports on the enrichment characteristics of selenium in fruits and vegetables, but there are fewer fruits and vegetables with higher selenium content [7-8]. Grape is one of the most cultivated fruit trees in the world and has a very high nutritional value [9]. In this experiment, the effects of different selenium concentrations were used on the grape seedlings, and the selenium accumulation characteristics of grape seedlings were studied.

2. Materials and methods

2.1. Materials
1-year-old 'Xiahei' grape cutting seedlings were collected and stored in sand at the Chongzhou Research and Demonstration Base of Sichuan Agricultural University in December 2018. In March 2019, the grape seedlings were transplanted to perlite and planted in a greenhouse at 25 °C.

2.2. Experimental design
In April 2019, when the new shoots of the grape seedlings were about 15 cm high, the grape seedlings with the same growth were selected and planted in the Hoagland solution. Na₂SeO₃ was added to the Hoagland solution to make the concentration of selenium in the solution was 0.00, 0.05, 0.10, 0.25, 0.50, 1.00 and 2.00 mg/L, respectively. One grape seedling was transplanted per pot, and each experiment was repeated five times and cultured in the greenhouse of Sichuan Agricultural University. One month later, the whole plant was harvested, and its roots and shoots were separated, washed with tap water, repeatedly rinsed with deionised water, and then dried at 80°C to constant weight. The dried roots, stems and leaves were weighed with an electronic balance. The dried plant samples were finely ground and then exactly 0.5000 g was used to determine the selenium content by digestion in HNO₃/HClO₄ (4:1, v/v) followed by ICP spectrometry (iCAP 6300 ICP, Thermo Scientific, Waltham, MA, USA) [10].

2.3. Statistical analyses
Statistical analysis was carried out by using SPSS 18.0 statistical software. The data were analyzed by one-way ANOVA, with the least significant difference at the 5% confidence level.

3. Results and Discussion
3.1. Effects of different selenium concentration on biomass of grape seedlings
The effects of different selenium concentration on biomass of grape seedlings are showed in Table 1. With the increase selenium concentration in culture medium, the root biomass, stem biomass, leaf biomass and shoot biomass of grape seedlings had an increase trend when the culture medium selenium was no more than 0.05 mg/L, and decreased when the culture medium selenium was exceeded than 0.05 mg/L. When the culture medium selenium was 0.05 mg/L, all of the root biomass, stem biomass, leaf biomass and shoot biomass of grape seedlings got the maxima, which increased by 6.57% \((p < 0.05)\), 22.06% \((p < 0.05)\), 31.93% \((p < 0.05)\), and 30.48% \((p < 0.05)\), respectively, compared with the control. When the culture medium selenium wer e 0.10, 0.25, 0.50, 1.00, and 2.00 mg/L, compared with the control, the root biomass of grape seedlings decreased by 22.29% \((p < 0.05)\), 28.00% \((p < 0.05)\), 56.57% \((p < 0.05)\), 66.14% \((p < 0.05)\), and 67.29% \((p < 0.05)\), respectively; the stem biomass decreased by 23.49% \((p < 0.05)\), 39.86% \((p < 0.05)\), 60.50% \((p < 0.05)\), 66.55% \((p < 0.05)\), and 75.09% \((p < 0.05)\), respectively; the leaf biomass decreased by 11.29% \((p < 0.05)\), 28.88% \((p < 0.05)\), 46.03% \((p < 0.05)\), 52.75% \((p < 0.05)\), and 56.84% \((p < 0.05)\), respectively; the shoot biomass decreased by 13.03% \((p < 0.05)\), 30.48% \((p < 0.05)\), 48.15% \((p < 0.05)\), 54.72% \((p < 0.05)\), and 59.51% \((p < 0.05)\), respectively.

| Se concentration (mg/L) | Root biomass (g/plant) | Stem biomass (g/plant) | Leaf biomass (g/plant) | Shoot biomass (g/plant) |
|-------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00                    | 0.700±0.011b           | 0.281±0.006b           | 1.638±0.064b           | 1.919±0.070b           |
| 0.05                    | 0.746±0.020a           | 0.343±0.008a           | 2.161±0.083a           | 2.504±0.091a           |
| 0.10                    | 0.544±0.007c           | 0.215±0.009c           | 1.453±0.063c           | 1.669±0.072c           |
| 0.25                    | 0.504±0.013d           | 0.169±0.006d           | 1.165±0.035d           | 1.334±0.041d           |
| 0.50                    | 0.304±0.010e           | 0.111±0.007e           | 0.884±0.022e           | 0.995±0.028e           |
| 1.00                    | 0.237±0.009f           | 0.094±0.006f           | 0.774±0.027ef          | 0.869±0.034f           |
| 2.00                    | 0.229±0.006f           | 0.070±0.004g           | 0.707±0.009f           | 0.777±0.013f           |

Value are means ± standard errors. Means with the same letter within each column are not significantly different at \(p < 0.05\).
3.2. Effects of different selenium concentration on selenium content in grape seedlings

Table 2. Selenium content in grape seedlings

| Se concentration (mg/L) | Roots (µg/g)       | Stems (µg/g)       | Leaves (µg/g)      | Shoots (µg/g)      |
|------------------------|--------------------|--------------------|--------------------|--------------------|
| 0.00                   | 0.93±0.014g        | 0.42±0.009g        | 1.19±0.061g        | 1.08±0.055g        |
| 0.05                   | 4.47±0.271f        | 0.84±0.008f        | 1.58±0.047f        | 1.48±0.043f        |
| 0.10                   | 43.07±1.336e       | 1.48±0.018e        | 3.23±0.051e        | 3.01±0.047e        |
| 0.25                   | 101.3±4.155d       | 3.62±0.020d        | 4.66±0.059d        | 4.53±0.054d        |
| 0.50                   | 151.6±5.515c       | 5.22±0.039c        | 6.01±0.027c        | 5.93±0.025c        |
| 1.00                   | 164.2±5.995b       | 6.45±0.088b        | 7.56±0.092b        | 7.44±0.089b        |
| 2.00                   | 176.9±6.459a       | 7.13±0.112a        | 8.88±0.117a        | 8.72±0.109a        |

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

The effects of different selenium concentration on biomass of grape seedlings are showed in Table 2. With the increase selenium concentration in culture medium, the selenium contents in roots, stems, leaves and shoots of grape seedlings had an increase trend. When the culture medium selenium were 0.05, 0.10, 0.25, 0.50, 1.00, and 2.00 mg/L, the selenium content in roots of grape seedlings were 4.76 \((p < 0.05)\), 46.06 \((p < 0.05)\), 108.34 \((p < 0.05)\), 162.14 \((p < 0.05)\), 175.61 \((p < 0.05)\), and 189.20 \((p < 0.05)\) times than the control, respectively; the selenium content in stems of grape seedlings were 1.99 \((p < 0.05)\), 3.49 \((p < 0.05)\), 8.51 \((p < 0.05)\), 12.27 \((p < 0.05)\), 15.15 \((p < 0.05)\), and 16.74 \((p < 0.05)\) times than the control, respectively; the selenium contents in leaves of grape seedlings were 1.33 \((p < 0.05)\), 3.91 \((p < 0.05)\), 5.05 \((p < 0.05)\), 6.34 \((p < 0.05)\), and 7.45 \((p < 0.05)\) times than the control, respectively; the selenium content in shoots of grape seedlings were 1.37 \((p < 0.05)\), 2.78 \((p < 0.05)\), 4.19 \((p < 0.05)\), 5.49 \((p < 0.05)\), 6.89 \((p < 0.05)\), and 8.07 \((p < 0.05)\) times than the control, respectively.

4. Conclusions

According to the experiment, with the increase of selenium concentration in culture medium, the biomass of grape seedlings had increase trend when the culture medium selenium was no more than 0.05 mg/L, and decreased when the culture medium selenium was exceeded than 0.05 mg/L. When the culture medium selenium was 0.05 mg/L, the biomass of grape seedlings got the maximum. For selenium content in plants, with the increase of selenium concentration in culture medium, the selenium contents in roots and shoots of grape seedlings increased. Therefore, lower selenium concentration in culture medium could promote the growth of grape seedlings, while higher selenium concentration inhibited, and grape seedlings had strong selenium uptake ability.

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