Effects of arsenic on growth, saponins and flavonoids yield of *Panax notoginseng* (Burk. F.H. Chen) and its control measurements

N. Li, S.C. Cheng, X.Y. Mei, Q. Li & Y.Q. Zu

College of Resources and Environment, Yunnan Agricultural University, Kunming, P.R. China

ABSTRACT: Arsenic stress inhibited the growth of *Panax notoginseng*. The citric acid and phosphorus fertilizer can promote the growth of *notoginseng*, increase the biomass and morphological index, improve the efficacy of saponins and flavonoid contents. They also make it release of soil arsenic, increasing arsenic content in *Panax notoginseng* to exceed the standard, phosphorus is not conducive to the release of arsenic in soil, reducing the absorption of arsenic in plants.

1 INTRODUCTION

Arsenic (As) is a naturally toxic element and widely distributed in the environment, and it is cancerogenic to humans. Environmental As pollution in soil has become more and more severe problem (Dudka & Adriano, 1997; Zhou *et al.*, 2016). High soil arsenic background value, which was mean 65.6 mg kg^{-1} in the range of 6.9 to 242.0 mg kg^{-1} , was found in Wenshan province. the main production area of *Panax notoginseng* (Burk. F.H. Chen), which has been cultivated for importantly traditional medicine in China, *Panax notoginseng* is an herbal species in the genus of *Panax*, family of Araliaceae (Dahui *et al.*, 2014; Guo *et al.*, 2010). The mining activities and unreasonable fertilization could cause arsenic content exceeding the standard and affect the growth and quality of *P. notoginseng*.

2 METHODS/EXPERIMENTAL

Field experiments were carried out in Dalongtan village ($22^{\circ}39'N$, $103^{\circ}06'E$, elevation 2251 m), Xundian County, Kunming prefecture, Yunnan province, China. Each plot was 3 m^2 in size. Soil collected from the 0–15 cm soil layer was mixed with the As stock solutions with As(V) 0, 20, 80, 140, 200, 260 mg kg^{-1} (prepared using H_3AsO_4). The As treated soil was incubated for two weeks. Soil before As treatment had a pH 5.32, organic matter content of 16.77 g kg^{-1} , total N content of 0.60 g kg^{-1} , total P content of 1.20 g kg^{-1} and As content at 12.00 mg kg^{-1} . Soil type was upland red soil with clay loam texture. Plot and pot experiments were conducted to study effects of citric acid (0, 4, 6, 8 mmol kg^{-1}) and calcium magnesium phosphate

fertilizer (0, 60, 120, 180 mg kg^{-1}) on growth, photosynthesis and medicinal components flavonoids and saponins of *P. notoginseng* under arsenic stress.

3 RESULTS AND DISCUSSION

The results showed that: (1) The biomass and plant growth under As 140 mg kg^{-1} treatment significantly decreased compared with control (0 mg kg^{-1} As treatment). For biennial *P. notoginseng*, arsenic stress had no significant effect on the contents of saponins. For triennial *P. notoginseng*, there was a negative correlation between content of saponins and content of arsenic ($P < 0.05$). There were no significant changes in PAL, SS and CHS enzyme activities of the *P. notoginseng* enzymes in the biosynthesis of flavonoids in triennial *P. notoginseng*. (2) Arsenic concentrations in main root under 140 mg kg^{-1} and 8 mmol kg^{-1} citric acid treatment reached the highest and increased by 30% coping with non citric acid treatment. Citric acid promoted the synthesis of photosynthetic pigments, increased the content of photosynthetic pigments, decreased the content of malondialdehyde (MDA). Citric acid effectively improved the flavonoids accumulation (Fig. 1). Under As 140 mg kg^{-1} treatment, flavonoid accumulation increased by 29% with 8 mmol kg^{-1} citric acid application. (3) The content of arsenic in 6 mmol kg^{-1} and 8 mmol kg^{-1} citric acid leaching solution was significantly higher 21% and 33% than that of non citric acid leaching solution, respectively. Compared with non citric acid, contents of F2 (specifically adsorbed arsenic), F3 (weak crystalline iron and aluminum oxide hydrate combination fraction) and F4 (crystalline hydrated iron aluminum oxide with arsenic) of 8 mmol kg^{-1} citric acid increased by 11%, 33% and

Figure 1. Effect of citric acid on the flavonoids accumulation under As 140 mg kg⁻¹ treatment.

Figure 2. Effect of different P levels on flavonoids accumulation of *P. notoginseng* under As stress.

32%, respectively. (4) Phosphate fertilizer could significantly improve the *P. notoginseng* biomass under As concentration of 200 mg kg⁻¹ and 260 mg kg⁻¹ and phosphate fertilizer 180 mg kg⁻¹ treatment, biomass significantly increased by 56% and 17%. Plant heights were significantly increased by 5% and 26%, respectively; the leaf area increased by 33% and 41%.

Flavonoids accumulation increased under different P treatment levels (Fig. 2).

4 CONCLUSIONS

Arsenic stress inhibited the growth of *Panax notoginseng*, the citric acid and phosphorus fertilizer can promote the growth of *notoginseng*, increased the biomass and morphological index, improve the efficacy of saponins and flavonoid content, but also easy to make soil arsenic release, lead arsenic content exceed the standard, phosphorus is not conducive to the release of arsenic in soil thus, reduce the absorption of arsenic in plants.

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