Effect of exogenous Selenium on the growth and Selenium accumulation of *Talinum paniculatum* (Jacq.) Gaertn

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**Abstract:** In this study, we added different Selenium (Se) concentrations (0 mg·kg⁻¹, 2.5 mg·kg⁻¹, 5.0 mg·kg⁻¹, 10.0 mg·kg⁻¹, 20.0 mg·kg⁻¹) into soil to study the effect of Se on the growth, quality and Se content of *Talinum paniculatum* (Jacq.) Gaertn. The results show that different Se concentration has significant different influence on the growth of *T. paniculatum*. Low Se concentration can promote the growth of *T. paniculatum*, but high Se concentration would inhibit the growth of *T. paniculatum*. The chlorophyll content of *T. paniculatum* increased with the increase of Se concentration, which was beneficial to the photosynthesis of *T. paniculatum*. The Se content of *T. paniculatum* increased gradually with the increase of Se concentration, and the rule of Se content of *T. paniculatum* was root > leaf > stem. Taken together, the optimum concentration of Se in the soil of *T. paniculatum* cultivation was about 5.0~10.0 mg·kg⁻¹.

1. Introduction

Natural wild vegetables, also known as wild vegetables, refer to wild and semi-wild plants that grow naturally, without artificial cultivation, whose roots, stems, leaves, flowers and fruits are edible. *Talinum paniculatum* (Jacq.) Gaertn is a perennial plant of the *Portulacaceae*. The edible part of *T. paniculatum* is stems, leaves and roots, which are rich in protein, amino acids, iron and zinc. *T. paniculatum* likes the warm climate and resistant to high temperature and humidity but not resistant to cold. So it is suitable for planting in subtropical and tropical regions. As a new healthy vegetable, it is gradually being accepted by people. Researching the reaction of *T. paniculatum* to different Selenium (Se) treatments is beneficial to the development of agriculture.

Se is one of the fourteen kinds of trace elements for human health. Se has the effects of anti-cancer, anti-aging and improving immunity [1]. Due to the special role of Se and the current status of Se deficiency in most areas of our country, intake of Se from food has become an important way for human body [2]. Se is absorbed by plants in the form of selenate, selenite or organic Selenium, and the roots and leaves of plants have certain absorption capacity [3]. Se needs to consume a certain amount of metabolic energy to transport into plants. After being converted into organic Se compounds, a small part of it was transported to the branches and leaves, and most of it remains in the roots [4]. Se directly affects crop biomass by acting on certain biochemical processes in plants. Se affects the quality of crops mainly by promoting the levels of certain organic compounds in the crops [5]. Hydroponic lettuce with 0.4 mg·L⁻¹ Se increased the total sugar, reducing sugar, chlorophyll, and soluble protein content in lettuce leaves, lowered the content of crude fiber and nitrite and played a good role in protecting human health [6]. The development of Se-enriched *T. paniculatum* can produce considerable market value and economic benefits. Therefore, exploring the optimal Se concentration for the growth of *T. paniculatum* is helpful to improve the cultivation technology of Selenium-rich
vegetables.
Through the simulation of Se-enriched environment, the relevant growth physiological mechanism of *T. paniculatum* in Se-rich soil and the influence of different concentrations of Se environment on the growth, quality and Se content of *T. paniculatum* were studied, so as to explore and understand the most Se concentration for *T. paniculatum* growth and find the suitable Se concentration in the cultivation soil for human needs, and provide certain technical support for the cultivation.

2. Materials and methods

2.1 Plant materials and Soil materials
The plant material of this experiment is *T. paniculatum*, provided by the college of horticulture, Sichuan agricultural university. The 6-8 cm long branches of annual *T. paniculatum* vegetables are selected for cutting cultivation. After the branches take root, they are disinfected with carbendazim, and then transplanted. The matrix used for cutting propagation of *T. paniculatum* branched seedlings is a 1:1 configuration of perlite and vermiculite after dry heat sterilization.

The soil is from Sichuan agricultural university (pH6.6, available nitrogen 53.6 mg·kg⁻¹, available phosphorus 44.1mg·kg⁻¹, available potassium 176.7mg·kg⁻¹, the organic matter 10.2 mg·kg⁻¹).

2.2 Treatment
The experiment was carried out by pot culture method. First, select a plastic basin with a size of 215 mm × 145 mm × 130 mm (upper diameter × lower diameter × height), wipe it with 70% alcohol, and dry it. Each pot contains 2.5 kg of soil. Prepare Na₂SeO₃ into Se solutions of different concentrations, and use no Se treatment as a control (CK). Add Se solutions with concentrations of 2.5, 5.0, 10.0, and 20.0 mg·kg⁻¹ to the soil and mix well. The annual *T. paniculatum* cutting seedlings were selected for transplanting, and five *T. paniculatum* seedlings were transplanted in each pot, and each treatment was repeated three times for a total of thirty pots. After marking the *T. paniculatum* vegetable seedlings treated with different Se concentrations, randomly place the plastic pots for cultivating the *T. paniculatum* vegetable seedlings and exchange the relative positions of the plastic pots from time to time to weaken the possible marginal effects of the *T. paniculatum* vegetable in the growth process.

Water regularly and keep the soil moisture content at about 70% of the field water holding capacity, and remove weeds in time. 40 days after the start of treatment, the various growth index of *T. paniculatum* dishes were detected.

2.3 Statistical analysis
All data were analyzed with statistical software SPSS version 22.0 (IBM Corporation). Comparisons of the means used the least significant difference (LSD) at *P* ≤ 0.05.

3. Results

3.1 Effects on growth
From the data in Table 1, it can be seen that with the increase of Se concentration, the plant height, stem thickness, root length and branch number of *T. paniculatum* showed a trend of firstly increasing and then decreasing. The plant height and stem thickness of *T. paniculatum* increased when the Se concentration was 0~10 mg·kg⁻¹ and decreased when the Se concentration was 10~20 mg·kg⁻¹, and reached the maximum when the Se concentration was 10 mg·kg⁻¹. The root length of *T. paniculatum* is the longest when the Se concentration is 5 mg·kg⁻¹, and the rest of the treatments are less than the control. When the Se concentration is 5.0 mg·kg⁻¹, the branch number of *T. paniculatum* is significantly higher than that of the control and when the soil Se concentration is 20.0 mg·kg⁻¹, the branch number of *T. paniculatum* is significantly lower than that of the control. It can be seen that when the soil Se concentration is low, it has a positive effect on the branch development of *T. paniculatum*, but when the Se concentration increases, the branch development of *T. paniculatum* is
poor and is obviously inhibited.

Table 1. Effect of different Se on the growth of *T. paniculatum*

| Se concentration (mg·kg⁻¹) | Plant height/(cm) | Stem thick/(mm) | Root length/(cm) | Branch number |
|-----------------------------|------------------|-----------------|-----------------|--------------|
| CK                          | 30.308±1.329a    | 0.447±0.007b    | 12.808±0.780a   | 3.667±0.289b |
| 2.5                         | 30.483±0.898a    | 0.451±0.029b    | 12.775±0.425a   | 3.833±0.144b |
| 5                           | 30.508±1.013a    | 0.450±0.009b    | 12.913±0.763a   | 4.583±0.382a |
| 10                          | 30.650±1.505a    | 0.494±0.007a    | 10.583±0.551b   | 3.583±0.144b |
| 20                          | 27.027±0.691b    | 0.405±0.032c    | 8.408±0.063c    | 3.083±0.289c |

Note: Different lowercase letters indicate significant differences at the *P*<0.05 level. Same below.

3.2 Effects on biomass

From the data in Table 2, with the Se concentration increases, the ground dry weight gradually increases and reaches the highest at a concentration of 10.0 mg·kg⁻¹. Under 2.5, 5.0, 10.0 mg·kg⁻¹ Se treatment had no significant effect on the dry weight of *T. paniculatum*. When the Se concentration was 20.0 mg·kg⁻¹, the dry weight of *T. paniculatum* was significantly lower than the control. The root dry weight of *T. paniculatum* increased when the Se concentration was 0~5.0 mg·kg⁻¹, but there was no significant difference compared to control and then decreased at 5.0~20.0 mg·kg⁻¹ Se concentration which was significantly different to the control. When the Se concentration was 20.0 mg·kg⁻¹, the total dry weight of *T. paniculatum* was significantly lower than that of the control, which was 48.67% less than the control. Different Se treatments have different effects on the root-shoot ratio of *T. paniculatum*. When the Se concentration is 2.5 mg·kg⁻¹, the root-to-shoot ratio of *T. paniculatum* is significantly higher than that of the control, and it is increased by 15.89% compared to the control group; when the Se concentration is 10.0 mg·kg⁻¹, the root-to-shoot ratio is 21.93% lower than the control group; when the Se concentration was 20.0 mg·kg⁻¹, the root-shoot ratio decreased by 29.24% compared to the control group.

Table 2. Effect of different Se on the biomass of *T. paniculatum*

| Se concentration/ (mg·kg⁻¹) | Ground dry weight/ (g) | Root dry weight/ (g) | Total dry weight/ (g) | Root-shoot ratio |
|-----------------------------|------------------------|----------------------|----------------------|-----------------|
| CK                          | 0.926±0.058a           | 0.198±0.010a         | 1.124±0.068a         | 0.214±0.003b    |
| 2.5                         | 0.860±0.035a           | 0.213±0.013a         | 1.073±0.029a         | 0.248±0.023a    |
| 5                           | 0.920±0.044a           | 0.216±0.013a         | 1.136±0.057a         | 0.234±0.004ab   |
| 10                          | 0.922±0.020a           | 0.157±0.013b         | 1.079±0.020a         | 0.170±0.007c    |
| 20                          | 0.501±0.004b           | 0.075±0.007c         | 0.577±0.009b         | 0.151±0.013c    |

3.3 Effects on chlorophyll content

From the data in Table 3, the chlorophyll content of *T. paniculatum* increased with the increase of Se concentration in the soil. Under low Se concentration, the chlorophyll content does not have significant different compared to the control group. When the Se concentration ≥ 10.0 mg·kg⁻¹, the chlorophyll a, chlorophyll b, total chlorophyll content, and carotenoid content of *T. paniculatum* was significantly higher than the control. When the Se concentration was 20.0 mg·kg⁻¹, the total content of chlorophyll a, chlorophyll b, and chlorophyll were the highest, which increased by 55.00%, 45.28%, and 52.77% respectively compared to the control. When the Se concentration was 10.0 mg·kg⁻¹, the carotenoid content was the highest, which increased by 41.93% compared to the control.
Table 3. Effect of Different Se on the chlorophyll content in *T. paniculatum*

| Se concentration (mg · kg⁻¹) | Chlorophyll a content/(mg · g⁻¹) | Chlorophyll b content/(mg · g⁻¹) | Total chlorophyll content/(mg · g⁻¹) | Carotenoid content/(mg · g⁻¹) |
|-----------------------------|----------------------------------|----------------------------------|-------------------------------------|-------------------------------|
| CK                          | 0.709±0.041b                     | 0.212±0.013c                     | 0.921±0.054c                        | 0.155±0.007c                  |
| 2.5                         | 0.726±0.016b                     | 0.209±0.007c                     | 0.935±0.022c                        | 0.159±0.005c                  |
| 5                           | 0.798±0.058b                     | 0.229±0.018c                     | 1.027±0.076c                        | 0.175±0.007b                  |
| 10                          | 1.022±0.051a                     | 0.273±0.014b                     | 1.294±0.065b                        | 0.220±0.001a                  |
| 20                          | 1.099±0.064a                     | 0.308±0.012a                     | 1.407±0.077a                        | 0.214±0.010a                  |

3.4 Effects on physiological and biochemical index

From the data in Table 4, with the Se concentration in the soil increases, the soluble sugar content in *T. paniculatum* gradually decreases and the soluble sugar content of *T. paniculatum* is significantly lower than that of the control group. It can be seen that when the Se concentration increases, it is not conducive to the accumulation of soluble sugar content. When the soil Se concentration was 20.0 mg·kg⁻¹, the soluble sugar content of *T. paniculatum* was the lowest, which was 44.6% less than the control. When the Se concentration in the soil was 0~10.0 mg·kg⁻¹, the soluble protein content of *T. paniculatum* increases, and it is significantly different from the control. It can be seen that under low Se concentration in the soil had a positive effect on the soluble protein accumulation of *T. paniculatum*. The soluble protein content in *T. paniculatum* was the highest under 5.0 mg·kg⁻¹ Se concentration in the soil, which increased by 9.8% compared to the control group.

Table 4. Effect of different Se on the quality of *T. paniculatum*

| Se concentration/(mg · kg⁻¹) | Soluble sugar(%) | Soluble protein/(mg/g) |
|-----------------------------|------------------|------------------------|
| CK                          | 0.132±0.004a     | 34.462±1.009c          |
| 2.5                         | 0.121±0.002b     | 37.350±0.456ab         |
| 5                           | 0.101±0.003c     | 37.847±1.140a          |
| 10                          | 0.102±0.008e     | 37.556±0.074ab         |
| 20                          | 0.073±0.005d     | 35.840±1.288bc         |

3.5 Effects on Se content

From the data in table 5, it can be seen that the Se content of *T. paniculatum* has obvious regularity with the change of the Se concentration in the soil. For different parts of the *T. paniculatum*, the Se content rule was root>leaf>stem. It can be seen from data that the Se content of *T. paniculatum* increased with the increase of Se concentration in soil, but no Se content was detected in the control group, the Se concentration at 20.0 mg·kg⁻¹ was significantly higher than the three groups. With lower Se concentration, the Se content of the root rose more rapidly with the increase of the Se concentration, and the Se content of the stem rose slowly when the Se concentration was low, when the Se concentration reached 10.0 mg·kg⁻¹, the Se content of the *T. paniculatum* stem and leaves increased significantly.

Table 5. Different concentration of Se on the Se content of *T. paniculatum*

| Se concentration/(mg · kg⁻¹) | Root/(mg · kg⁻¹) | Stem/(mg · kg⁻¹) | Leaf/(mg · kg⁻¹) |
|-----------------------------|------------------|------------------|------------------|
| 0                           | 0.000d           | 0.000d           | 0.000d           |
| 2.5                         | 0.220±0.014cd    | 0.068±0.012c     | 0.081±0.008cd    |
| 5                           | 0.412±0.034c     | 0.095±0.010c     | 0.126±0.011c     |
| 10                          | 1.226±0.108b     | 0.386±0.026b     | 0.477±0.126b     |
| 20                          | 2.449±0.508a     | 0.714±0.029a     | 0.749±0.026a     |
4. Conclusions
In this experiment, the Se-enriched T. paniculatum cultivation was explored through different concentrations of Se-containing soil. The final experimental results showed that different Se concentrations had obvious differences in the growth and development of T. paniculatum. Low Se concentration has a certain promoting effect on the growth of T. paniculatum. When the Se concentration rises to a certain level, it obviously inhibits the growth of T. paniculatum. Among them, when the Se concentration is 5.0 mg·kg⁻¹, the comprehensive growth data of T. paniculatum was the highest, and the effect on the growth of T. paniculatum is the best. Se can increase the chlorophyll content of T. paniculatum, which is beneficial to the photosynthesis of T. paniculatum. Under 5.0 mg·kg⁻¹ Se condition, the soluble substance content of T. paniculatum is relatively highest, which has the best effect on the quality of T. paniculatum. Based on various indicators, the optimal concentration of Se-containing soil for T. paniculatum cultivation is about 5.0~10.0 mg·kg⁻¹.

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