Effects of different selenium concentrations on the stress resistance of grape seedlings

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Abstract. The effects of different concentrations of selenium (0.00, 0.05, 0.10, 0.25, 0.50, 1.00, 2.00 mg/L) on the stress resistance of grape seedlings were studied by pot experiment. The results showed that the proline content in different parts of grape seedlings showed an increasing trend with the increase of selenium concentration. The activities of SOD, POD and CAT, as well as the relative conductivity, malondialdehyde and soluble protein content of grape seedlings increased first and then decreased with the increase of exogenous selenium concentration. When the concentration of selenium was 0.50 mg/L, the antioxidant enzyme activity and the content of permeate in grape seedlings reached the maximum. In summary, low concentration of selenium can effectively improve the stress resistance of grape seedlings, but when the concentration of selenium is higher than 0.50 mg/L, it has a toxic effect on grape seedlings.

1. Introduction
Selenium is an essential trace element and has important biological functions in animals and humans. The level of selenium in the human body is closely related to human health. Selenium deficiency or excessive intake of selenium can lead to various diseases [1]. As a producer in the ecosystem, plants play an important role in the chemical cycle of selenium and are the main carriers for the conversion of inorganic selenium into organic selenium. As the level of consumption increases, it is especially important to upgrade the commodity value and nutritional value of agricultural products to meet the growing market demand. In recent years, many researchers have devoted themselves to the research and promotion of selenium-accumulation fruits and have achieved remarkable results [2-3]. However, for plants, studies has shown that although low concentrations of selenium can effectively promote plant growth, high concentrations of selenium have a significant toxic effect on plants [4-5]. Grape is one of the most cultivated fruit trees in the world and has a very high nutritional value. Although study has shown that grapes have good physiological effects under the condition of exogenous selenium, the study on the tolerance of grapes to selenium has not yet been reported [6]. Therefore, this experiment investigated the effects of different selenium concentrations on the stress resistance of grapes.
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 upper mature leaves of grape seedlings were collected and their activities of SOD, POD, CAT, relative conductivity, malondialdehyde content and soluble protein content were determined by Li [7]. Then the whole grape seedlings were harvested and divided into roots, stems and leaves, and the proline content was determined respectively [7].

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 selenium on antioxidant enzyme activity of grape seedlings

As can be seen from Table 1, compared with the control, selenium increased the SOD, POD and CAT activities of grape seedlings to different extents. Moreover, the activities of SOD, POD and CAT of grape seedlings increased first and then decreased with the increase of selenium concentration. When the concentration of selenium was 0.50 mg/L, the activities of SOD, POD and CAT of grape seedlings reached the highest, which increased by 218.77%, 70.29% and 114.03% compared to control, respectively.

3.2. Effects of selenium on proline content of grape seedlings

As can be seen from Table 2, the proline content of different parts of grape seedlings showed an upward trend with the increase of selenium concentration. And when the selenium concentration was 2.0 mg/L, the proline content of root, stem and leaf in grape seedlings reached the highest level, which increased by 188.28%, 110.05% and 98.23% respectively compared with the control.

| Se concentration (mg/L) | SOD activity (U/g) | POD activity (U/g/min) | CAT activity (mg/g/min) |
|-------------------------|-------------------|-----------------------|------------------------|
| 0.00                    | 29.89±1.36f       | 570.2±11.78f          | 0.720±0.012g           |
| 0.05                    | 31.05±1.04f       | 681.0±20.84d          | 0.909±0.009f           |
| 0.10                    | 56.74±2.03d       | 746.8±18.11c          | 0.980±0.021e           |
| 0.25                    | 68.40±2.43c       | 860.9±20.91b          | 1.358±0.014c           |
| 0.50                    | 95.28±2.76a       | 971.0±32.75a          | 1.541±0.039a           |
| 1.00                    | 81.17±3.73b       | 838.2±18.45b          | 1.489±0.047b           |
| 2.00                    | 51.89±2.09e       | 617.6±16.41e          | 1.256±0.040d           |

Value are means ± standard errors. Means with the same letter within each column are not significantly different at \( p < 0.05 \).
### Table 2. Effects of selenium on proline content of grape seedlings

| Se concentration (mg/L) | Root (µg/g) | Stem (µg/g) | Leaf (µg/g) |
|-------------------------|-------------|-------------|-------------|
| 0.00                    | 106.7±0.13g | 85.36±1.69g | 157.8±5.08f |
| 0.05                    | 128.8±1.94f | 113.6±3.39f | 209.2±3.71e |
| 0.10                    | 191.5±0.31e | 123.5±0.52e | 212.9±1.84e |
| 0.25                    | 215.6±6.14d | 135.9±1.63d | 233.9±3.85d |
| 0.50                    | 230.8±3.64c | 146.4±3.30c | 262.8±3.89c |
| 1.00                    | 247.9±8.66b | 153.0±2.38b | 288.6±4.12b |
| 2.00                    | 307.6±11.02a| 179.3±6.48a | 312.8±5.87a |

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

3.3. Effects of selenium on permeate content of grape seedlings

As can be seen from Table 3, the Relative conductivity, malondialdehyde content and soluble protein content of grape seedlings first increased and then decreased with the increase of selenium concentration. When selenium concentration was 0.50 mg/L, the relative conductivity, malondialdehyde content and soluble protein content of grape seedlings reached the highest, which increased by 37.20%, 66.41% and 187.11% respectively compared with the control.

### Table 3. Effects of selenium on permeate content of grape seedlings

| Se concentration (mg/L) | Relative conductivity | Malondialdehyde content (µmol/kg) | Soluble protein content (µg/g) |
|-------------------------|-----------------------|-----------------------------------|-------------------------------|
| 0.00                    | 238.2±9.19e          | 23.10±1.66e                       | 3.18±0.12f                   |
| 0.05                    | 239.2±3.75e          | 27.89±0.90d                       | 5.88±0.07e                   |
| 0.10                    | 290.2±3.68d          | 34.76±2.13c                       | 7.21±0.11c                   |
| 0.25                    | 296.7±4.81d          | 36.27±1.79b                       | 8.47±0.19b                   |
| 0.50                    | 326.8±8.77a          | 38.44±1.59a                       | 9.13±0.08a                   |
| 1.00                    | 315.8±4.95b          | 33.59±0.82c                       | 8.59±0.09b                   |
| 2.00                    | 305.4±6.72c          | 29.18±1.33d                       | 6.07±0.10d                   |

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

4. Conclusions

According to the experiment, the proline content in different parts of grape seedlings showed an increasing trend with the increase of selenium concentration. The activities of SOD, POD and CAT, as well as the relative conductivity, malondialdehyde and soluble protein content of grape seedlings increased first and then decreased with the increase of exogenous selenium concentration. When the concentration of selenium was 0.50 mg/L, the antioxidant enzyme activity and the content of permeate in grape seedlings reached the maximum. In summary, low concentration of selenium can effectively improve the stress resistance of grape seedlings, but when the concentration of selenium is higher than 0.5 mg / L, it has a toxic effect on grape seedlings.

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