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

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Abstract. To study the effects of intercropping with post-grafting generation of *Impatiens balsamina* on photosynthesis of grape seedlings, a plurality of photosynthesis indicators of the grape were measured by a pot experiment. The results showed that intercropping with ungrafted and post-grafting generation of *I. balsamina* all reduced the photosynthesis parameters of grape to some extent. After four intercropping treatments, the net photosynthetic rate (Pn), stomatal conductance (Gs), CO_2 concentration of intercellular (Ci), transpiration rate (Tr) and value of pressure deficit leaf (Vpdl) were all lower than that of grape monoculture. Therefore, intercropping with post-grafting generation of *I. balsamina* could not improve but reduce the photosynthesis of grape seedling.

1. Introduction

Grafting is an agronomic measure widely used in the production of fruit trees and vegetables. It has important application value in improving plant yield, stress resistance and improving fruit quality [1]. Different grafting methods significantly affect the growth and development of plants [2]. Intercropping is an important production mode in agricultural production [3]. After intercropping, Plants will change the utilization of light energy as well as the water and nutrients resource underground [4-5]. The effects of intercropping on chlorophyll synthesis, soluble protein content and antioxidant enzyme activities of plants under heavy metal stress have been studied [6], while there is less research on photosynthesis. Therefore, we used grape seedlings and *Impatiens balsamina* to intercrop to study the effects on photosynthetic characteristics of grape seedlings.

2. Materials and methods

2.1. Materials

The seeds of the *I. balsamina* used in this experiment were collected from the same plant in the farmland surrounding Chengdu Campus of Sichuan Agricultural University (30°42′ N, 103°50′ E). The species of the experimental cultivar of grape is Kyoho and the cutting seedlings were purchased from seedling base in Longquanyi area of Chengdu. The soil for the experiment was collected from the surrounding farmland at Chengdu campus of Sichuan Agricultural University.

2.2. Experimental design
The seeds were collected from the same flower of *I. balsamina*. Then, they were put in the climate chamber to germination in two batches whose interval was 2 weeks. Grafting treatment was carried out when the first batch of seedlings were about 10 cm higher (the second batch of seedlings were about 5 cm higher), the grafting treatments are as follows: (1) Ungrafted: the seedlings of *I. balsamina* transplanted directly, and the seeds were collected for preservation as the ungrafted generation of *I. balsamina* (UG). (2) Self-rooted grafting by the same one seedling: the seedlings of *I. balsamina* were cut off from 6 cm above the ground. The upper parts were scion and the lower parts were rootstock, and then retained rootstock leaves. Scions and rootstocks were physiologically consistent and collected seeds for preservation as the post-grafting generation of *I. balsamina* of self-rooted grafting by the same one seedling (SG). (3) Self-rooted grafting by two different sizes seedlings: *I. balsamina* seedlings were about 10 cm high, cut off from 6 cm above the ground, the lower parts were rootstock. The scions were cut the upper seedling (4 cm) from seedlings of *I. balsamina* which were about 5 cm high, and the leaves of rootstock were retained after grafting. There is a big difference between the scion and rootstock in physiology, and the seeds were collected for preservation as the post-grafting generation of *I. balsamina* of self-rooted grafting by two different sizes seedlings (SDG). (4) Self-rooted grafting by two same sizes seedlings: when the *I. balsamina* seedlings were about 10 cm high, one was cut off from 6 cm above the ground, kept the lower parts as rootstocks; one was cut off from 6 cm above the ground, kept the upper parts as scion (4 cm). The leaves of rootstock were retained after grafting. Scion and rootstock are different in physiology, and seeds should be collected for preservation as the post-grafting generation of *I. balsamina* of self-rooted grafting by two same sizes seedlings (SSG).

The seeds of *I. balsamina* that treated with different grafting technologies were put in the climate chamber to germination and further cultivation. Then, the seedlings of *I. balsamina* were transplanted together with grape seedlings into a pot containing soil with a Cd concentration of 5 mg/kg when the two true leaves expanded. There were five treatments in the experiment: grape monoculture (MG), grape seedling intercropping with UG (IUG), grape seedling intercropping with SG (ISG), grape seedling intercropping with SDG (ISDG) and grape seedling intercropping with SSG (ISSG). One *I. balsamina* seedling of different treatments and one grape seedling were transplanted into each pot. For each treatment with six replicates and the pots placed completely random. The distance between pots was 15 cm, and the position of pots was exchanged periodically to weaken the impact of the marginal effects. The soil moisture content was maintained at 80% of field capacity until the plants were harvested.

After 2 months,The photosynthetic parameters of the photosynthesis meter were manual control CO2 concentration 400 μmol/mol, temperature 30 °C, light intensity 1000 μmol/m2/s. The determination of photosynthetic parameters was Pn, Gs, Ci, Tr and Vpdl, and each treatment was repeated for three times.

2.3. Statistical analyses
Statistical analyses were carried out by SPSS 17.0 statistical software. Data were analyzed by one-way analysis of variance with least significant difference (LSD) at 5% confidence level.

3. Results and discussion

3.1. Net photosynthetic rate of grape seedling
Under cadmium stress, the net photosynthetic rate of grape seedling intercropping with UG, SG, SDG and with SSG was lower than that of grape monoculture (Figure 1, $p < 0.05$), which decreased by

2.28%, 3.25%, 6.6% and 14% respectively. Among them, the net photosynthetic rate of the grape intercropping with SDG and SSG was significantly reduced compared with monoculture.

3.2. Stomatal conductance of grape seedling

Compared with monoculture, intercropping with UG reduced the stomatal conductance of grape only by 1.9% (Figure 2, $p < 0.05$), which was insignificantly, while the stomatal conductance of grape intercropping with SG, SDG and with SSG was lower than that of grape monoculture significantly, which decreased by 7.86%, 22.84% and 20.73% respectively.

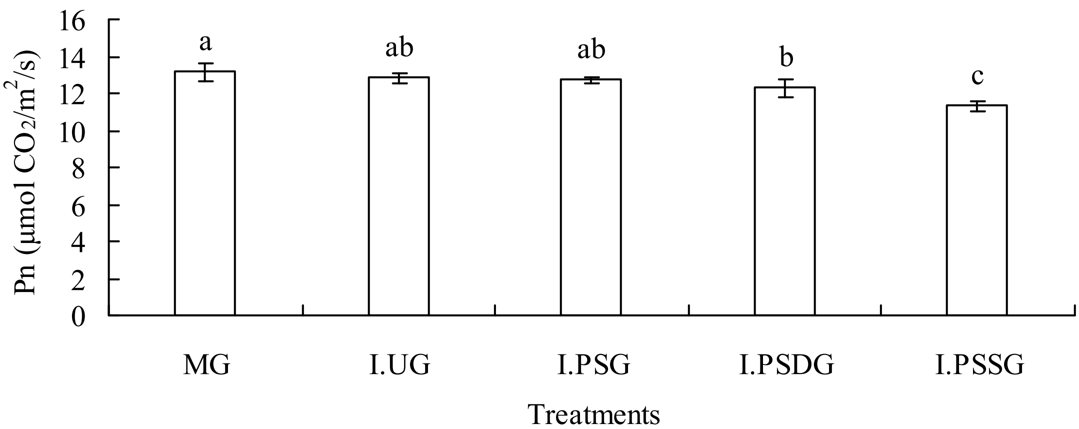

Figure 1 Net photosynthetic rate of grape seedling

Means with the same letter within each column are not insignificantly different at 0.05 levels.

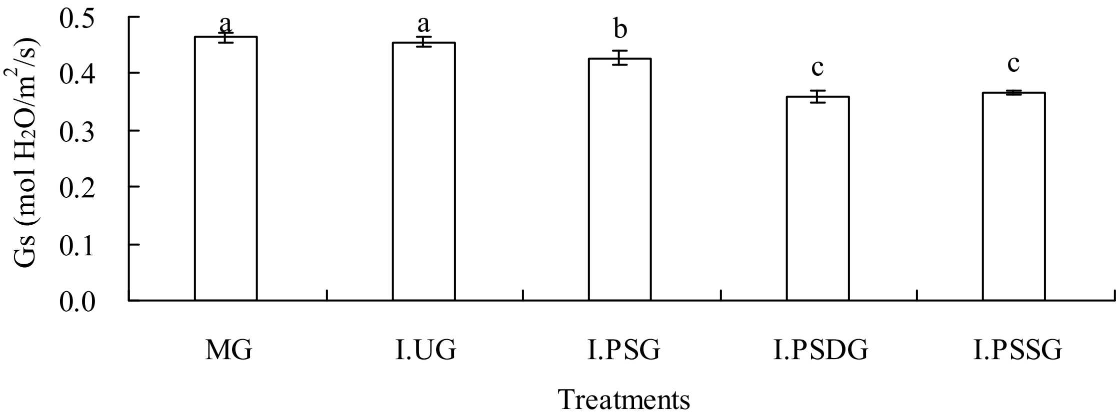

Figure 2 Stomatal conductance of grape seedling

Means with the same letter within each column are not insignificantly different at 0.05 levels.

3.3. CO_2 concentration of intercellular of grape seedling

Under cadmium stress, intercropping with UG, SG and SDG all reduced the CO_2 concentration of intercellular compared with monoculture (Figure 3, $p < 0.05$), which decreased by 0.9%, 1.95% and 2.51% respectively, while the CO_2 concentration of intercellular of grape intercropping with SSG was the lowest, which decreased by 3.93%.

3.4. Transpiration rate of grape seedling

The transpiration rate of grape seedling intercropping with UG, SG, SDG and with SSG was lower than that of grape monoculture significantly (Figure 4, $p < 0.05$), which decreased by 15.29%, 16.84%, 26.85% and 29.36% respectively.

3.5. Value of pressure deficit leaf of grape seedling

Intercropping with UG reduced the value of pressure deficit leaf of grape by 1.45% compared with monoculture (Figure 5, $p < 0.05$), while the value of pressure deficit leaf of grape intercropping with SG, SDG and SSG was decreased by 11.26%, 12.97% and 28.73% respectively, which was reduced significantly.

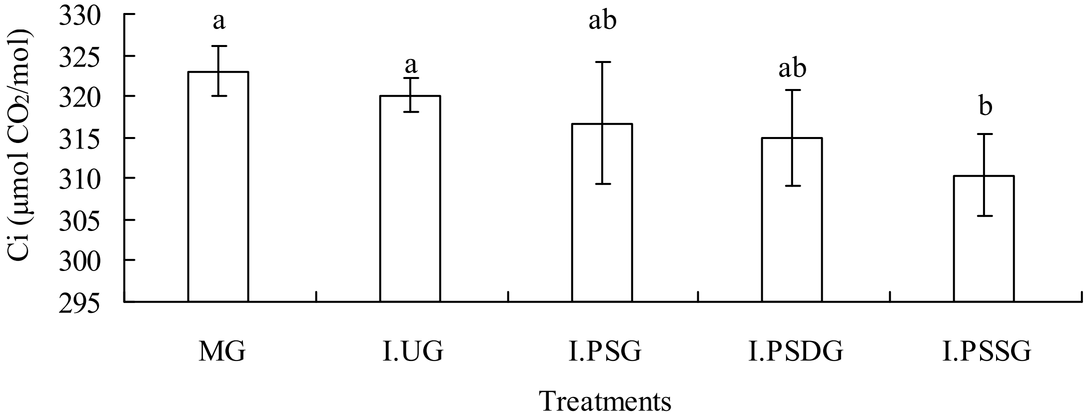

Figure 3 CO2 concentration of intercellular of grape seedling
Means with the same letter within each column are not insignificantly different at 0.05 levels.

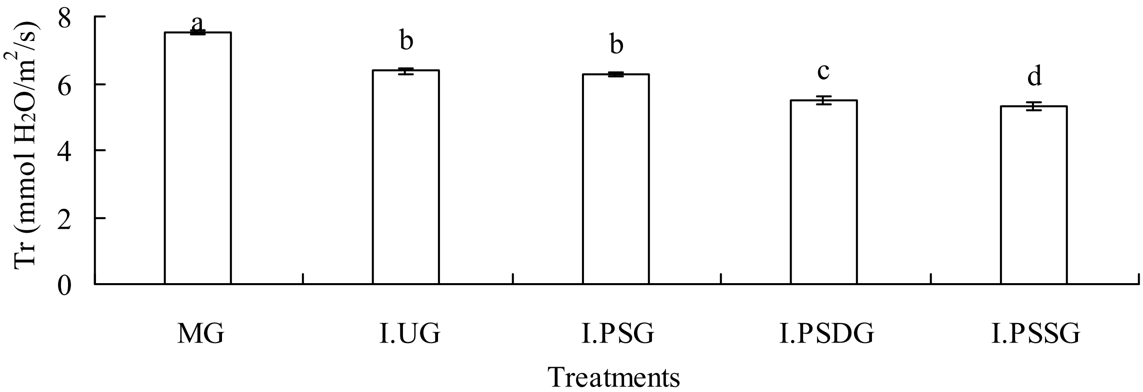

Figure 4 Transpiration rate of grape seedling
Means with the same letter within each column are not insignificantly different at 0.05 levels.

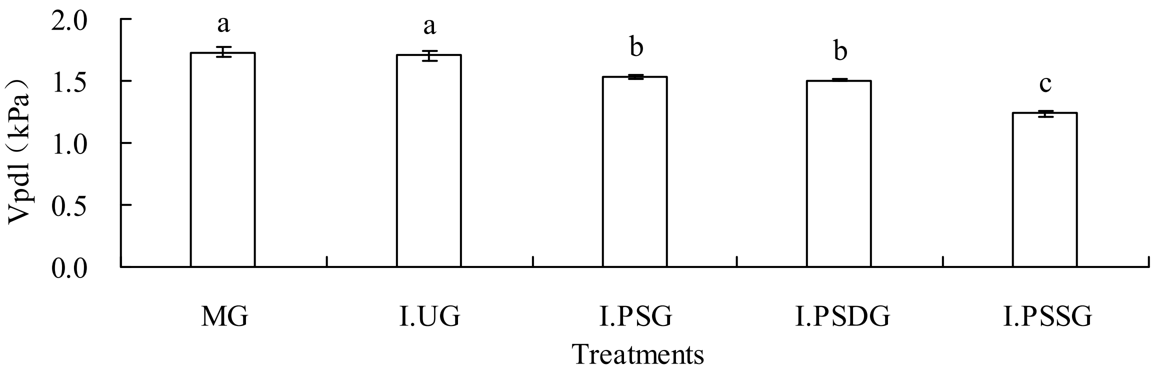

Figure 5 Value of pressure deficit leaf of grape seedling
Means with the same letter within each column are not insignificantly different at 0.05 levels.

4. Conclusions

Under Cd stress, after four intercropping treatments, the results showed that intercropping with ungrafted and post-grafting generation of *I. balsamina* all reduced the Pn, Gs, Ci, Tr and Vpdl of grape seedling, among them. The Tr was affected most significantly, with a maximum decrease of 29.36% compared with grape monoculture. Therefore, intercropping with post-grafting generation of *I. balsamina* is not conducive to the photosynthesis of grape in general.

Acknowledgements

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