https://doi.org/10.17221/348/2024-PSE

The impact of organic selenium on the growth and physiological traits of *Salvia miltiorrhiza* Bunge. seedlings

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Citation: Luo Y., Zhang X.Q., Zhang Y.B., Shan C.J. (2025): The impact of organic selenium on the growth and physiological traits of *Salvia miltiorrhiza* Bunge. seedlings. Plant Soil Environ., 71: 269–277.

Abstract: This study examined the impact of selenomethionine (SeMet) on the growth and physiological traits of *Salvia miltiorrhiza* seedlings. Application of SeMet significantly improved the photosynthetic performance by reducing stomatal limitation value (Ls) and increasing soil and plant analyser development (SPAD) value, net photosynthetic rate (P_n), transpiration rate (T_r), stomatal conductance (g_s) and water use efficiency (WUE), compared to the control. Furthermore, SeMet also improved the photosynthetic performance by reducing non-photochemical quenching (NPQ) and increasing the actual photochemical efficiency of photosystem II (Y(II)), photochemical quenching (qP), maximum photochemical efficiency of PSII (F_v/F_m) and apparent electron transport rate (ETR). Meanwhile, the findings indicated that SeMet was able to enhance the antioxidant capacity of *S. miltiorrhiza* seedlings by increasing the activities of antioxidant enzymes ascorbate peroxidase (APX), glutathione reductase (GR), peroxidase (POD), catalase (CAT) and superoxide dismutase (SOD), thereby reducing the contents of malondialdehyde (MDA) and hydrogen peroxide (H_2O_2). Besides, SeMet notably impacted plant growth by promoting plant height, basal diameter and biomass. Among different concentrations, 60 mg/L exhibited the most favourable impact on photosynthetic performance, antioxidant capacity and the growth of *S. miltiorrhiza* seedlings. In summary, the appropriate dosage of SeMet can stimulate the growth of *S. miltiorrhiza* by enhancing photosynthetic and antioxidant capacities. These findings can serve as a solid theoretical foundation for the application of SeMet in the cultivation and production of *S. miltiorrhiza*.

Keywords: Chinese red sage; medicinal herb; chlorophyll fluorescence properties; antioxidant activity

Salvia miltiorrhiza Bunge. is a traditional Chinese medicinal herb. The desiccated roots are utilised for medicinal purposes. The medicinal ingredients in the root of *S. miltiorrhiza* include lipid-soluble and water-soluble ingredients, which have a long history of applications in the prevention and treatment of cardiovascular diseases (Meim et al. 2019, Dong et al. 2023). The water-soluble ingredients of *S. miltiorrhiza* mainly include salvianolic acid A, salvianolic acid B and rosmarinic acid (Lam et al. 2006). The lipid-soluble ingredients mainly include tanshinone I, tanshinone IIA, dihydrotanshinone and cryptotanshinone (Huang et al. 2022). Among the above medicinal ingredients, tanshinone I am the

Supported by the Key Scientific and Technological Research Projects in Henan Province, Project No. 242102111110.

https://doi.org/10.17221/348/2024-PSE

principal component of tanshinones and possesses a wide range of functions, including anti-inflammatory, antibacterial, antioxidant, anti-tumour, neuroprotective, cardioprotective and others (Qiu et al. 2024). Selenium (Se) has been reported to have similar physiological functions as the medicinal ingredients of *S. miltiorrhiza* (Zhang et al. 2023). Therefore, it has become a trend to study the application of Se in cultivation in order to increase the medicinal value of *S. miltiorrhiza*.

As an essential non-metallic trace element, Se is crucial for human health, and different degrees of Se deficiency negatively impact human health (Tao et al. 2023). Se-rich cultivation can effectively increase the content of Se in plants. It has been reported that Se-rich cultivation can be achieved by soil supplements and foliar spraying (Su et al. 2017). As Se-rich soil is very limited, foliar spraying is the main form of Se application in cultivation. Meanwhile, the foliar application of organic Se has a higher Se absorption and utilisation efficiency in plants than inorganic Se. Therefore, foliar spraying of organic Se is the main choice for Se-rich cultivation. As reported, selenomethionine (SeMet) had a substantial influence on the photosynthetic process of strawberries by impacting photosynthetic indicators and chlorophyll fluorescence parameters, such as net photosynthetic rate (P_n), water use efficiency (WUE), transpiration rate (T_r), F_v/F_m, qP, ETR, Y(II), and others (Gao et al. 2020). An appropriate dosage of Se fertiliser has been proven to boost the antioxidant capacity of peanut seedlings by increasing superoxide dismutase (SOD) and peroxidase (POD) activities and decreasing malondialdehyde (MDA) content (Shi et al. 2022). Adequate levels of sodium selenite have been found to increase chlorophyll content and promote root length, root volume and stem diameter of *Luffa aegyptiaca* Mill., thereby improving the photosynthetic performance and growth of *L. aegyptiaca* (Li et al. 2022).

In areas of Se-rich soils, the cultivation of Se-rich *S. miltiorrhiza* is mainly achieved through soil supplements. However, the soil is deficient in Se in most areas where *S. miltiorrhiza* is cultivated, which induces a low content of Se in *S. miltiorrhiza* (Su 2017). Fortunately, a previous study showed that the content of Se in *S. miltiorrhiza* can be effectively increased by foliar spraying of inorganic Se (Su et al. 2017). As we all know, there are two types of Se fertilisers, namely inorganic and organic Se fertilisers, and organic Se fertiliser demonstrates superior safety and efficacy than inorganic Se. Meanwhile, organic Se is assimilated into the soil and then transformed into bioavailable Se. This process not only supplies essential Se for plant growth but also enhances the overall quality of the soil (Ma et al. 2024). However, inorganic Se readily forms insoluble complexes with oxides in acidic soils, impeding Se absorption by plants. Furthermore, excessive application of inorganic Se may lead to phytotoxicity (Wang et al. 2017). Currently, organic Se has been adopted in the cultivation of *Fragaria × ananassa* Duch., *Arachis hypogaea* L. and *L. aegyptiaca* (Gao et al. 2022, Li et al. 2022, Shi et al. 2022). Nonetheless, the impact of organic Se on the growth of *S. miltiorrhiza* remains unexplored. Thus, it is important to investigate the influence of SeMet on the growth of *S. miltiorrhiza*, which can offer insights into the application of SeMet in cultivation.

In general, the impact of SeMet on the growth and physiological traits of various crops indicated that SeMet had potential application value in crop cultivation. This research posited that the application of SeMet to the leaves of *S. miltiorrhiza* seedlings could regulate photosynthetic and antioxidant capacities, thereby promoting growth. To verify this hypothesis, we measured indicators related to the photosynthetic performance, antioxidant capacity and growth of *S. miltiorrhiza* seedlings before and after SeMet treatment in June. Through this research, we aimed to elucidate the regulatory mechanism of SeMet in promoting the growth of *S. miltiorrhiza*, which can establish a theoretical foundation for the application of SeMet in the cultivation of *S. miltiorrhiza*.

MATERIAL AND METHODS

Plant material and treatments. *S. miltiorrhiza* seedlings were provided by Henan Modern Agricultural Research and Development Base in Xinxiang City, Henan Province, China. In March, healthy seedlings with similar height were selected and planted in pots with two seedlings per pot. The size of the pot was 26.8 cm × 22.0 cm × 28.9 cm (upper diameter × lower diameter × height). Each pot contained 15 kg of Alisols, which were defined as eutric cambisols according to the World Reference Base for Soil Resources (WRB). The basic properties of the Alisols were as follows: the cation exchange capacity (CEC) of 23 $mmol_+$/100 g, the soil pH of 6.34, the soil organic carbon (SOC) of 9.77 g/kg, the electrical conductivity (EC) of 0.36 mS/cm,

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the available nitrogen of 18.0 mg/kg, the available potassium of 60.0 mg/kg and the available phosphorus of 24.0 mg/kg. The SOC was determined using the potassium dichromate oxidation-spectrophotometry method (Tian et al. 2020), while other soil nutrient indicators were measured using the soil tester from pronamic research solutions (PRS). Soil moisture was monitored and maintained at 60% of field capacity using the weighing method. To study the effects of SeMet on the growth and physiological traits of *S. miltiorrhiza*, different concentrations of SeMet solution (10, 30, 60 and 120 mg/L) were respectively applied to plants by foliar spray in May and marked as T1, T2, T3 and T4. Foliar sprays of different SeMet concentrations were all applied in a volume of 100 mL. The control seedlings were treated with equal distilled water and marked as control. Five replicates were set for each treatment, namely 5 pots per treatment. In June, the indicators related to the photosynthetic performance, antioxidant capacity, growth and Se concentration of *S. miltiorrhiza* were determined to elucidate the impact of foliar application of organic Se on the growth and physiological traits of *S. miltiorrhiza*.

Assays of SPAD and gas exchange parameters. The soil and plant analyser development (SPAD) value was determined through the SPAD-502 Plus chlorophyll meter (Tokyo, Japan). Gas exchange parameters net photosynthetic rate (P_n), water use efficiency (WUE), transpiration rate (T_r), stomatal limitation (Ls) and stomatal conductance (g_s) were determined through Li-cor6400 photosynthetic meter (Lincoln, USA) from 10:00–11:00. There was no unit for SPAD value and Ls. Units of P_n, T_r, g_s and WUE were respectively expressed as μmol/m^2/s, mmol/m^2/s, mmol/m^2/s and μmol/mmol, respectively.

Assays of chlorophyll fluorescence parameters. Before assessing chlorophyll fluorescence parameters, *S. miltiorrhiza* leaves underwent dark adaptation for 20 min. Chlorophyll fluorescence parameters maximum photochemical efficiency of PSII (F_v/F_m), non-photochemical quenching (NPQ), photochemical quenching (qP), actual photochemical efficiency of photosystem II (Y(II)) and electron transport rate (ETR) were evaluated with PAM-2500 portable modulated chlorophyll fluorometer from 8:00–11:00. There was no unit for above chlorophyll fluorescence parameters.

Assays of antioxidant indicators. The activities of ascorbate peroxidase (APX, EC 1.11.1.11) and glutathione reductase (GR, EC 1.6.4.2) were assessed following the method of Shan and Liang (2010). The activities of superoxide dismutase (SOD, EC 1.15.1.1), peroxidase (POD, EC 1.11.1.7) and catalase (CAT, EC 1.11.1.6) were respectively determined according to Masayasu and Hiroshi (1979), Doerge et al. (1997) and Johansson et al. (1988). The activities of these antioxidant enzymes were expressed as units per gram of fresh weight (U/g FW). Malondialdehyde (MDA) content was quantified by the method of Lian et al. (2023). The content of hydrogen peroxide (H_2O_2) was measured according to Amin and Olson (1967) and calculated based on the H_2O_2 standard curve. Units of MDA content and H_2O_2 content were expressed as nmol per gram of fresh weight (nmol/g FW) and μmol per gram of fresh weight (μmol/g FW).

Assessment of the growth indicators and selenium concentration in *S. miltiorrhiza*. The growth indicators of *S. miltiorrhiza* included plant height and basal diameter. Plant height was assessed using the meter ruler, and basal diameter was assessed using vernier callipers. Plant height and basal diameter units were expressed as cm and mm, respectively. After washing with distilled water, each *S. miltiorrhiza* plant was divided into shoot and root. Then, the shoot and root were encapsulated in envelopes and dried in an oven at a temperature of 65 °C for 3 days. The shoot and root's dry weight was weighed and recorded using an electronic balance. The root/shoot ratio was expressed as the ratio of root dry weight to shoot dry weight. Units of shoot dry weight per plant and root dry weight per plant were all expressed as g. There was no unit for root/shoot ratio. The contents of Se in shoots and roots were quantified by using the hydride generation-atomic fluorescence spectrometry method (Su 2017). The unit of Se content was expressed as μg per g of dry weight (μg/g DW).

Data analysis. The data was analysed through SAS 8.2 (Statistical Analysis System, Cary, USA), and the variation was examined through one-way analysis of variance (ANOVA) and Fisher's least significant difference (*LSD*) test. The significant difference was examined at $P < 0.05$. The graphical representation was also generated through Origin 2017 (Northampton, USA).

RESULTS

Impact of selenomethionine on photosynthetic performance of *S. miltiorrhiza*. In contrast with the control group, the application of different concentra-

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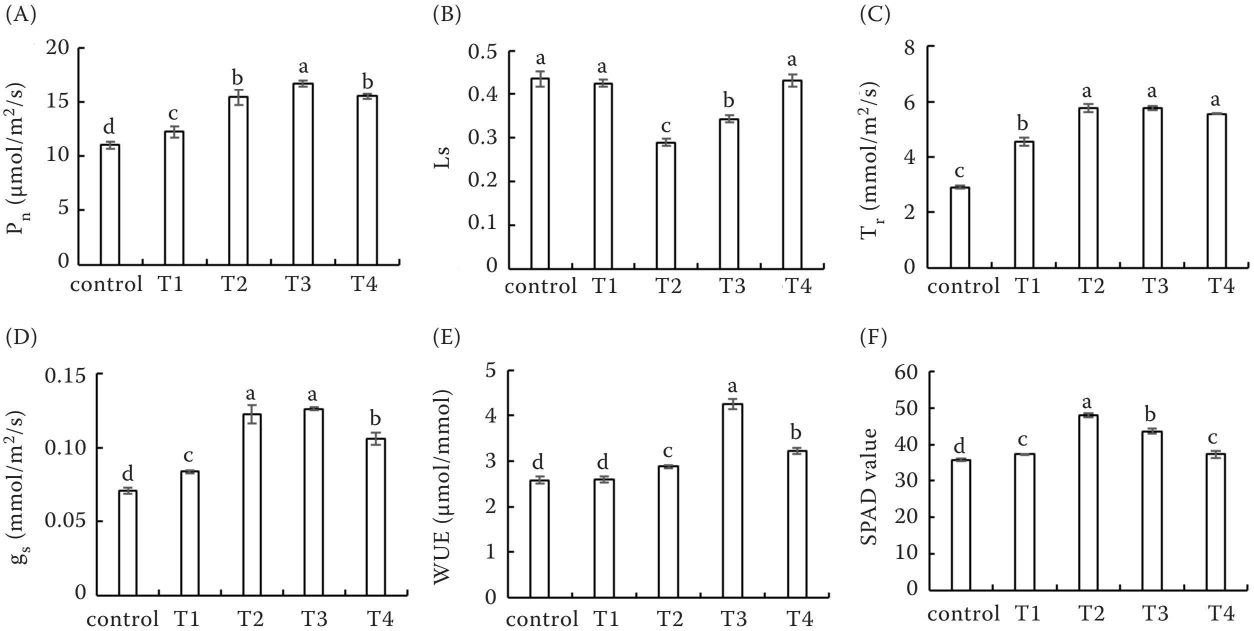

Figure 1. Impacts of selenomethionine (SeMet) on (A) net photosynthetic rate (P_n); (B) stomatal limitation value (Ls); (C) transpiration rate (T_r); (D) stomatal conductance (g_s); (E) water use efficiency (WUE), and (F) soil and plant analyser development (SPAD) value of *Salvia miltiorrhiza* seedlings in June. Different small letters indicated significant differences between treatments at $P < 0.05$. Control – 0 mg/L SeMet; T1 – 10 mg/L SeMet; T2 – 30 mg/L SeMet; T3 – 60 mg/L SeMet; T4 – 120 mg/L SeMet

tions of SeMet had different effects on indicators related to photosynthetic performance (Figures 1 and 2). Among different concentrations, 60 mg/L SeMet exhibited better effects on most indicators related

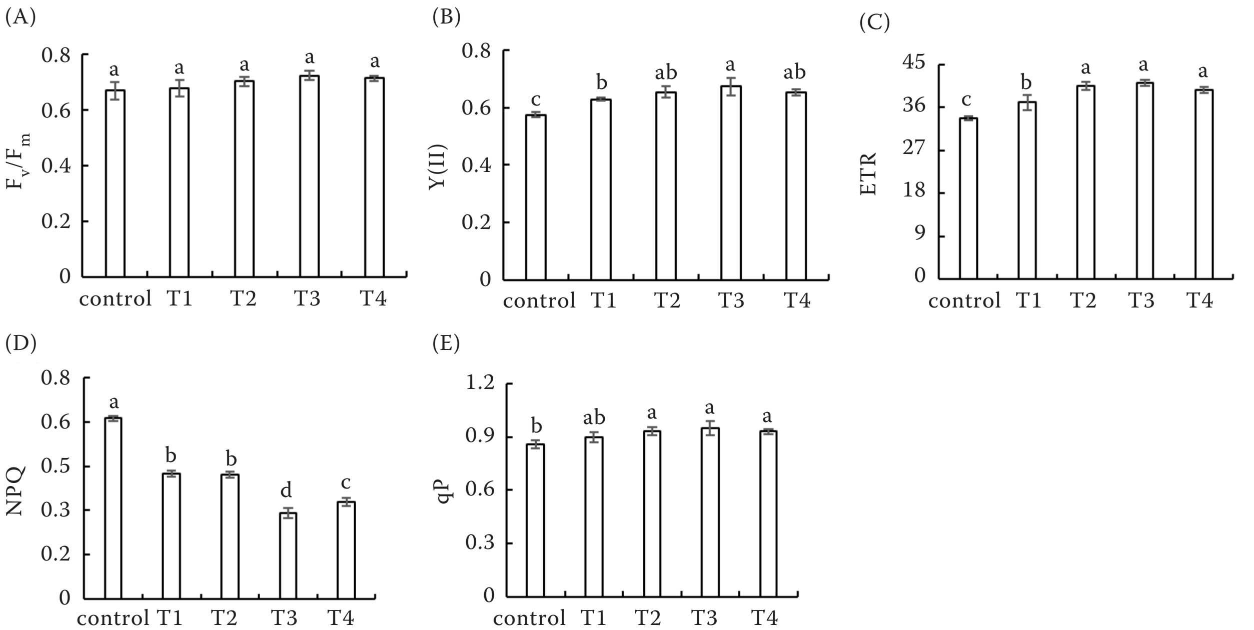

Figure 2. Impacts of selenomethionine (SeMet) on (A) maximum photochemical efficiency of PSII (F_v/F_m); (B) actual photochemical efficiency of photosystem II (Y(II)); (C) apparent electron transport rate (ETR); (D) non-photochemical quenching (NPQ), and (E) photochemical quenching (qP) of *Salvia miltiorrhiza* seedlings in June. Different small letters indicated significant differences between treatments at $P < 0.05$. Control – 0 mg/L SeMet; T1 – 10 mg/L SeMet; T2 – 30 mg/L SeMet; T3 – 60 mg/L SeMet; T4 – 120 mg/L SeMet

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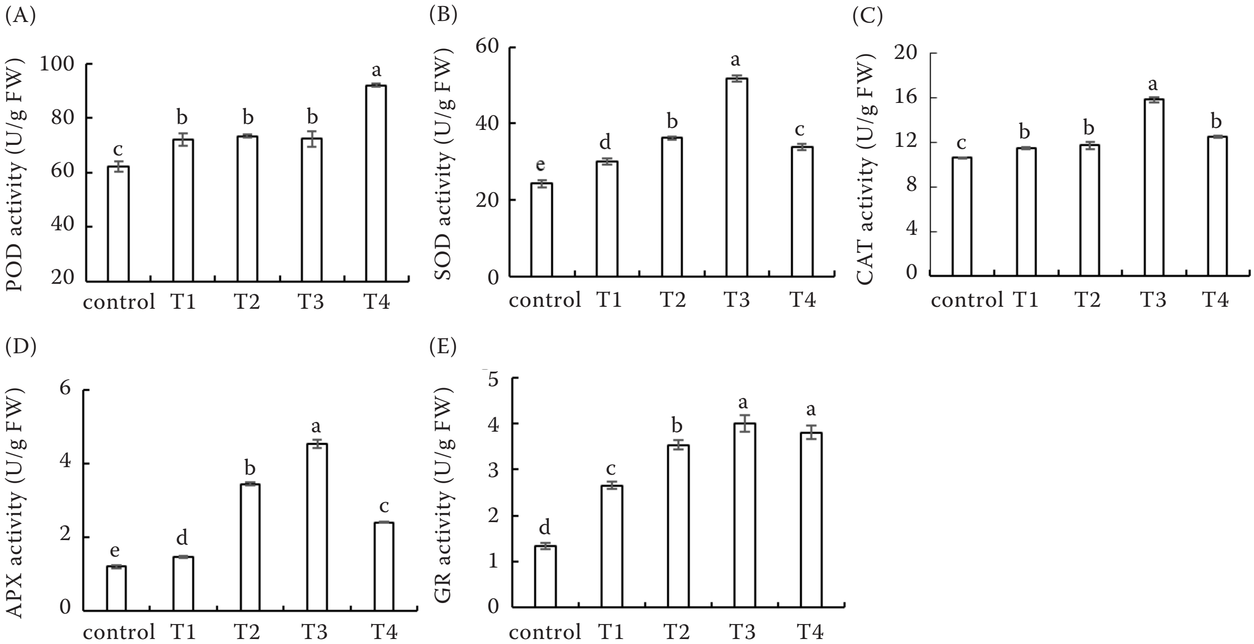

Figure 3. Impacts of selenomethionine (SeMet) at different concentrations on (A) superoxide dismutase (SOD) activity; (B) peroxidase (POD) activity; (C) catalase (CAT) activity; (D) ascorbate peroxidase (APX) activity, and (E) glutathione reductase (GR) activity in *Salvia miltiorrhiza* seedlings in June. Different small letters indicated significant differences between treatments at $P < 0.05$. Control – 0 mg/L SeMet; T1 – 10 mg/L SeMet; T2 – 30 mg/L SeMet; T3 – 60 mg/L SeMet; T4 – 120 mg/L SeMet; FW – fresh weight

to the photosynthetic performance. Compared to the control, 60 mg/L SeMet significantly increased soil and plant analyser development value, net photosynthetic rate, transpiration rate, stomatal conductance, water use efficiency, electron transport rate and the actual photochemical efficiency of photosystem II by 21.81, 51.27, 99.08, 78.22, 63.99, 21.72 and 17.10%, respectively. Conversely, 60 mg/L SeMet significantly reduced non-photochemical quenching and stomatal limitation values by 52.11% and 21.07%, respectively. However, different concentrations of SeMet showed no notable impact on F_v/F_m. These findings indicated that SeMet could enhance the photosynthetic performance of *S. miltiorrhiza*.

Impact of selenomethionine on the antioxidant capacity of *S. miltiorrhiza*. Based on the data presented in Figure 3, it can be observed that different concentrations of SeMet led to a notable enhancement in activities of antioxidant enzymes (such as SOD, POD, APX, etc.) in *S. miltiorrhizae* when compared to the control group (Figure 3). Additionally, SeMet notably reduced the levels of malondialdehyde (MDA) and hydrogen peroxide (H_2O_2) in *S. miltiorrhiza* leaves (Figure 4). With the increase

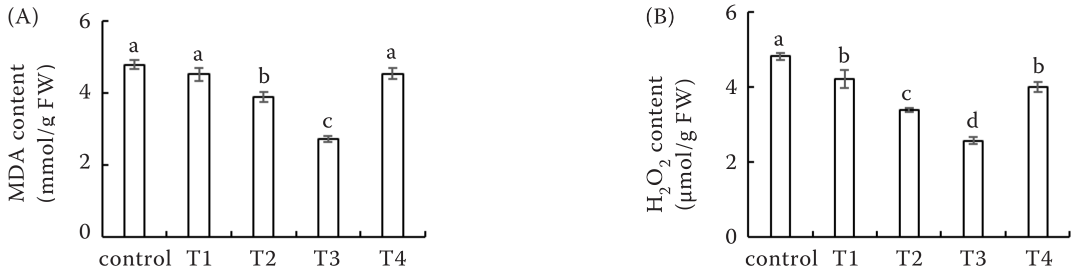

Figure 4. Impacts of selenomethionine (SeMet) at different concentrations on (A) malondialdehyde (MDA) content and (B) hydrogen peroxide (H_2O_2) content in *Salvia miltiorrhiza* seedlings. Different small letters indicated significant differences between treatments at $P < 0.05$. Control – 0 mg/L SeMet; T1 – 10 mg/L SeMet; T2 – 30 mg/L SeMet; T3 – 60 mg/L SeMet; T4 – 120 mg/L SeMet; FW – fresh weight

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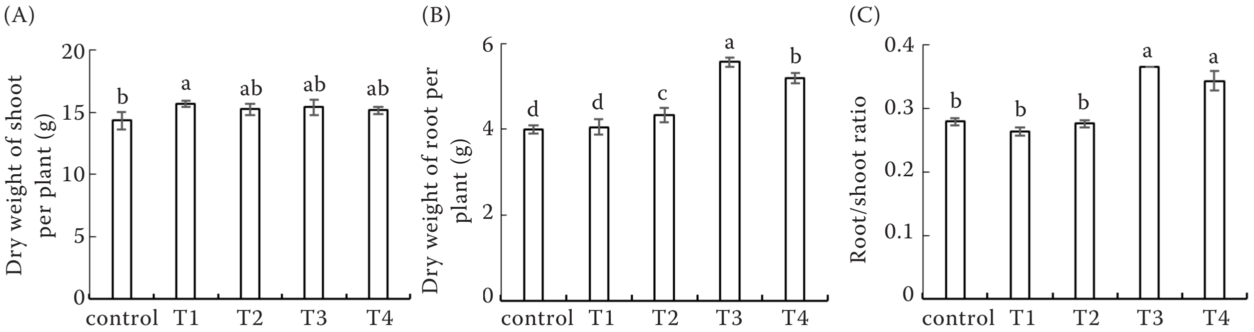

Figure 5. Impacts of selenomethionine (SeMet) at different concentrations on (A) dry weight of shoot per plant; (B) dry weight of root per plant and (C) root/shoot ratio in *Salvia miltiorrhiza* seedlings. Different small letters indicated significant differences between treatments at $P < 0.05$. Control – 0 mg/L SeMet; T1 – 10 mg/L SeMet; T2 – 30 mg/L SeMet; T3 – 60 mg/L SeMet; T4 – 120 mg/L SeMet

in SeMet concentration, the activities of superoxide dismutase, peroxidase, catalase, ascorbate peroxidase and glutathione reductase in *S. miltiorrhiza* leaves were initially enhanced and then decreased. Conversely, the effects of SeMet on malondialdehyde and hydrogen peroxide were opposite. Among various concentrations, 60 mg/L SeMet demonstrated the most favourable outcomes for all the above parameters. In comparison with the control group, 60 mg/L SeMet significantly enhanced the activities of POD, SOD, CAT, APX and GR by 16.42,133.29, 49.30, 277.78 and 199.80%, respectively. Meanwhile, 60 mg/L SeMet led to a 43.32% and 46.67% decrease in the levels of MDA and H_2O_2, respectively. According to the above findings, the foliar application of organic selenium could potentially enhance the antioxidant capacity to scavenge free radicals in *S. miltiorrhiza* by increasing the activities of antioxidant enzymes of *S. miltiorrhiza*.

Impacts of selenomethionine on the growth indicators and selenium concentration of *S. miltiorrhiza*. According to Figures 5 and 6, plant height, basal diameter, biomass, and root/shoot ratio of *S. miltiorrhiza* seedlings treated with SeMet exhibited superior performance compared to the control group. Specifically, 60 mg/L SeMet exhibited the most favourable outcomes across the abovementioned indicators. In comparison with the control group, the application of 60 mg/L SeMet increased the dry weight of shoots, the dry weight of roots, root/shoot ratio, basal diameter and plant height by 6.21, 46.20, 37.60, 19.37 and 26.58%, respectively. These findings suggest that SeMet can potentially enhance the growth and biomass production of *S. miltiorrhiza*, particularly in promoting biomass allocation towards the roots. Furthermore, the promoting effect of SeMet was initially increased and then decreased with the increase in SeMet concentration. Among different concentrations, 60 mg/L SeMet demonstrated a better influence on the growth indicators of *S. miltiorrhiza*. According to Figure 7, the selenium concentrations in the shoots and roots of *S. miltiorrhiza* subjected to SeMet treatment were significantly elevated compared to those observed in the control group. With the increase in SeMet concentration, the selenium content in the roots and shoots of *S. miltiorrhiza* showed an increasing trend. This finding suggested that the application of organic selenium

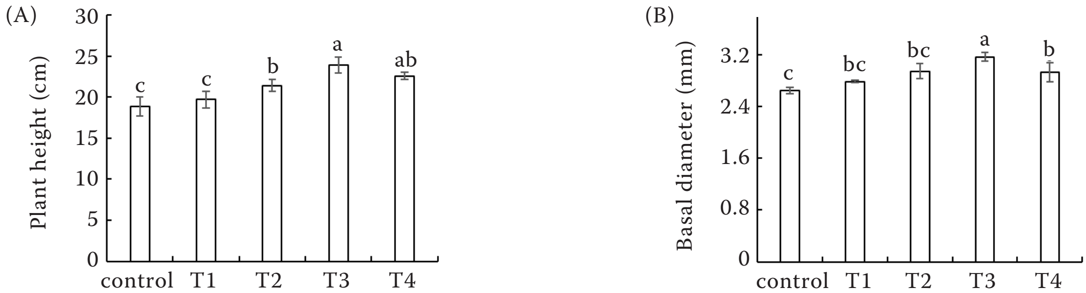

Figure 6. Impacts of selenomethionine (SeMet) at different concentrations on (A) plant height and (B) basal diameter in *Salvia miltiorrhiza* seedlings. Different small letters indicated significant differences between treatments at $P < 0.05$. Control – 0 mg/L SeMet; T1 – 10 mg/L SeMet; T2 – 30 mg/L SeMet; T3 – 60 mg/L SeMet; T4 – 120 mg/L SeMet

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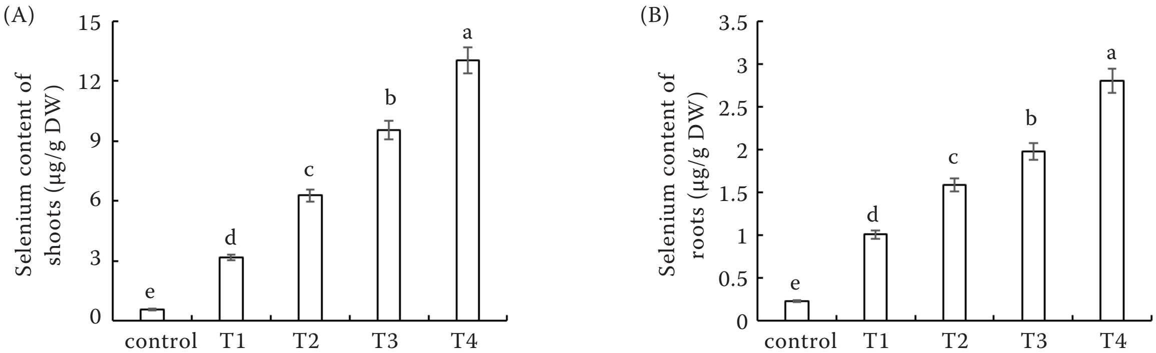

Figure 7. Impacts of selenomethionine (SeMet) at different concentrations on selenium content of (A) shoots and (B) roots in *Salvia miltiorrhiza* seedlings. Different small letters indicated significant differences between treatments at $P < 0.05$. Control – 0 mg/L SeMet; T1 – 10 mg/L SeMet; T2 – 30 mg/L SeMet; T3 – 60 mg/L SeMet; T4 – 120 mg/L SeMet; DW – dry weight

through foliar application effectively enhanced the selenium content in *S. miltiorrhiza*. Meanwhile, the shoots exhibited the highest selenium concentration, followed by the roots.

DISCUSSION

As an essential non-metallic trace element, selenium is vital in maintaining human health. Substantial evidence indicates that adequate Se intake is critical to preventing Keshan disease, cardiovascular complications, and cancer and enhancing the human immune system (Deng et al. 2019). Sufficient supplementation of this indispensable mineral can greatly enhance general health and welfare (Deng et al. 2019). Compared with inorganic Se, organic Se has the characteristics of strong activity, low toxicity, good absorption and high safety (Hadrup and Ravn-Haren 2023, Nie et al. 2024). Recent agronomic studies have revealed that foliar applications of organic Se promote plant growth and improve soil physicochemical properties (Ma et al. 2024). However, the application of organic Se in *S. miltiorrhiza* cultivation remains unexplored. This knowledge gap provides an important opportunity for the development of Se-rich *S. miltiorrhiza* with higher nutritional value and therapeutic potential. Therefore, exploring the application of organic Se in *S. miltiorrhiza* cultivation will be interesting.

It has been documented that Se enhanced the photosynthetic performance of plants (Gao et al. 2022, Li et al. 2022, Chen et al. 2024). Chen et al. (2024) showed that an appropriate dosage of Se not only improved the contents of photosynthetic pigments but also effectively boosted P_n, thereby enhancing the photosynthetic performance of *Bambusa oldhamii* Munro. It was also discovered that an appropriate Se dosage could enhance chloroplast ETR. In this study, 60 mg/L SeMet showed the most pronounced effects, and organic Se application significantly increased SPAD value, P_n, Y(II) and ETR, compared with control, but reduced NPQ. These findings agreed with previous findings about the effects of SeMet on Y(II), F_v/F_m, ETR, qP and NPQ of strawberry and luffa (Gao et al. 2022, Li et al. 2022). Therefore, the application of organic Se on the leaf surface could increase the photosynthesis rate and light energy utilisation efficiency of *S. miltiorrhiza*. Lei et al. (2023) discovered that Se could improve the WUE of common buckwheat. Wu et al. (2021) reported a similar finding in *Camellia sinensis* (L.) O. Ktze. The present study demonstrated that the application of organic Se not only improved SPAD value, P_n and ETR but also improved WUE of *S. miltiorrhiza* seedlings. Therefore, the application of organic Se also provided a novel approach to improve water use efficiency in the cultivation of *S. miltiorrhiza*.

Reactive oxygen species (ROS) are naturally generated during oxygen metabolism in plants and can act as pivotal signaling molecules in maintaining redox homeostasis. However, excessive accumulation of ROS can trigger the peroxidation of membrane lipids, thereby resulting in membrane damage and destruction. To remove excessive ROS in cells, plants can employ enzymatic and non-enzymatic antioxidants (Jiménez et al. 1998, Rizwan et al. 2017). Recent studies have established the role of Se in enhancing antioxidant defenses (Liang et al. 2014, Sharma and Uttam 2020, Wu et al. 2022). Wu et al. (2022) reported that SOD and CAT activities were increased in broccoli (*Brassica oleracea* var. *italica*) under Se treatment. Sharma and Uttam 2020 (2020) observed that Se reduced MDA content by 30% in

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wheat (*Triticum aestivum*). Liang et al. (2014) further demonstrated Se increased GR activity by 1.8-fold in foxtail millet (*Setaria italica* var. *germanica*). As a result, the antioxidant capacity of plants can be evaluated by the activities of antioxidant enzymes in plants. In this study, we found that foliar application of organic Se enhanced the activities of antioxidant enzymes SOD, POD, CAT, APX and GR, thereby reducing MDA and H_2O_2 contents in *S. miltiorrhiza* seedlings. Among different concentrations, 60 mg/L SeMet exhibited better effects on these antioxidant enzymes, thereby showing better effects on the reduction in MDA and H_2O_2 contents. These findings revealed that 60 mg/L SeMet exhibited stronger ROS scavenging ability, which provided a theoretical basis for the application of this concentration of organic Se in the cultivation of *S. miltiorrhiza*.

As reported, two types of Se fertilisers increased the biomass of tomatoes (Fan et al. 2024). Similarly, we found that organic Se treatment also increased the biomass of *S. miltiorrhiza*. Guo et al. (2023) noted that treatments of 0.5 and 1.0 mg/L Se^{6+} demonstrated notable impacts on the edible yield of red radish sprouts. Previous studies have demonstrated that selenium supplementation enhances plant growth by improving key parameters such as plant height, basal diameter, shoot dry weight, root dry weight, and root/shoot ratio (Wu et al. 1998, Li et al. 2003, Kan et al. 2021). Consistent with these findings, the current study showed that SeMet significantly increased all aforementioned growth parameters, including plant height, basal diameter, shoot dry weight per plant, root dry weight per plant and root/shoot ratio. Among different concentrations, 60 mg/L SeMet had a better influence on these growth parameters of *S. miltiorrhiza*. As plant growth is closely related to photosynthetic performance, SeMet could potentially stimulate growth by improving the photosynthetic performance of *S. miltiorrhiza* seedlings.

Planting *S. miltiorrhiza* in Se-rich soil and applying exogenous Se can enhance the Se content in the plants. However, the availability of Se-rich soil is limited. Therefore, the application of exogenous Se has become a key focus for the production of safe Se-rich *S. miltiorrhiza*. In this study, organic Se was found to improve the photosynthetic and antioxidant capacities of *S. miltiorrhiza* seedlings compared to the control group. In this way, organic Se promoted the growth of *S. miltiorrhiza*. This experiment observed that 60 mg/L SeMet had the most significant effects on the photosynthetic and antioxidant capacities and growth of *S. miltiorrhiza* seedlings. Previous studies have reported similar findings on other crops, such as *Prunus persica* (L.) Batsch, *Fragaria* × *ananassa* and *L. aegyptiaca* (Wang et al. 2013, Gao et al. 2022, Li et al. 2022). Meanwhile, we found that foliar sprays with high concentrations of SeMet could increase Se content in *S. miltiorrhiza* but did not have the best effect on photosynthetic properties, antioxidant properties, and growth. Therefore, this study demonstrated that the appropriate concentration of organic Se effectively promoted the growth of *S. miltiorrhiza* seedlings by enhancing the photosynthetic performance and antioxidant capacity, which provided a theoretical basis for the application of organic Se in the cultivation of this plant species.

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Received: June 27, 2024
Accepted: March 25, 2025
Published online: April 26, 2025