Effects of different rootstocks grafting on potassium absorption in post generations of Cyphomandra betacea seedlings

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Abstract: The pot experiments were conducted to study the effects of Solanum nigrum, tomato and eggplant as rootstocks on potassium contents in post generations of Cyphomandra betacea seedlings. The results showed that the potassium content of grafted generations of S. nigrum as rootstock was significantly higher than that of ungrafted generations, which increased by 85%, 6.4%, 7.5% and 5.5%, respectively. The potassium content of each part of grafted generations of C. betacea seedling by tomato and eggplant rootstock was lower than that of ungrafted generations. The content of available phosphorus and potassium in soil after grafting treatment was significantly higher than that of control, which was 1.11 times and 1.13 times respectively. Therefore, grafting on rootstocks of S. nigrum was more conducive to potassium absorption in post generations of C. betacea seedling.

1. Introduction
Cyphomandra betacea is a perennial evergreen semi-woody shrub or small tree that integrates flower, fruit and food. It has been Introduction and cultivation are common in southern China [1-2]. Grafting can enhance the absorption capacity of plant nutrients, improve its disease resistance and yield [3]. Qi et al. found that plants grew vigorously after grafting, and their ability to absorb nitrogen and potassium was higher than that of non-grafted plants [4]. Li et al. showed that the yield of tomato grafted seedlings was significantly higher than that of ungrafted seedlings, and the nitrogen uptakes of tomato plants were significantly higher than that of ungrafted seedlings [5]. Potassium is one of the nutrient elements needed for plant growth and development. It not only promotes photosynthesis and protein synthesis in plants, but also improves cold resistance, salt resistance, disease and insect resistance of plants [6]. In this study, under the condition of cadmium pollution, the effects of different rootstocks on potassium content and soil nutrient content of grafted generations of C. betacea seedlings were studied, in order to select the best grafting mode which can increase potassium absorption of tree tomato and promote plant growth and development.

2. Materials and Methods
2.1 Experiment materials
Young branches of C. betacea as grafting scions were collected from a 6-year-old tree of C. betacea planted...
in Chengdu campus farm of Sichuan Agricultural University (30°42′N, 103°51′E) in March 2018. S. nigrum seeds were collected from the Chengdu campus farm of Sichuan Agricultural University in October 2017, and tomato and eggplant and seeds were purchased in a local market. Fluvo-aquic soil was also collected from the Chengdu campus farm in February 2018, and its basic properties were the same as reported by Liu et al. (2015) [7], with an available Cd concentration of 0.028 mg/kg.

2.2 Graft methods
The rootstocks’ seeds of S. nigrum, tomato, and eggplant were sown on the Chengdu campus of Sichuan Agricultural University in February 2018. When the seedlings of rootstocks had reached a height of about 10 cm (March 2018), the grafting started. The scions were 5-cm long of young C. betacea branches. Four treatments were applied in the experiment: ungrafted, S. nigrum rootstock, tomato rootstock, and eggplant rootstock. The grafting details and management after grafting were the same as Liu et al. (2019) [8] and Zhang et al. (2019) [9]. When the fruits of four treatments C. betacea attained maturity, mature seeds were collected, air-dried, and stored separately at 4 °C.

2.3 Experiment design
The experiment was conducted in a greenhouse in the Chengdu campus of Sichuan Agricultural University, 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 Lx at 10 h night time. The C. betacea seeds of four treatments were sown on the Chengdu Campus of Sichuan Agricultural University in November 2018. Soil samples were air-dried and filtered through a 5-mm mesh sieve in November 2018, and 3.0-kg portions were placed in polyethylene pots (15 cm height and 18 cm diameter). Cd was incorporated into the soil as a saturated heavy-metal solution in the form of CdCl₂·2.5 H₂O to achieve a final soil Cd concentration of 5 mg/kg. The soil was immediately mixed, maintained at a soil water holding capacity of 80%, and mixed again after 4 weeks. In December 2018, the prepared seedlings of C. betacea were transplanted into the soil-filled pots, with four seedlings placed in each pot. Four treatments were set up: post generation of ungrafted, post-grafting generations of S. nigrum rootstock, tomato rootstock, and eggplant rootstock. Each treatment was replicated five times (one pot per repeat) in a completely randomised design. Pots were watered daily from plant transplantation until harvest to maintain the soil water holding capacity at 80%. After 60 days, the whole plant was harvested and the content of potassium in roots, stems and leaves was determined [10].

2.4 Statistical Analyses
Statistical analyses were performed using SPSS 20.0 statistical software (IBM, Chicago, IL, USA). Data were analysed by one-way analysis of variance, with significant differences assessed at the 5% confidence level.

3. Results and Discussion
3.1 Potassium content in the generations of C. betacea seedlings
As shown in Table 1, the order of potassium content in roots of C. betacea seedlings after different rootstock grafting treatments was as follows: S. nigrum rootstock grafting > ungrafted > eggplant rootstock grafting > tomato rootstock grafting, in which the potassium content of S. nigrum rootstock grafted generation increased by 85% compared with the control, and the potassium content of tomato and eggplant rootstock grafted generation decreased significantly compared with the control. The potassium content of stem was the highest in all treatments, which increased by 6.4% compared with the control. The potassium content of tomato and eggplant rootstock grafted generations decreased significantly compared with the control. The potassium content of leaves of S. nigrum rootstock grafted generations increased by 7.4% compared with the control. The potassium content of tomato and eggplant rootstock grafted generations was not significantly different from the control. As far as whole shoots is concerned, the order of potassium content of C. betacea seedling generations by
different rootstock grafting is: \( S. \ nigrum \) rootstock grafting > ungrafted > eggplant rootstock grafting > tomato rootstock grafting.

### Table 1 Potassium content in post generations of \( C. \ betacea \) seedlings

| Treatments     | Roots (mg/g) | Stems (mg/g) | Leaves (mg/g) | Whole shoots (mg/g) |
|----------------|--------------|--------------|---------------|--------------------|
| CK             | 0.154±0.005b | 0.669±0.011b | 1.005±0.035ab | 0.848±0.013b       |
| \( S. \ nigrum \) | 0.285±0.008a | 0.712±0.017a | 1.079±0.029a  | 0.895±0.010a       |
| Tomato         | 0.136±0.005b | 0.548±0.007d | 0.960±0.023b  | 0.747±0.008d       |
| Eggplant       | 0.148±0.009b | 0.599±0.006c | 0.990±0.028b  | 0.799±0.012c       |

Note: Different letters indicate significant difference at 5% level among different treatments.

#### 3.2 Soil pH and nutrient content

| Treatments     | Available phosphorus (mg/kg) | Available potassium (mg/kg) | Alkaline nitrogen (mg/kg) | pH          |
|----------------|------------------------------|----------------------------|---------------------------|-------------|
| CK             | 397.5±9.94b                  | 33.21±1.25b                | 304.8±25.17a              | 8.05±0.14a  |
| \( S. \ nigrum \) | 442.4±6.69a                  | 37.69±0.83a                | 284.6±17.40a              | 7.95±0.07a  |
| Tomato         | 370.1±8.72b                  | 25.10±0.73c                | 130.2±23.76c              | 8.05±0.07a  |
| Eggplant       | 380.8±12.4b                  | 32.70±1.74d                | 218.8±15.06b              | 8.0±0.03a   |

As shown in Table 2, the soil pH value of \( S. \ nigrum \) grafting treatment decreased slightly compared with that of control, while the soil pH content of tomato and eggplant grafting treatment was not significantly different from that of control. The order of available phosphorus content in soil after different rootstock grafting treatments was as follows: \( S. \ nigrum \) grafting > ungrafted > eggplant grafting > tomato grafting. The content of available phosphorus in soil after \( S. \ nigrum \) grafting treatment increased by 11.3% compared with that of control, while the content of available potassium in tomato and eggplant grafted treatments was not significantly different from that of control. The most significant increase in the available potassium content in the soil was the \( S. \ nigrum \) grafting treatment of nightshade, which increased by 13.5%, while the grafting treatment of tomato and eggplant was significantly lower than that of the control. The grafting treatment of eggplant was the lowest of all the treatments. The order of soil alkaline nitrogen content after different rootstocks grafting treatment was as follows: ungrafted > \( S. \ nigrum \) grafting > eggplant grafting > tomato grafting. The content of alkaline nitrogen in the soil after \( S. \ nigrum \) grafting was the maximum of the three grafting treatments but lower than the control.

#### 4. Conclusion

Under the condition of cadmium pollution, different rootstocks grafting had effects on potassium absorption in the generation of \( C. \ betacea \) seedlings. Compared with the control, the potassium content in roots, stems, leaves and whole shoots of \( C. \ betacea \) seedlings after grafting with \( S. \ nigrum \) rootstock was higher than that of the control, which increased by 85%, 6.4%, 7.5% and 5.5% respectively. The content of available phosphorus and potassium in soil increased by 11.3% and 13.5% respectively, compared with the control. The results showed that the grafting of \( S. \ nigrum \) rootstocks promoted the transport of potassium to all parts of the plant, and increased the nutrient content in soil, which was beneficial to alleviating cadmium pollution in soil.

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