Effects of Cutting after Grafted on Nutrient Uptake of *Nasturtium officinale* under Selenium Stress

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Abstract: To study the effects of cutting after grafted on nutrient uptake of wild vegetables, four rootstocks (*Brassica pekinensis, Brassica napus, Raphanus sativus* and *Rorippa dubia*) were used to graft *Nasturtium officinale*, and then cutting the seedlings of scions and planted in selenium (Se) contaminated soil. The nitrogen (N), phosphorus (P) and potassium (K) uptakes of *N. officinale* were investigated by the pot experiment. The rootstocks of *B. pekinensis*, *B. napus*, *R. sativus,* and *R. dubia* improved the N uptake ability of *N. officinale* in Se-contaminated soil, but reduce K uptake ability of that. The rootstocks of *B. pekinensis*, *B. napus*, and *R. sativus* increased the P contents in shoots of *N. officinale*, and the rootstock of *R. dubia* had on significant effects on that. Therefore, the rootstocks of *B. pekinensis*, *B. napus*, *R. sativus,* and *R. dubia* could significantly affect the N, P, and K uptake of *N. officinale* cutting seedlings after grafted, and the best rootstock was *R. sativus* in Se-contaminated soil.

Introduction

Since ancient times, people have cut and joined together plants of different varieties or species so they would grow as a single plant--a process known as grafting [1]. Grafting can not only affect the traits, quality and yield of scion, but also enhance the disease resistance, drought resistance, salt tolerance, heat resistance, improve the nutrient uptake function, and promote plant growth [2-4]. Some studies indicate that grafting can limit the uptake of heavy metals in shoots of plants, and increase the absorption of nutrients [5]. Grafting causes the exchanges between the scion and rootstock of two different plants species [6-7], which also leads to the transfer and integration of the genetic material of the rootstock and scion [8-10]. These studies provide a theoretical basis for cutting after grafted to affect plant nutrient uptake under stress conditions.

Selenium (Se) is a special trace element, with low concentrations of Se can promote plant growth, and excess Se is toxic to plants and produces stress on plants [11-13]. In this study, four rootstocks (*Brassica pekinensis*, *Brassica napus*, *Raphanus sativus* and *Rorippa dubia*) were used to graft *Nasturtium officinale* (wild vegetable with rapid growth and easy propagation from cuttings), after grafting, the cutting of shoots of *N. officinale* grew in Se contaminated soil, and the effects of nutrient uptake of *N. officinale* were studied. The aim of this study was to screen the best rootstock that could improve the nutrient uptake ability of *N. officinale* in Se-contaminated soil, and provide a reference for other wild vegetables improvement.

Materials and Methods

Materials. The soil samples used in the experiment were paddy soil that were collected from the Chengdu Campus Farm of the Sichuan Agricultural University (29° 59′ N, 102° 59′ E). The basic soil properties were pH 7.42, organic matter 31.73 g/kg, total nitrogen (N) 1.05 g/kg, total phosphorus (P) 0.37 g/kg, total potassium (K) 25.71 g/kg, alkali-hydrolysable N 56.13 mg/kg, available P 17.15 mg/kg, available K 56.65 mg/kg, total Se 0.35 mg/kg.

The seedlings of *N. officinale* were collected from a ditch in Ya'an, Sichuan, China, and potted in greenhouse of Chengdu Campus of Sichuan Agricultural University. The seedlings of rootstocks *B. pekinensis*, *B. napus*, *R. sativus*, and *R. dubia* were collected from the Chengdu Campus Farm of the Sichuan Agricultural University, and planted in the pots in June, 2016. 5 cm stems of rootstock seedlings were selected, and 3 cm sections of *N. officinale* grafting were used for grafting. When the grafting was completed, the soil moisture content was maintained at 80% of field capacity, and all of the seedlings were covered with transparent plastic film and a shade net. After 10 d, the transparent plastic film, the shade net and the plastic binding film were removed, and all the germinating buds of rootstocks were also removed.

Experimental Design. The experiment was conducted from November, 2016 to March, 2017 in the greenhouse of Chengdu Campus of Sichuan Agricultural University. Air-dried soil (3.0 kg) was weighed and placed into each polyethylene pot (11 cm high, 22 cm diamete) in November 2016. Se was added to the soil samples as analytical reagent Na_2SeO_3 at the concentration of 10 mg/kg, and then 3 g of compound fertilizer was applied to each pot and the soil was thoroughly mixed. The soils were soaked in the Se solution for 4 weeks, and then the soil in each pot was mixed thoroughly again. In December 2016, three uniform of 5 cm length of *N. officinale* branches were cut and transplanted to the pot. Five treatments were applied in the experiment: control (not grafted), and rootstocks of *B. pekinensis*, *B. napus, R. sativus*, and *R. dubia*. Each treatment was repeated six times and completely randomized design with 15-cm spacing between pots. The water depth was 1 cm higher than the soil surface in the first 2 weeks of the experiment, and 2 cm above the soil surface from 2 weeks until the time that the *N. officinale* seedlings were harvested. After 60 d (March 2017), the entire plants of each pot were harvested, the roots, stems and leaves were separated, washed, dried, crushed, and the N, P and K content were determined [14].

Statistical Analyses. Each treatment used 18 seedlings (repeated six times, 3 seedlings for each repeat) for statistical analyses. Statistical analyses were conducted using SPSS 13.0 statistical software (IBM, Chicago, IL, USA). Data were analyzed by one-way analysis of variance with least significant difference (LSD) at the p = 0.05 confidence level.

Results and Discussion

N Content in *N. officinale*. In the Se-contaminated soil, the N content in roots of *N. officinale* from grafting treatments was significantly higher than those of control (Table 1). The N content in roots of *N. officinale* treated by rootstock of *R. sativus* was the highest and significantly higher than that of other grafting treatments, and the N content increased by 31.19% ($p < 0.05$) compared with the control. The N content in shoots of *N. officinale* significantly increased by the rootstocks of *B. pekinensis*, *B. napus* and *R. sativus*, which increased by 15.66% ($p < 0.05$), 8.80% ($p < 0.05$) and 22.91% ($p < 0.05$) respectively compared with the control. For the whole plants, the N content in whole plants of *N. officinale* by four grafting treatments was significantly higher than the control, and the rootstock of *R. sativus* was the highest among the grafting treatments. Therefore, the four rootstocks used in this experiment conld improve the N absorption ability of *N. officinale* in Se-contaminated soil, and the rootstock of *R. sativus* was the best.

P Content in *N. officinale*. In the Se-contaminated soil, the P content in roots of *N. officinale* were significantly lower than those of the control, but the P content in stems was significantly higher than that of the control (Table 2). The P content in leaves of *N. officinale* was ranked as rootstock of *R. sativus* > rootstock of *B. pekinensis* > rootstock of *B. napus* > control > rootstock of *R. dubia*. The P contents in shoots of *N. officinale* by the rootstocks of *B. pekinensis, B. napus,* and *R. sativus* were significantly higher than that of control. The P content in whole plants of *N. officinale* by the rootstock of *R. sativus* was significantly higher than the control, and there were no significant differences between the other grafting treatments and the control. Therefore, the rootstocks of *B. pekinensis*, *B. napus*, and *R. sativus* could improve the P uptake of *N. officinale* in the Se-contaminated soil, and the rootstock of *R. sativus* was the best for the P uptake in whole plants of *N. officinale*.

Table 1 N content in *N. officinale*

Treatments	Roots (mg/g)	Stems (mg/g)	Leaves (mg/g)	Shoots (mg/g)	Whole plants (mg/g)
Control	17.92±0.45d	15.45±1.99b	25.02±2.17bc	20.56±0.98d	19.71±0.77c
B. pekinensis	20.87±0.77c	20.63±1.36a	25.76±2.16b	23.78±1.80ab	22.85±1.48b
B. napus	20.22±0.58c	20.71±0.71a	23.51±0.89c	22.37±0.78bc	21.68±0.73b
R. sativus	23.51±0.60a	20.16±1.00a	28.52±1.15a	25.27±1.04a	24.76±0.92a
R. dubia	22.19±0.79b	16.28±1.09b	24.68±0.62bc	21.51±0.76cd	21.70±0.76b

Values are means ± standard errors. Means with the same letter within each column are not significantly different at $p < 0.05$.

Table 2 P content in *N. officinale*

Treatments	Roots (mg/g)	Stems (mg/g)	Leaves (mg/g)	Shoots (mg/g)	Whole plants (mg/g)
Control	6.31±0.26a	15.02±1.70b	5.09±0.08c	9.49±0.28b	8.46±0.23bc
B. pekinensis	5.15±0.28d	17.69±1.54a	5.28±0.16b	10.07±0.62a	8.48±0.52bc
B. napus	5.55±0.15c	17.62±1.02a	5.11±0.13c	10.21±0.45a	8.70±0.37ab
R. sativus	6.00±0.21b	17.25±0.69a	5.68±0.17a	10.18±0.38a	8.96±0.34a
R. dubia	5.48±0.12c	16.54±0.69a	4.82±0.12d	9.25±0.37b	8.16±0.30c

Values are means ± standard errors. Means with the same letter within each column are not significantly different at $p < 0.05$.

K Content in *N. officinale*. The K contents in roots and whole plants of *N. officinale* by grafting treatments were significantly lower than those of control in Se-contaminated soil (Table 3). However, the K content in whole plants of *N. officinale* by the root stock of *R. sativus* was significantly higher than that of the other three grafting treatments. There were no significant differences of K contents in stems of *N. officinale* by the rootstocks of *R. sativus* and *R. dubia*, while the K content in stems of *N. officinale* by the rootstocks of *B. pekinensis* and *B. napus* were significantly lower than the control. The K contents in leaves and shoots of *N. officinale* by grafting treatments were lower than those of the control except the rootstock of *R. sativus*. Therefore, in the Se-contaminated soil, the four rootstocks (*B. pekinensis, B. napus, R. sativus,* and *R. dubia*) could reduce the K uptakes in *N. officinale*.

Table 3 K content in *N. officinale*

Treatments	Roots (mg/g)	Stems (mg/g)	Leaves (mg/g)	Shoots (mg/g)	Whole plants (mg/g)
Control	32.12±0.92a	43.61±1.83a	26.59±3.26a	34.12±2.89a	33.50±2.00a
B. pekinensis	18.97±0.82d	39.70±2.54b	22.51±1.67b	29.15±1.89b	25.86±1.58c
B. napus	26.61±0.70c	39.12±0.82b	17.76±0.78c	26.46±0.85c	26.51±0.80c
R. sativus	25.74±0.77c	44.29±0.83a	24.68±0.80a	32.30±0.90a	30.40±0.88b
R. dubia	29.37±0.65b	42.74±0.98a	16.59±0.99c	26.47±0.95c	27.31±0.85c

Values are means ± standard errors. Means with the same letter within each column are not significantly different at $p < 0.05$.

Conclusions

Different rootstocks (*B. pekinensis*, *B. napus*, *R. sativus,* and *R. dubia*) for grafting could affect the nutrient uptake of *N. officinale* cuttings in Se-contaminated soil, and the effects of nutrient uptake were different by different rootstocks. The rootstocks of *B. pekinensis*, *B. napus*, *R. sativus,* and *R. dubia* improved the N uptake ability of *N. officinale* in Se-contaminated soil, but reduce K uptake ability of that. The rootstocks of *B. pekinensis*, *B. napus*, and *R. sativus* increased the P contents in shoots of *N. officinale*, and the rootstock of *R. dubia* had on significant effects on that. Therefore, the rootstocks of *B. pekinensis*, *B. napus*, *R. sativus,* and *R. dubia* could significantly affect the N, P, and K uptake of *N. officinale* cutting seedlings after grafted, and the best rootstock was *R. sativus* in Se-contaminated soil.

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References

[1] C.W. Melnyk and E.M. Meyerowitz: Current Biology Vol. 25 (2015), p. 183.

[2] R.M. Rivero, J.M. Ruiz and L. Romero: Journal of Food Agriculture & Environment Vol. 1 (2003), p. 70.

[3] R.M. Rivero, J.M. Ruiz and L. Romero: Journal of the Science of Food & Agriculture Vol. 83 (2003), p. 1315.

[4] E. Sánchez-Rodríguez, L. Romero and J.M. Ruiz: Journal of Plant Growth Regulation Vol. 32 (2013), p. 831.

[5] D. Savvas, G. Colla, Y. Rouphael, D. Schwarz and G. Colla: Scientia Horticulturae Vol. 127 (2010), p. 156.

[6] J.S. Cheng: *Garden Plant Genetics and Breeding* (China Forestry Publishing House, Beijing 2000).

[7] Y.C. Guan: Acta Agronomica Sinica Vol. 26 (2000), p. 975.

[8] Y. Ohta: Euphytica Vol. 55 (1991), p. 91.

[9] Y. Hirata: Japanese Journal of Breeding Vol. 30 (1980), p. 83.

[10] D. Zhang, Z. Meng, W. Xiao, X. Wang and Sodmergon: Acta Botanica Sinica Vol. 44 (2002), p. 832.

[11] S.D. Gregorio, S. Lampis, F. Malorgio, G. Petruzzelli, B. Pezzarossa and G. Vallini: Plant & Soil Vol. 285 (2006), p. 233.

[12] P.A. Biacs, H.G. Daood and I. Kadar: Journal of Agricultural & Food Chemistry Vol. 43 (1995), p. 589.

[13] B. Pezzarossa, G. Petruzzelli, F. Petacco, F. Malorgio and T. Ferri: Chemosphere Vol. 67 (2007), p. 322.

[14] S.D. Bao: *Agrochemical Soil Analysis* (3rd edition, China Agriculture Press, Beijing 2000).