Study on selenium accumulation characteristics of different ploidies *Solanum nigrum*

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Abstract. The selenium accumulation characteristics of *Solanum nigrum* with different ploidy were studied by the pot experiment, and the biomass, selenium content and selenium accumulation of diploid (*Solanum photeinocarpum*), tetraploid (*Solanum photeinocarpum*) and hexaploid (*Solanum nigrum*) plants were determined, the results showed that there was a difference between the biomass and selenium content of three kinds of ploidy plants of *S. nigrum*. The biomass of various organs and shoots of hexaploid *S. nigrum* plants was significantly higher than that of tetraploid and diploid plants. In terms of selenium content and selenium accumulation, the hexaploid plants had the highest selenium content and selenium accumulation in stems, leaves and shoots. After comprehensive comparison, the hexaploid *S. nigrum* has large biomass and strong selenium-enriching ability, so it can be used as an excellent plant material for soil selenium absorption and transformation.

1 Introduction

Selenium (Se) is an essential trace element in human body, and its physiological functions mainly include antioxidant, cardiovascular protection, resistance to toxic substances and inhibition of cancer cells [1], low levels of selenium in the body may be one of the causes of some major diseases in human beings [2]. Selenium cannot be synthesized by human body itself, but it can be absorbed through food [3], in order to meet the demand of human body for selenium element, selenium application in soil or spraying selenium on leaves are often used to convert inorganic selenium into organic selenium by plants which have become the main source of selenium supplementation through diet such as crops or vegetables [4-5].

As a unique plants in China, *Solanum nigrum* is distributed all over the country and is mostly wild in field houses and roadside areas [6], studies in recent years have found that it has important medicinal and edible value [7-8], in addition, some studies have shown that under the condition of suitable soil selenium content, *S. nigrum* can grow normally and has high selenium enrichment capacity [9]. Polyploidization is a major evolutionary factor and an important mechanism of genetic variation affecting genome size and number of gene copies, and plays an important role in eukaryotic evolution [10], there are two species and one variety of *S. nigrum* in China [11]: diploid (*Solanum photeinocarpum*), tetraploid (*Solanum photeinocarpum*) and hexaploid (*Solanum nigrum*), polyploid formation of *S. nigrum* may be a natural doubling under geographical and natural conditions [6]. Studies have shown that there are significant differences between polyploid plants and

diploid plants in external morphology, physiology, biochemistry and heredity [12-13], the purpose of this paper is to study the selenium enrichment characteristics of different ploidy *S. nigrum*, so as to provide theoretical basis for the effective utilization of selenium in it.

2 Materials and methods

2.1 Materials.

Seeds of *S. nigrum* with different ploidy were collected from *S. photeinocarpum* (diploid), *S. photeinocarpum* (tetraploid) and *S. nigrum* (hexaploid) respectively in the farm near the Chengdu Campus of Sichuan Agricultural University (30°42'N, 103°50'E), the soil for the experiment was collected from the same place.

2.2 Experimental design.

In August 2018, after air-drying, pulverizing and passed through a 5-mm sieve, 3.0 kg of soil was weighed and put into a plastic pot (20 cm high, 21 cm in diameter), analytical pure Na₂SeO₃ solution was added to make the soil selenium concentration 5 mg/kg. Keep the soil field water capacity at about 80% and leave it naturally to balance for 4 weeks, turn over and stir it irregularly to make it fully mixed. In September 2018, the seeds of three *S. nigrum* with different ploidy were sown and placed in a climate box for breeding, in October 2018, when the seedlings expanded 5-6 true leaves, the strong and consistent plants of three *S. nigrum* with different ploidy were transplanted into the prepared selenium-containing soil separately.

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There were three treatments in the experiment: diploid, tetraploid and hexaploid. There were 4 *S. nigrum* plants per pot of single species, and each treatment was repeated 3 times. The distance between the pots was 15 cm and was completely random. According to the water shortage in the basin, watering occasionally to meet the plants growth needs, during the whole growth process, the position between the pots was exchanged irregularly to weaken the influence of the marginal effect, and the weeds were removed in time to prevent pests and diseases.

After 60 days, the whole plants of *S. nigrum* with different ploidy were harvested respectively and washed with water and then rinsed with distilled water for 3 times. After that, the material was divided into roots, stems and leaves, which were dried in the oven until constant weight, then the biomass was measured. The selenium content of *S. nigrum* was determined and the selenium accumulation in various organs, translocation factor, translocation accumulation factor were calculated [14]: selenium accumulation = selenium content $\times$ biomass, translocation factor = shoots selenium content/roots selenium content, translocation accumulation factor = (shoots selenium content $\times$ shoots biomass)/(roots selenium content $\times$ roots biomass).

2.3 Statistical analyses

Statistical analyses were carried out by SPSS 17.0 statistical software. Data were analyzed by one-way analysis of variance with least significant difference (LSD) at 5% confidence level.

Table 1. Biomass of *S. nigrum* with different ploidy.

Treatment	Roots (g plant ⁻¹)	Stems (g plant ⁻¹)	Leaves (g plant ⁻¹)	Shoots (g plant ⁻¹)	Root-shoot ratio
Diploid	0.157 $\pm$ 0.004c	0.311 $\pm$ 0.011c	1.175 $\pm$ 0.003c	1.485 $\pm$ 0.008c	0.106 $\pm$ 0.003b
Tetraploid	0.207 $\pm$ 0.003b	0.351 $\pm$ 0.007b	1.283 $\pm$ 0.043b	1.634 $\pm$ 0.050b	0.127 $\pm$ 0.002a
Hexaploid	0.269 $\pm$ 0.011a	0.457 $\pm$ 0.013a	1.523 $\pm$ 0.024a	1.980 $\pm$ 0.011a	0.136 $\pm$ 0.005a

Means with the same letter within each column are not insignificantly different at 0.05 levels.

Table 2. Selenium content of *S. nigrum* with different ploidy.

Treatment	Roots (mg kg ⁻¹)	Stems (mg kg ⁻¹)	Leaves (mg kg ⁻¹)	Shoots (mg kg ⁻¹)	Translocation factor
Diploid	6.558 $\pm$ 0.162a	1.139 $\pm$ 0.017c	1.935 $\pm$ 0.022a	1.769 $\pm$ 0.019b	0.270 $\pm$ 0.009c
Tetraploid	6.217 $\pm$ 0.266a	1.550 $\pm$ 0.070b	2.017 $\pm$ 0.014a	1.916 $\pm$ 0.025a	0.309 $\pm$ 0.017b
Hexaploid	4.213 $\pm$ 0.167b	1.899 $\pm$ 0.080a	2.039 $\pm$ 0.068a	2.006 $\pm$ 0.072a	0.476 $\pm$ 0.002a

Means with the same letter within each column are not insignificantly different at 0.05 levels.

3.3 Selenium accumulation of *S. nigrum* with different ploidy.

The selenium accumulation in roots of three kinds of ploidy plants ranked as tetraploid > hexaploid > diploid (Table 3), while the selenium accumulation in stems,

3 Results and discussion

3.1 Biomass of *S. nigrum* with different ploidy.

The biomass of roots, stems, leaves and shoots of hexaploid *S. nigrum* was the largest (Table 1), followed by tetraploid and diploid, moreover, the biomass of each organ of the three ploidy plants was significantly different. In terms of roots-shoots ratio, the hexaploid plant was the largest and had no significant difference with tetraploid, but the root-shoot ratio of diploid was significantly lower than that of hexaploid and tetraploid.

3.2 Selenium content of *S. nigrum* with different ploidy.

Under the condition of soil containing selenium, the selenium content in roots of diploid and tetraploid was significantly higher than that of hexaploid, but the difference between the two was not significant (Table 2). The selenium content in stems of three kinds of ploidy plants ranked as hexaploid > tetraploid > diploid. In terms of selenium content in leaves, hexaploid plants was the highest but had no significant difference with tetraploid and diploid plants. The shoots of hexaploid and tetraploid plants contain significantly higher selenium content than those of diploid plants. From the perspective of transport factor, the hexaploid has the highest transport coefficient, followed by tetraploid and diploid.

leaves and shoots of hexaploid was significantly higher than that of the other two ploidy plants, and except for in roots, the selenium content in all organs of diploid plants was the lowest. The translocation accumulation factor of hexaploid was the highest, followed by diploid and tetraploid, respectively.

Table 3. Selenium accumulation of *S. nigrum* with different ploidy.

Treatment	Roots ($\mu\text{g plant}^{-1}$)	Stems ($\mu\text{g plant}^{-1}$)	Leaves ($\mu\text{g plant}^{-1}$)	Shoots ($\mu\text{g plant}^{-1}$)	Translocation accumulation factor
Diploid	1.029 $\pm$ 0.002b	0.354 $\pm$ 0.018c	2.273 $\pm$ 0.031b	2.627 $\pm$ 0.013c	2.553 $\pm$ 0.018b
Tetraploid	1.290 $\pm$ 0.076a	0.544 $\pm$ 0.014b	2.587 $\pm$ 0.068b	3.131 $\pm$ 0.055b	2.430 $\pm$ 0.101b
Hexaploid	1.135 $\pm$ 0.092ab	0.868 $\pm$ 0.012a	3.105 $\pm$ 0.154a	3.973 $\pm$ 0.165a	3.507 $\pm$ 0.140a

Means with the same letter within each column are not insignificantly different at 0.05 levels.

4 Conclusions

This study showed that there is a difference between the biomass and selenium content of three kinds of ploidy plants of *S. nigrum*. The biomass of various organs and shoots of hexaploid *S. nigrum* plants was significantly higher than that of tetraploid and diploid plants. In terms of selenium content and selenium accumulation, the hexaploid plants had the highest selenium content and selenium accumulation in stems, leaves and shoots which are the most important and direct edible part of vegetables. After comprehensive comparison, the hexaploid *S. nigrum* has large biomass and strong selenium-enriching ability, so it can be used as an excellent plant material for soil selenium absorption and transformation.

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