Study on selenium accumulation characteristics of Lycopersicon esculentum, Solanum melongena and Solanum nigrum

Xun Wang¹, Zhi Huang², Lijin Lin¹ and Ming'an Liao*¹

¹Institute of Pomology and Olericulture, Sichuan Agricultural University, Chengdu, Sichuan, 611130, China
²College of Horticulture, Sichuan Agricultural University, Chengdu, Sichuan, 611130, China
*Corresponding author’s e-mail: lman@sicau.edu.cn

Abstract. The difference of three plants Lycopersicon esculentum, Solanum melongena and Solanum nigrum on the selenium accumulation were studied by a pot experiment. The results showed that selenium accumulation S. nigrum was the highest, L. esculentum was the second, S. melongena was the lowest. The root biomass of S. nigrum was 36.79% and 81.35% respectively, higher than L. esculentum and S. melongena. The selenium content in the root and the shoot of S. nigrum were higher than L. esculentum and S. melongena by 16.50% and 13.35% and 35.76% and 35.76% respectively. In conclusion, the selenium accumulation of treatment S. nigrum is the best, L. esculentum followed it.

1. Introduction
Selenium is an essential trace element in the human body, which can fight against cancer, resist various diseases (such as cardiovascular and cerebrovascular diseases, keshan disease, etc.), and delay aging, etc. The human body can enhance immunity by supplementing appropriate amount of selenium [1-2]. The content of selenium in human body depends on the content of selenium in food, and the content of selenium in food mainly depends on the content of selenium in soil and the ability of crops to accumulate selenium [3]. In order to meet the demand of human body for selenium element, at present, the method of selenium application in soil or selenium spraying in leaf surface is most widely used, and inorganic selenium is transformed into organic selenium by plants for human body to use [4-5]. Vegetables play an important role in the daily life of urban and rural residents. Selenium-accumulation vegetables have nutritional and health functions. Edible vegetables are an important way for human body to supplement selenium. Studies on selenium uptake and enrichment in vegetables have been reported [6-7]. Southeast Asia is the largest area of Solanum melongena cultivation in the world, and China is the largest S. melongena producer in the world. S. melongena cultivation in China has a long history, and there are many types of cultivation. It is generally believed that China is the second origin of S. melongena. S. melongena is one of the widely cultivated fruit vegetables in China. It is a widely distributed, annual supply and economical bulk vegetable. It is welcomed by the vast number of producers and consumers [8]. Solanum lycopersicum has wide adaptability, high yield, rich nutrition, unique flavor and diverse cultivation methods. It is the first vegetable crop widely planted in the world [9]. Study has shown that selenium can be quickly absorbed by S. lycopersicum roots and transported to other organs of plants. The total amount of selenium uptake and translocation increases with the
extension of absorption time [10]. Solanum nigrum is an annual upright branched herbal leafy vegetable of solanaceae. It grows mostly in orchards, fields, villages and roadsides, and is one of the common wild vegetables. In recent years, people are interested in the wild, coarse and non-spraying characteristics of S. nigrum. It has been widely ingested and cultivated [11]. This experiment used the three popular vegetables (S. melongena, S. lycopersicum and S. nigrum) as materials. The aim of this research was to study the absorption, accumulation ability and characteristics of selenium in soil of three Solanaceous vegetables, and to compare the differences of selenium accumulation. It was expected to provide a basis for evaluating the quality of vegetables and for people to choose vegetables to regulate the intake of selenium.

2. Materials and Methods

2.1. Materials

In September 2018, L. esculentum, S. melongena and S. nigrum seeds were placed in an artificial climate chamber for seedling. On October 16, 2018, the soil was air-dried, crushed, and sieved through 5 mm. The analytical pure Na₂SeO₃ solution was added to the soil, and the soil was dumped and mixed periodically to make it fully mixed. Finally, the concentration of selenium in the soil reached 10 mg/kg. The soil 3.0 kg was put into a plastic pot of 18 cm × 15 cm (diameter × height).

2.2. Experimental design

On November 15, 2018, when the seedlings grew 3-5 true leaves, the robust and identical seedlings of L. esculentum, S. melongena and S. nigrum were transplanted into plastic pots with selenium-containing soil. There were three treatments in the experiment: the monoculture of L. esculentum, the monoculture of S. melongena, and the monoculture of S. nigrum. Three plants were planted in each pot, and each treatment was repeated three times. The plastic pot was placed in the climate culture room for culture, with the relative humidity of 75%, the air temperature of 28°C, and the light intensity of 20000 Lux at 14 h day time; the relative humidity of 90%, the air temperature of 22°C, and the light intensity of 0 Lux at 10 h night time. The distance between the basins was 15 cm, completely randomly placed. During the management period, according to the situation of soil water shortage in the basin, irrigated irregularly to meet the needs of plant growth. During the whole growth process, the positions of pots and pots were exchanged periodically to weaken the influence of marginal effect, and weeds were removed in time to control pests and diseases. Finally, the whole plant was harvested. The plant was divided into three parts according to roots, stems, and leaves. The plant was washed with tap water, then rinsed with deionized water three times. The green was killed at 110°C for 15 minutes, and dried at 80°C to weigh. Then it was crushed and stored separately after 100 mesh sieving to determine the biomass and selenium content of each part of the grafted seedlings [12].

2.3. Statistical analyses

Statistical analyses were performed using SPSS 20.0 statistical software. Data were analyzed with one-way analysis of variance with least significant difference at the 5% significance level.

3. Results and Discussion

3.1. The biomass of L. esculentum, S. melongena and S. nigrum

Among the three treatments, the root biomass under treatment S. nigrum reached the maximum, but the stems, leaves and shoots were the highest under the treatment L. esculentum (Table 1). The stems, leaves and shoots biomasses of the treatment L. esculentum were 87.71% (P < 0.05), 67.76% (P < 0.05) and 76.47% (P < 0.05), respectively, higher than the treatment S. melongena, and were 70.73% (P < 0.05), 5.00% (P > 0.05) and 33.70% (P < 0.05), respectively, higher than the treatment S. nigrum. The roots biomasses of the treatment S. nigrum were 36.79% (P < 0.05) and 81.35% (P < 0.05), respectively, higher than the treatment L. esculentum and S. melongena.
3.2. The selenium content of *L. esculentum*, *S. melongena* and *S. nigrum*

Among the three treatments, the roots, stems, leaves and shoots selenium content of the treatment *S. nigrum* reached the maximum, the treatment *S. melongena* followed it (Table 2). The selenium content of the roots and shoots of *S. nigrum* is higher than *L. esculentum* and *S. melongena* by 16.50% (*P* < 0.05) and 13.35% (*P* < 0.05) and 35.76% (*P* < 0.05) and 35.76% (*P* < 0.05) respectively.

| Treatments   | Roots (g/plant) | Stems (g/plant) | Leaves (g/plant) | Shoots (g/plant) |
|--------------|-----------------|-----------------|------------------|------------------|
| *L. esculentum* | 0.244±0.005b    | 1.001±0.009a    | 1.281±0.064a     | 2.282±0.072a     |
| *S. melongena* | 0.072±0.001c    | 0.123±0.005c    | 0.413±0.005b     | 0.537±0.010c     |
| *S. nigrum*   | 0.386±0.015a    | 0.293±0.015b    | 1.220±0.035a     | 1.513±0.020b     |

Table 1. Biomass of *L. esculentum*, *S. melongena* and *S. nigrum*.

Different lowercase letters indicate significant differences based on one-way analysis of variance in SPSS 20.0 followed by the least significant difference test (*P* < 0.05).

3.3. The selenium accumulation of *L. esculentum*, *S. melongena* and *S. nigrum*

The selenium accumulations in roots, leaves and shoots were the treatment *S. nigrum* reached the maximum (Table 3). The selenium accumulation in roots, stems, leaves and shoots of *S. nigrum* were 9.294, 2.382, 8.395 and 10.777 μg/plant, respectively. The selenium accumulation in the roots and shoots of *S. nigrum* is 0.98 and 0.03 times as many as *L. esculentum* and 5.21 and 3.29 times as many as *S. melongena* respectively.

| Treatments   | Roots (mg/kg) | Stems (mg/kg) | Leaves (mg/kg) | Shoots (mg/kg) |
|--------------|---------------|---------------|----------------|----------------|
| *L. esculentum* | 20.983±1.035b | 5.921±0.085c  | 3.525±0.101c   | 4.575±0.044b   |
| *S. melongena* | 21.776±0.274b | 6.519±0.128b  | 4.136±0.030b   | 4.684±0.018b   |
| *S. nigrum*   | 25.130±0.506a | 8.121±0.107a  | 6.882±0.048a   | 7.122±0.044a   |

Table 2. Selenium content of *L. esculentum*, *S. melongena* and *S. nigrum*.

Different lowercase letters indicate significant differences based on one-way analysis of variance in SPSS 20.0 followed by the least significant difference test (*P* < 0.05).

4. Conclusions

The experiment showed that different types of plants (*L. esculentum*, *S. melongena* and *S. nigrum*) had different effects on biomass, selenium content and selenium accumulation under the soil accumulating in selenium. Comparing the three treatments, the biomass of roots, selenium content and selenium accumulation except for stems of *S. nigrum* showed the same trend, and it showed that it was the largest of the three treatments. Selenium accumulation in three treatments except stems ranked in the following order: *S. nigrum > L. esculentum > S. melongena*. In conclusion, the accumulation ability of selenium in soil of different vegetables was different. In this experiment, *S. nigrum* was the best, *L. esculentum* was the second, and *S. melongena* was the worst.
Acknowledgments
This work was financially supported by the Project of Education Department of Sichuan Province (17ZB0342).

References
[1] Qu, L.Z., Yang, S.J., Zhuo, S. (2010) Role of trace essential element selenium. Chin. Agric. Sci. Bull., 26: 94-97.
[2] Zhao, H.J., Liu, P.H., Sun, Q.Y. (2007) Progress in the role of selenium in cancer prevention and treatment. Prog. in Veter. Medic., 28: 96-99.
[3] Wu, D., Fang, K.M., Shen, H.F. (2012) Comparative study on selenium enrichment ability of different vegetables in Leping, Jiangxi Province. Jiangxi J. of Agric. 24: 23-24.
[4] Wang, D.H., Zhou, H.Z. (2013) Organic selenium products in urgent need of development and utilization. Light Indus. Sci. and Tech., 1: 6-7.
[5] Luo, S.W., Zhang, M.Q., Wu, Y.Y. (2007) Research and utilization of plant selenium. Anhui Agric. Sci., 35: 4087-4088.
[6] Huang, K.F., Shi, Z., Feng, J.Y. (2011) Research status of selenium-rich vegetables. Yangtze River Veget., 10: 14-17.
[7] Du, Z.Y., Shi, Y.X., Wang, Q.H. (2004) Absorption of selenium by vegetables and suitable amount of selenium supplementation. J. of Ecol. Environ., 13: 230-231.
[8] Li, Z.L., Li, Z.X., Huang, Z.W. (2006) Current situation of eggplant production and breeding in China and future research strategies. Guangdong Agric. Sci., 1: 24-26.
[9] Lin, T., Zhu, G.T., Zhang, J.H. (2014) Genome analysis revealed the history of Lycopersicum esculentum breeding. Heredity, 36: 1275-1276.
[10] Shi, H.P., Zhang, Y.J., Liu, Z.S. Absorption, distribution and transformation of selenium in Lycopersicum esculentum. J. of Integr. Plant Biol., 7: 541-546.
[11] Long, X. Artificial cultivation of wild vegetable and Solanum nigrum. Tech. and market, 3: 29-29.
[12] State Health and Family Planning Commission of the People's Republic of China, State Food and Drug Administration. (2017) Determination of Selenium in Food Safety National Standards GB5009.93-2017. SC Publishing, Beijing, China.