ATLANTIS PRESS
*Advances in Engineering Research, volume 163*
7th International Conference on Energy, Environment and Sustainable Development (ICEESD 2018)

# Effects of Selenium on Photosynthetic Characteristics of Tomato Seedlings

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**Key words:** Selenium; Tomato seedlings; Photosynthetic characteristics

**Abstract:** A pot experiment was conducted to study the effects of different concentrations selenium (Se) on the photosynthetic characteristics of tomato seedlings. The results showed that the photosynthetic parameters and photosynthetic pigment content of tomato seedlings increased first and then decreased, and reached the maximum at 5 mg/kg Se concentration. Compared with control, tomato plant height, stem diameter and root length increased by 35.44%, 20.59% and 85.40%, respectively, net photosynthetic rate, stomatal conductance, intercellular $CO_2$ concentration and transpiration rate increased by 22.80%, 25.27%, 0.48% and 15.38%, respectively, chlorophyll a increased by 50.81%, chlorophyll b increased by 57.53%, total chlorophyll increased by 52.60% and carotenoid increased by 37.30%. In conclusion, the optimal concentration of Se was 5 mg/kg, the net photosynthetic rate and stomatal conductance of tomato seedlings were increased, the content of photosynthetic pigment was increased, and the growth of tomato seedlings was promoted.

## Introduction

Selenium (Se) is one of relatively rare element, and it is also a necessary trace element for human and animal body to maintain health [1]. 72% of the regions in China belong to low Se and Se deficiency zones [2], Se deficiency can cause a variety of human or animal diseases, such as Kashin-Beck disease, Keshan disease [3-4], Inadequate intake of Se will seriously affect people's health [5-7]. With the development of science and society, the application of Se in agriculture has been paid more and more attention in the world, the studies have shown that a moderate concentration of Se can promote plant growth, excessive inhibition of plant growth, serious harm, and it has been proved in *Cryptotaenia japonica* [8], lettuce [9], potato [10]. In the study of cauliflower [11] and rape [12], it was found that different Se concentration could affect the chlorophyll content of plants, which showed the phenomenon of low concentration promotion and high concentration inhibition. The effects of Se on physiological characteristics, Se content and quality of garlic were studied by Xia et al. [13]. The effects of Se on the photosynthetic characteristics of tomato seedlings were studied by pot experiment in order to find the best concentration for promoting tomato photosynthesis.

## Materials and Methods

**Materials.** The soil was taken from farmland around Sichuan agricultural university (Chengdu campus) and was sandy loam soil. Its basic physical and chemical properties were pH 6.29, organic matter 21.16 g/kg, total nitrogen 1.09 g/kg, total phosphorus 1.2 g/kg, total potassium 22 g/kg, available phosphorus 16.22 mg/kg and available potassium 156.2 mg/kg. After retrieving it, spread it flat and dry it for one week, screened it with 1 cm sieve, and set aside. Red cherry tomato seeds were collected from Sichuan Agricultural University. The $Na_2O_3Se{\cdot}5H_2O$ purchased from Chengdu Kelong chemical reagent factory.

**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 3.0 kg respectively and placed in a plastic basin of 15 cm × 18 cm (high × diameter), added with analytical pure $Na_2CO_3 \cdot 5H_2O$ solution, and the Se 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. After 30 days, the plants were harvested.

**Index Measurement Method.** The plant height and root length were measured with a ruler with a precision of mm, the stem diameter was measured with vernier caliper, and the photosynthetic pigment content (chlorophyll a, chlorophyll b, total chlorophyll content and carotenoid) was measured with acetone-ethanol mixture (1:1) extraction. Photosynthesis was measured by Li-6400 portable photosynthetic apparatus (Li-cor Inc., USA) and began at 9 a.m. The photosynthetic rate (Pn), transpiration rate (Tr), stomatal conductance (Gs) and intercellular $CO_2$ concentration (Ci) were measured by controlling the concentration of $CO_2$ at 400 μmol$CO_2$/mol, temperature at 25□ and illumination intensity at 1000 μmol/$m^2$/s.

**Statistics analyses.** Using Excel 2010 for data recording and finishing, SPSS 20.0 was used for statistical analysis, compare of different significance using Duncan's new multiple range method.

## Results and Analysis

**Growth of Tomato Seedlings.** It can be seen from table 1, that with the increase of Se concentration, the plant height, stem diameter, root length, root fresh weight and fresh weight of aboveground of tomato seedling increased first and then decreased. The plant height, stem diameter, root length, root fresh weight and aboveground fresh weight of tomato increased by 35.44% ($P < 0.05$), 20.59% ($P < 0.05$), 85.40% ($P < 0.05$), 94.46% ($P < 0.05$) and 35.62% ($P < 0.05$) respectively compared with control under Se concentration of 5 mg/kg. Tomato plant height and root length increased significantly compared with control by 11.97% ($P < 0.05$) and 76.28% ($P < 0.05$), respectively, while stem diameter, root fresh weight and aboveground fresh weight did not increase significantly under 10 mg/kg, however, at the 25 mg/kg Se concentration, the plant height, stem diameter, root fresh weight and aboveground fresh weight decreased significantly compared with control except that the root length of tomato increased significantly, which decreased by 17.41% ($P < 0.05$), 17.85% ($P < 0.05$), 52.51% ($P < 0.05$) and 68.39% ($P < 0.05$).

Table 1 Growth of tomato seedlings

| Se concentration (mg/kg) | Plant height (cm) | Stem diameter (cm) | Root length (cm) |
|---|---|---|---|
| 0 | 64.333±3.194c | 0.437±0.010b | 20.100±0.872c |
| 5 | 87.133±2.371a | 0.527±0.025a | 37.267±1.350a |
| 10 | 72.033±0.306b | 0.454±0.007b | 35.433±0.569a |
| 25 | 53.133±4.596d | 0.359±0.022c | 24.600±1.778b |

Note: The data followed by different lowercase indicate significant difference of 5% level, the same as follow tables.

**Photosynthetic Parameters of Tomato Seedlings.** As can be seen from Table 2, the net photosynthetic rate of tomatoes increased by 22.80% ($P < 0.05$) and 1.87%($P > 0.05$) at 5 mg/kg and 10 mg/kg compared with control, the net photosynthetic rate of tomato decreased under the Se concentration of 25 mg/kg. The stomatal conductance of tomato increased significantly by 25.27% ($P < 0.05$) at 5 mg/kg and decreased significantly by 26.92% ($P < 0.05$) at 10 mg/kg compared with control. The intercellular $CO_2$ concentration of tomato increased under 5 mg/kg, but not significant, the other two treatments all decreased, and the intercellular $CO_2$ concentration of tomato decreased significantly by 9.75% ($P < 0.05$) compared with control under 10 mg/kg. The transpiration rate increased significantly at 5 mg/kg, increased by 15.38% ($P < 0.05$) compared with control, and decreased at 10 and 25 mg/kg, reached a significant level under the Se concentration of 10 mg/kg,

decreased by 24.03% ($P < 0.05$) compared with control.

Table 2 Photosynthetic parameters of tomato seedlings

| Se concentration (mg/kg) | Net photosynthetic rate (μmol $CO_2/m^2/s$) | Stomatal conductance (mol $H_2O/m^2/s$) | Intercellular $CO_2$ concentration (mmol $CO_2$/mol) | Transpiration rate (mol $H_2O/m^2/s$) |
|---|---|---|---|---|
| 0 | 8.601±0.281b | 0.182±0.025b | 305.850±9.527a | 3.108±0.314b |
| 5 | 10.562±0.397a | 0.228±0.030a | 307.332±3.230a | 3.586±0.339a |
| 10 | 8.762±0.462b | 0.133±0.038c | 276.026±2.827b | 2.361±0.408c |
| 25 | 8.217±0.344b | 0.155±0.011bc | 296.882±2.287a | 2.819±0.094b |

**Photosynthetic Pigment Content Tomato Seedlings.** From Table 3, it was found that chlorophyll a, chlorophyll b, total chlorophyll content and carotenoid content were higher than that of control, Chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content increased compared with control, showing a trend of increasing first and then decreasing. Compared with control, chlorophyll a increased by 50.81% ($P < 0.05$), 13.44% ($P < 0.05$) and 5.71% ($P > 0.05$), Chlorophyll b increased 57.53%($P < 0.05$), 13.47% ($P < 0.05$) and 4.34% ($P > 0.05$), The total chlorophyll content increased by 52.60% ($P < 0.05$), 13.51% ($P < 0.05$) and 5.43% ($P > 0.05$) and the content of carotenoid increased by 37.30% ($P < 0.05$), 8.68% ($P > 0.05$) and 4.50% ($P > 0.05$), respectively. The content of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid in tomato increased compared with the control by 50.81%, 57.53%, 52.60% and 37.30% respectively under the Se concentration of 5 mg/kg.

Table 3 Photosynthetic pigment content in tomato seedlings

| Se concentration (mg/kg) | Chlorophyll a (mg/g) | Chlorophyll b (mg/g) | Total chlorophyll (mg/g) | Chlorophyll a/b | Carotenoid (mg/g) |
|---|---|---|---|---|---|
| 0 | 1.295±0.045c | 0.438±0.038c | 1.732±0.073c | 2.958 | 0.311±0.020b |
| 5 | 1.953±0.086a | 0.690±0.042a | 2.643±0.127a | 2.832 | 0.427±0.017a |
| 10 | 1.469±0.058b | 0.497±0.098b | 1.966±0.119b | 2.956 | 0.338±0.053b |
| 25 | 1.369±0.057bc | 0.457±0.054bc | 1.826±0.111bc | 2.995 | 0.325±0.037b |

## Conclusion

The photosynthetic characteristics of tomato seedlings were affected by applying different concentrations of Se in soil, which showed a trend of increasing first and then decreasing. Compared with control, tomato seedling height, stem diameter, root length, net photosynthetic rate, stomatal conductance, transpiration rate, chlorophyll a, chlorophyll b, total chlorophyll and carotenoids increased significantly and reached the maximum value at the Se concentration of 5 mg/kg, and the effect was better than the other three treatments.

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