Effects of intercropping with post-grafting generation of *Impatiens balsamina* on potassium uptake of grape seedlings under cadmium stress

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Abstract. Grape seedlings and post-grafting generation of *Impatiens balsamina* were used as materials to intercrop for exploring the effects of the potassium uptake of grape seedling under the stress of cadmium. There were five treatments in this experiment including one grape seedling monoculture and four intercropping treatments. According to the results, the testing indicated that the content of total potassium in leaf, stem and root of seedling and soil available potassium in grape seedling monoculture were all higher than that in intercropping treatments, and the content was all ranked as: grape seedling intercropping with PSSG < intercropping with PSDG < intercropping with PSG < intercropping with UG < grape seedling monoculture. In terms of soil available potassium, the content had no significant difference when grape seedling intercropped with PSSG, PSDG and PSG. So while intercropping with *Impatiens balsamina* of post-grafting generation, the total potassium and soil available content could not increase. On the contrary, it decreased. Therefore, intercropping treatment did not play a positive role in potassium uptake and had no significant promoting effects on plant growth and development.

1. Introduction

It is a topic of conversation that heavy metal contamination in orchard, indirectly, has a significant impact on human health. There is a study showing about heavy metals and their health risks in fruits and the apple orchard soils in Northeast China [1]. Obviously, there are countless examples of that. So gardeners have to consider ways to control heavy metal pollution in orchards [2]. Intercropping is a simple and effective method, and it is also an ancient agricultural practice that influences biomass accumulation and nutrient absorption of plant [3], in particular, the absorption of potassium mentioned in this experiment. The potassium content increased when cherry seedling intercropping with two ecotypes of enriched plants (mine ecotype and non-mine ecotype) under cadmium stress [4]. Intercropping with *I. balsamina* reduces the nutrient uptake of grape seedling under the stress of cadmium [5].

*Impatiens balsamina*, an annual herbaceous plant in the Balsamineaceae family, is also called rose balsam or garden balsam acted as an ornamental plants in gardens, and they are applied to traditional...
Chinese medicine for human health and also used as anticancer herb or a kind of vegetable [6]. Therefore, grape seedlings and \textit{I. balsamina} seedlings were regarded as materials to intercrop in this experiment, so that the effects of potassium uptake can be made clear.

2. Materials and methods

2.1. Materials

The experimental field was located at Chengdu Campus of Sichuan Agricultural University. In October 2014, the \textit{I. balsamina} seeds were gathered from the same \textit{I. balsamina} with yellow-flowered and double-petaled in the surrounding farmland. In May 2015, the cutting seedlings of grape were Kyoho, which bought from breeding base in Longquanyi, Chengdu. The experimental soil was also collected from the surrounding farmland, pH 7.09, the available potassium 149.58 mg·kg\(^{-1}\), and the total potassium 18.01 g·kg\(^{-1}\), and the measurement indexes of the soil chemical properties and basic physical were based upon references [7]. The cadmium regarded as a heavy metal was in the testing. The Cd (in the form of CdCl\(_2\)·2.5H\(_2\)O) was added into the soil, and Cd concentration in soil was 5 mg/kg.

2.2. Experimental design

In October 2014, the \textit{I. balsamina} seeds were germinated in the climate chamber, separated into two batches of \textit{I. balsamina} seedlings at the beginning, and the growth of the two seedlings must be guaranteed at a two-week interval. While the first batch of seedlings were approximately 5 cm higher (the second batch of seedlings were approximately 10 cm higher), the grafting treatments were set up, concretely as follows: (1) Ungrafted of \textit{I. balsamina} seedlings: the seedlings transplanted directly, gathered the seeds and preservatives as the ungrafted generation of \textit{I. balsamina} (UG). (2) The same one seedling for own-rooted grafting: the seedlings were sheared off from 6 cm overground, and selected the upper parts as scions and the lower as rootstocks. When the seeds of the grafted plant matured which were gathered and preserved soon afterwards, as the post-grafting generation of \textit{I. balsamina} of own-rooted grafting by the same one seedling (PSG). (3) The same size of two seedlings for own-rooted grafting: the seedlings were about 10 cm high, one was sheared off from 6 cm overground, made the lower parts as rootstocks; the other one was sheared off from 6 cm overground, made the upper parts as scions (4 cm), and gathered the seeds and preserved as the post-grafting generation of \textit{I. balsamina} of own-rooted grafting by the same size of two seedlings (PSSG). (4) The different sizes of two seedlings for own-rooted grafting: While seedlings were about 10 cm high, sheared off from 6 cm overground, the lower parts were selected as rootstocks. The scions that sheared off the upper seedling (4 cm) from \textit{I. balsamina} seedlings were about 5 cm high. The seeds were gathered and preserved as the post-grafting generation of \textit{I. balsamina} of own-rooted grafting by the different sizes of two seedlings (PSDG). In four grafting treatments, the rootstock leaves were retained after grafting.

The preserved seeds as the descendants of \textit{I. balsamina} were placed in the climate chamber for germination and further cultivation in May 2015. Until the two true leaves expanded, the \textit{I. balsamina} seedlings were transplanted into plastic pot to intercrop with grape seedlings. For this experiment, there were five intercropping treatments: grape seedling monoculture, grape seedling intercropping with PSSG, PSDG, PSG and UG, respectively. Every pot had two seedlings that one was grape seedling and the other one was \textit{I. balsamina} seedling from different treatments. Each treatment was set up for six repetitions, and the interval between two pots was 15 cm. In order to reduce the impact of the marginal utility, the pot position exchanged regularly. Until harvesting the plants, the content of soil moisture was always retained at 80% of field capacity.

After 60 days, grape seedlings were dug out, separated into leaf, stem and root for three parts. After that, they were washed by tap-water firstly, and then three times of washing by deionized water. Finally, obtained the fresh weight by weighing and then simmered for 10 min at 115 °C in the oven. The whole plants were dried at 85 °C as far as constant weight, then weighed, and got the amount of
dry matter by a 100-mesh sieve for the measurement of total potassium content in leaf, root and stem of grape seedling and the content of available potassium in soil.

3. Results and discussion

3.1. Available K content in soil

The soil available potassium content in grape seedling monoculture was the highest. Intercropping with PSSG, PSDG, PSG and UG prominently reduced the soil available potassium content under stress of cadmium, and which decreased by 43.17%, 41.16%, 39.18% and 15.11%, respectively (Figure 1, $P < 0.05$). The content of soil available potassium had no obvious difference when grape seedling intercropped with PSSG, PSDG and PSG. But they evidently reduced compared with grape seedling monoculture.

3.2. Total K content in leaf of grape seedling

In grape seedling monoculture, the total potassium content was prominently higher than that in intercropping treatments, and the content in leaves was reduced by 41.76%, 38.98%, 28.94% and 26.64% compared with the control when grape seedling intercropped with PSSG, PSDG, PSG and UG (Figure 2, $P < 0.05$). There was no obviously difference between grape seedling intercropping with PSG and UG. Similarly, intercropping with PSSG, the total potassium content was the lowest in leaf.

3.3. Total K content in stem of grape seedling

From figure 3, it appeared that the total potassium content in stems was respectively decreased by 42.88%, 20.38%, 35.02% and 13.01% compared to the control when grape seedling intercropped with PSSG, PSDG, PSG and UG (Figure 3, $P < 0.05$).

3.4. Total K content in root of grape seedling

In grape seedling monoculture, the total potassium content was the highest in roots. However, intercropping with PSSG, PSDG, PSG and UG were all remarkably lower than monoculture and reduced by 51.45%, 40.51%, 35.16% and 29.89%, respectively (Figure 4, $P < 0.05$). When grape seedling intercropped with the *I. balsamina* of post-grafting generation of own-rooted grafting by the same sizes of two seedlings, the K content in roots was the lowest.
4. Conclusions

There were five treatments being set up with grape seedling and *I. balsamina* of post-grafting generation in this experiment, and aimed at the absorption of total potassium in parts of grape seedling and soil available potassium under the stress of cadmium. The results showed that the content of total potassium in leaf, stem and root was the highest in grape seedling monoculture. Similarly, in soil, the content of available potassium was also the highest in monoculture. For intercropping treatments, the total potassium content in parts of seedlings showed the same change trend, and the order was: grape seedling intercropping with PSSG < intercropping with PSDG < intercropping with PSG < intercropping with UG < grape seedling monoculture. The testing showed that the total potassium content was higher than other intercropping treatments when grape seedling intercropped with the *I. balsamina* of ungrafted generation.

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