Effects of Different Selenium Concentrations on Photosynthetic Physiology of Grape Seedlings

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Abstract. A hydroponic experiment was conducted to study the effects of different concentrations of selenium (0.00, 0.05, 0.10, 0.25, 0.50, 1.00, 2.00 mg/L) on photosynthetic physiology of grape seedlings. The result showed that the selenium concentration of 0.05 mg/L could significantly improve the chlorophyll a, chlorophyll b, carotenoid and total chlorophyll of grape seedlings, while the chlorophyll content reduced significantly when the concentration was 1.00 mg/L and 2.00 mg/L. Besides, the net photosynthetic rate (Pn), stomatal conductance (Gs), CO₂ concentration of intercellular (Ci) and transpiration rate (Tr) of grape seedlings all significantly increased at 0.05 mg/L, while the Pn, Gs, Ci and Tr of grape seedlings reduced significantly when the concentration was 1.00 mg/L and 2.00 mg/L. Therefore, the selenium concentration of 0.05 mg/L concentration was beneficial to photosynthesis.

1. Introduction
As a necessary trace element in human body, selenium has many biological functions, such as protecting heart, preventing Keshan disease and Kashin-Beck disease, improving body immunity, preventing cancer and anticancer, anti-cancer, delaying aging [1-2]. Selenium is a necessary trace element for plant growth [3]. Trace selenium can increase the activity of peroxidase in plants, strengthen the antioxidant ability of the plant in vivo, so as to improve the resistance to stress and aging, and ensure the normal growth of the plant [4]. There are 22 selenium-deficient provinces in China. 72% of the land area is in the areas of serious selenium-deficiency and selenium-deficiency, resulting in extremely low selenium content in agricultural products [5]. In recent years, selenium-rich cultivation at present is a major research direction of crop cultivation in China [6], the results of a lot of research show that selenium can increase the yield of crops at the right concentration quantity, quality and resistance were significantly improved [7-8]. The study found that proper selenium can promote garlic growth, while excessive selenium can inhibit garlic growth, resulting in weak emergence, slow growth and yield decline [9]. The study also found that selenium has similar effects on carrots: low selenium concentration is beneficial to carrots, while high selenium concentration is toxic and inhibits the growth of carrots [10]. The fruits of peach, jujube and strawberry could be improved by applying suitable selenium fertilizer on the leaf surface selenium content[11]. But the report about grape selenium test is rare. Therefore, this study investigated the effects of different concentrations of selenium (0.00, 0.05, 0.10, 0.25, 0.50, 1.00, 2.00 mg/L) on photosynthetic...
physiology of grape then to screen out the optimum concentration that can improve the absorption of photosynthetic pigment of grape seedlings.

2. Materials and methods

2.1. Materials

In March 2019, the grape branches after sand storage were cutting culture. One month later, seedlings growing well above ground and below ground were selected for the experiment. The grape variety is Xiahei and perlite was used as matrix.

2.2. Experimental design

The experiment was conducted in Chengdu Campus of Sichuan Agricultural University from March to May 2019. In April 2019, grape cut seedlings were planted in nutrient solution and the basic nutrient solution was formulated by the Hoaglang nutrient solution. 7 treatments were conducted: 0.00, 0.05, 0.10, 0.25, 0.50, 1.00 and 2.00 mg/L were added in the form of Na₂SeO₃. Each plastic pot was planted with one plant, which was repeated five times and arranged randomly in a tray. Nutrient solution by watered twice a week. After a month, the photosynthesis of each grape seedling was determined by using LI-6400 portable photosynthesis meter (LI-COR Inc., USA) in May 2019. The photosynthetic parameters of the photosynthesis meters were manual control CO₂ concentration 400 µmol/mol, temperature 30°C, and light intensity 1000 µmol m⁻² s⁻¹. The determination of photosynthetic parameters were net photosynthetic rate (Pn), transpiration rate (Tr), stomatal conductance (Gs), CO₂ concentration of intercellular (Ci) and value of pressure deficit leaf (VpdL). And then, the upper mature leaves of grape cut seedlings were collected to determine the photosynthetic pigment (chlorophyll a, chlorophyll b, total chlorophyll and carotenoid) contents [12].

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. Chlorophyll content of grape seedlings under different selenium concentrations

Chlorophyll a increased by 11.76 % at 0.05 mg/L and decreased by 14.60 % at 2.00 mg/L compared with the control. There was no significant difference in other concentrations. Chlorophyll b only increased by 13.98 % at 0.05 mg/L compared with the control, and there was no significant difference in other concentrations. Carotenoid reduced by 15.57 % at 2.00 mg/L compared with the control, and there was no significant difference in other concentrations. When the total chlorophyll content was 0.05 mg/L, it was significantly increased by 11.93% compared with the control, and there was no significant difference in other concentrations. With the increase of selenium concentration, chlorophyll reached its highest value at 0.05 mg/L and it began to decline.

| Treatments (mg/L) | Chlorophyll a (mg/g) | Chlorophyll b (mg/g) | Carotenoid (mg/g) | Total chlorophyll (mg/g) | Chlorophyll a/b |
|------------------|----------------------|----------------------|-------------------|-------------------------|-----------------|
| 0.00             | 1.82±0.030b          | 0.60±0.009bc         | 0.379±0.006ab     | 2.422±0.040b            | 3.030           |
| 0.05             | 2.026±0.058a         | 0.685±0.007a         | 0.394±0.009a      | 2.711±0.065a            | 2.959           |
| 0.10             | 1.755±0.043bc        | 0.613±0.011b         | 0.363±0.005bc     | 2.368±0.035bc           | 2.861           |
| 0.25             | 1.758±0.023bc        | 0.603±0.012bc        | 0.357±0.012bcd    | 2.361±0.036bc           | 2.916           |
| 0.50             | 1.725±0.028bc        | 0.553±0.016d         | 0.355±0.010cde    | 2.279±0.045c            | 3.118           |
| 1.00             | 1.715±0.022c         | 0.577±0.021ed        | 0.338±0.011de     | 2.292±0.044e            | 2.972           |
| 2.00             | 1.589±0.032d         | 0.559±0.003d         | 0.320±0.009e      | 2.147±0.029d            | 2.844           |

Value are means ± standard errors. Means with the same letter within each column are not significantly different at p < 0.05.
3.2. Photosynthetic characteristics of grape seedlings

The Pn and Gs of grape seedlings was significant difference in different concentrations and the Pn and Gs of grape seedlings increased by 28.84 % and 139.66 % at 0.05 mg/L and decreased by 55.40 % and 68.97 % at 2.00 mg/L compared with the control, respectively. For the Ci and Tr of grape seedlings, with the increase of selenium concentration, they reached theirs highest value at 0.05 mg/L and they began to decline. The Ci and Tr of grape seedlings increased by 39.99 % and 151.50 % at 0.05 mg/L and decreased by 55.10 % and 69.19 % at 2.00 mg/L compared with the control, respectively. On the contrary, the VpdL of grape seedlings was highest at 2.00 mg/L and lowest at 0.05 mg/L.

| Treatments (mg/L) | Pn (µmol CO₂ m⁻² s⁻¹) | Gs (µmol H₂O m⁻² s⁻¹) | Ci (µmol CO₂ mol⁻¹) | Tr (mmol H₂O m⁻² s⁻¹) | VpdL (kPa) |
|-------------------|-------------------------|------------------------|---------------------|------------------------|------------|
| 0.00              | 7.04±0.091b             | 0.058±0.003b           | 183.3±4.64b         | 1.402±0.018b           | 2.712±0.016b |
| 0.05              | 9.07±0.037a             | 0.139±0.006a           | 256.6±8.70a         | 3.526±0.035a           | 2.409±0.012c |
| 0.10              | 5.55±0.065c             | 0.049±0.002c           | 182.1±5.22b         | 1.448±0.029b           | 2.733±0.020b |
| 0.25              | 5.11±0.041d             | 0.039±0.002d           | 129.4±6.02c         | 1.172±0.022c           | 2.752±0.028b |
| 0.50              | 3.94±0.050e             | 0.029±0.001e           | 106.8±4.63d         | 0.904±0.018d           | 2.754±0.033b |
| 1.00              | 3.72±0.065f             | 0.016±0.001f           | 88.62±4.88e         | 0.483±0.012e           | 2.868±0.031a |
| 2.00              | 3.14±0.025g             | 0.018±0.002f           | 82.30±2.61e         | 0.432±0.005e           | 2.887±0.037a |

Values 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 selenium concentration of 0.05 mg/L could significantly improve the chlorophyll a, chlorophyll b, carotenoid and total chlorophyll of grape seedlings, while the chlorophyll content reduced significantly when the concentration was 1.00 mg/L and 2.00 mg/L, indicating that high concentration of selenium was not good for photosynthesis. Besides, the Pn, Gs, Ci and Tr of grape seedlings all significantly increased at 0.05 mg/L, while the Pn, Gs, Ci and Tr of grape seedlings reduced significantly when the concentration was 1.00 mg/L and 2.00 mg/L. Therefore, the selenium concentration of 0.05 mg/L concentration was beneficial to photosynthesis. On the contrary, high concentration of selenium was not good for photosynthesis.

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