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Effects of Living Pterocypsela laciniata and Its Straw on Phosphorus Uptake of Grape Seedlings under Selenium Stress

Effects of Living Pterocypsela laciniata and Its Straw on Phosphorus Uptake of Grape Seedlings under Selenium Stress

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Abstract. Based on the selenium stress, the effects of living *Pterocypsela laciniata* and its straws on phosphorus (P) uptake of grape seedlings were carried out. There were some important results and showed that in parts of grape seedlings. The total P content was lower in roots than that in stems, leaves and shoot. Among five treatments, there was quite different about the total P content. Compared to grape seedlings monoculture, living *P. laciniata* and its straws could significantly increase the total P content in parts of grape seedlings. Among them, applying the leaf straw of *P. laciniata* in soil made the total P content the highest. For the total P content in root, stem, leaf and shoot of grape seedlings, it was always ordered from high to low: PLG > PG > PRG > PSG > MG. The available P content in soil was a little changed in relation to the total P content in plants. Applying *P. laciniata* straws also could increase the available P content. On the contrary, grape seedlings intercropping with *P. laciniata* seedlings decreased the available content, compared to the monoculture. In a word, living *P. laciniata* and its straws was good for the growth of grape seedlings and improved the P uptake in plants.

1. Introduction

This experiment was based on selenium stress for talking about the phosphorus (P) uptake. Selenium is an essential mineral element for human beings and animals and provide sufficient plant nutrients to meet the global food demand [1-2]. Study on soil P fraction is a necessary aspect in probing the mechanisms of P accumulation in farmland [3]. Straw retention can decrease the available P content in the soil, but during plant growth, it dose not alter the trend of available P content in soil [4]. Furthermore, straws provide sufficient P to grow plant without additional P [5]. The study was conducted to research the P uptake by living *Pterocypsela laciniata* which showed the characteristics of a Cd hyperaccumulator and a perennial herb of *Pterocypsela* [6-7]. *P. laciniata* was selected as material to find out the P absorption mechanism in grape seedlings under selenium stress.

2. Materials and methods

2.1. Materials

During this experimental process, grape and *P. laciniata* seedlings were used as materials to study the effects of P uptake by living *P. laciniata* and its straw. The seeds of *P. laciniata* were collected from the farmland around Sichuan Agricultural University. In January 2019, the soil was also supposed to prepare and weighed 3 kg air-dried soil putting into each plastic pot (15 cm high, 18 cm in diameter), soaking uniformly by 10 mg/kg Se (in the form of Na_2SeO_3) solution for four weeks.

2.2. Methods

In January 2019, the *P. laciniata* seeds were placed in the climate chamber for culture. At the same time, the cutting seedlings of grape for the experiment were prepared. In February 2019, it was time to select uniform seedlings for intercropping while the fifth true leaves grew from *P. laciniata* seedlings. Three grape seedlings were transplanted into pot for monoculture and two of them intercropped with one *P. laciniata* seedlings. Furthermore, some *P. laciniata* seedlings were collected and divided into three parts of root, stem and leaf. Then, using deionized water to wash them for three times and simmered for 15 min at 110 °C. Finally, dried at 80 °C until constant weight and cut them into small pieces less than 1 cm as different straws. The three parts of *P. laciniata* straws were respectively blended with soil. Each pot contained 6 g *P. laciniata* straws and it meant that every kilogram soil was mixed with 2 g straws of *P. laciniata*. The soil was kept moist and balanced for one week. Then three uniform grape seedlings were transplanted into soil with straws. In a word, this experiment consisted of five treatments: (1) grape seedlings monoculture (MG); (2) grape seedlings intercropping with *P. laciniata* seedlings (PG); (3) applying the leaf straw of *P. laciniata* in soil with grape seedlings (PLG); (4) applying the stem straw of *P. laciniata* in soil with grape seedlings (PSG); (5) applying the root straw of *P. laciniata* in soil with grape seedlings (PRG). Each treatment set up three repetitions and the soil moisture was made 80%. Also, the distance between pots was 15 cm and the position was often exchanged to mitigate marginal effects.

After 2 months, the soil was collected and the whole grape seedlings were harvested and divided into three parts of root, stem and leaf, and washed them successively with tap water and deionized water. Then weighed the fresh weight, simmered for 15 min at 110 °C, dried at 80 °C until constant weight and passed through a 100-mesh sieve to analyze P content of root, stem, leaf and shoot and the dried soil was also to measure the available P content [8].

3. Results and discussion

3.1. Total P content in root of grape seedlings

Under selenium stress, the total P content in root of grape seedling had significant difference in five treatments (Figure 1). Among them, applying the leaf straw of *P. laciniata* made the content the highest. Compared to grape seedlings monoculture, the total P content in PG, PLG, PSG and PRG was all higher. It meant that grape seedlings living *P. laciniata* and its straws could increase the total P content and was beneficial for the growth of grape seedlings.

3.2. Total P content in stem of grape seedlings

For the total P content in stems, it was still the highest when applying the leaf straw of *P. laciniata* in soil with grape seedlings (Figure 2). There was no significant difference between PG and PLG. However, applying the stem or root straw of *P. laciniata* decreased the total P content in stem of grape seedlings compared with applying the leaf straw. Living *P. laciniata* and its straws could increase the total P content and it was increased by 297.35% ($p < 0.05$), 320.88% ($p < 0.05$), 69.55% ($p < 0.05$) and 152.42% ($p < 0.05$), respectively, compared with the control.

3.3. Total P content in leaf of grape seedlings

From Figure 3, it showed that the total P content in leaves had prominent change among treatments. Compared to the monoculture, grape seedlings intercropping with *P. laciniata* seedlings and applying the *P. laciniata* straws in soil always increased the total P content in leaf which was ranked as: PLG > PG > PRG > PSG > MG. By calculation, the content was increased by 228.24% ($p < 0.05$), 266.58% ($p < 0.05$), 150.18% ($p < 0.05$) and 187.01% ($p < 0.05$), respectively.

IOP Conf. Series: Earth and Environmental Science **310** (2019) 042042 doi:10.1088/1755-1315/310/4/042042

3.4. Total P content in shoot of grape seedlings

In terms of the total P content in shoot, it presented the same change trend as that in roots and leaves (Figure 4). Similarly, living *P. laciniata* and its straws significantly increased the content of total P in shoot of grape seedlings. Also, applying leaf straw of *P. laciniata* in soil could increase the content the best. The order of the total P content from high to low was also the same: PLG > PG > PRG > PSG > MG. Compared with the control, the content was increased by 248.82% ($p < 0.05$), 282.38% ($p < 0.05$), 127.07% ($p < 0.05$) and 176.97% ($p < 0.05$), respectively.

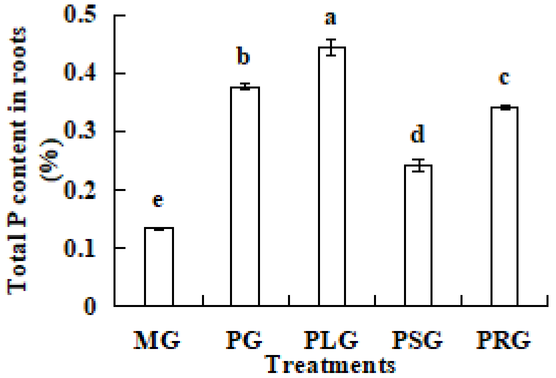

Figure 1. Total P content in roots of grape seedlings. Different lowercase letters indicated significant differences among treatments at 0.05 levels. MG = grape seedlings monoculture; PG = grape seedlings intercropping with *P. laciniata* seedling; PLG = applying the leaf straw of *P. laciniata* in soil with grape seedlings; PSG = applying the leaf straw of *P. laciniata* in soil with grape seedlings; PRG = applying the leaf straw of *P. laciniata* in soil with grape seedlings.

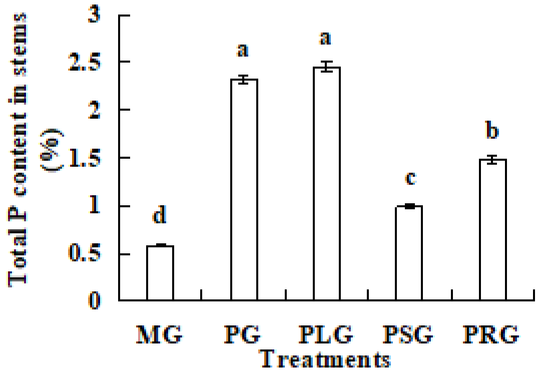

Figure 2. Total P content in stems of grape seedlings. Different lowercase letters indicated significant differences among treatments at 0.05 levels. MG = grape seedlings monoculture; PG = grape seedlings intercropping with *P. laciniata* seedling; PLG = applying the leaf straw of *P. laciniata* in soil with grape seedlings; PSG = applying the leaf straw of *P. laciniata* in soil with grape seedlings; PRG = applying the leaf straw of *P. laciniata* in soil with grape seedlings.

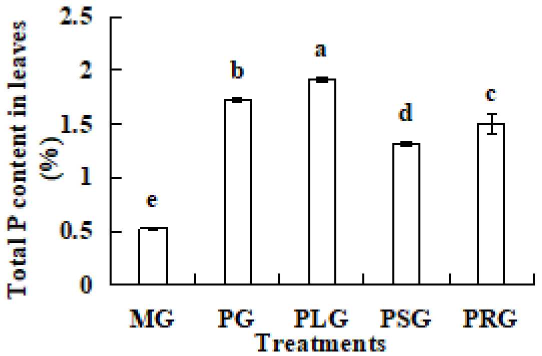

Figure 3. Total P content in leaves of grape seedlings. Different lowercase letters indicated significant differences among treatments at 0.05 levels. MG = grape seedlings monoculture; PG = grape seedlings intercropping with *P. laciniata* seedling; PLG = applying the leaf straw of *P. laciniata* in soil with grape seedlings; PSG = applying the leaf straw of *P. laciniata* in soil with grape seedlings; PRG = applying the leaf straw of *P. laciniata* in soil with grape seedlings.

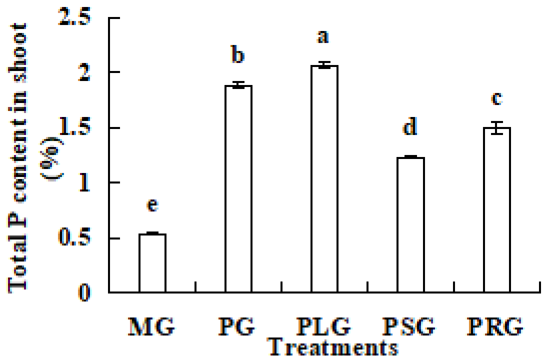

Figure 4. Total P content in shoots of grape seedlings. Different lowercase letters indicated significant differences among treatments at 0.05 levels. MG = grape seedlings monoculture; PG = grape seedlings intercropping with *P. laciniata* seedling; PLG = applying the leaf straw of *P. laciniata* in soil with grape seedlings; PSG = applying the leaf straw of *P. laciniata* in soil with grape seedlings; PRG = applying the leaf straw of *P. laciniata* in soil with grape seedlings.

3.5. Available P content in soil

There was a big difference between the P content in plant and soil. The Figure 5 appeared the content of available P in soil. Among five treatments, applying *P. laciniata* straws in soil could significantly increase the available P content. But on the contrary, the content was decreased while grape seedlings intercropping with *P. laciniata* seedlings. So the available P content from high to low was ranked as: PRG > PSG > PLG > MG > PG. Then compared with PG, the available P content was increased by 40.36% ($p < 0.05$), 81.39% ($p < 0.05$), 97.74% ($p < 0.05$) and 115.11% ($p < 0.05$), respectively.

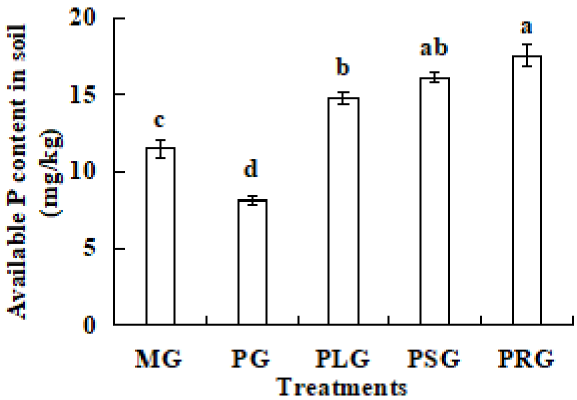

Figure 5. Available P content in soil. Different lowercase letters indicated significant differences among treatments at 0.05 levels. MG = grape seedlings monoculture; PG = grape seedlings intercropping with *P. laciniata* seedling; PLG = applying the leaf straw of *P. laciniata* in soil with grape seedlings; PSG = applying the leaf straw of *P. laciniata* in soil with grape seedlings; PRG = applying the leaf straw of *P. laciniata* in soil with grape seedlings.

4. Conclusions

Under selenium stress, this experiment was setting up five treatments to study the effects of living *P. laciniata* and its straws on P uptake in plants and soil. The results showed that the P content was different in parts of grape seedlings. Similarly, it was different among five treatments. In parts of grape seedlings, the total P content was higher while applying leaf straw of *P. laciniata* in soil and then it was intercropping. All in all, living *P. laciniata* and its straws could increase the total P content in plants. But in soil, the available P content was decreased by intercropping but increased while applying straws. In brief, applying *P. laciniata* straws was good for the growth of grape seedlings.

References

[1] White, P.J. (2015) Selenium accumulation by plants. Ann. Bota., 117: 217-235.

[2] Battini, F., Grønlund, M., Agnolucci, M., Giovannetti, M., Jakobsen, L. (2017) Facilitation of phosphorus uptake in maize plants by mycorrhizosphere bacteria. Sci. Repor., 7: 4686.

[3] Li, Y.Y., Yang, R., Gao, R., Wei, H.A., Chen, A.L., Li, Y. (2015) Effects of long-term phosphorus fertilization and straw incorporation on phosphorus fractions in subtropical paddy soil. J. Integra. Agric., 14: 365-373.

[4] Yan, C., Zhan, H.Q., Yan, S.S., Dong, S.K., Ma, C.M., Song, Q.L., Gong, Z.P. (2015) Effects of straw retention and phosphorous fertilizer application on available phosphorus content in the soil solution during rice growth. Padd. Water Environ., 14: 61-69.

[5] Lee, J., Moon, j., Kim, H., Ha, I., Lee, S. (2011) Reduced nitrogen, phosphorus, and potassium rates for intermediate-day onion in paddy soil with incorporated rice straw plus manure. HortScience: Publ. Am. Soci. Hort. Sci., 46: 470-474.

[6] Zhong, L.S., Lin, L.J., Liao, M.A., Wang, J., Tang, Y., Sun, G.C., Liang, D., Xia, H., Wang, X., Zhang, H.F., Ren, W. (0) Phytoremediation potential of *Pterocypsela laciniata*, as a cadmium hyperaccumulator. Environ. Sci. Poll. Res., pp.1-9.

IOP Conf. Series: Earth and Environmental Science **310** (2019) 042042 doi:10.1088/1755-1315/310/4/042042

[7] Xu, D., Wei, Y., Gao, Y. (2018) Study on selenium accumulation characteristics of *Pterocypsela laciniata*. IOP Confer. Ser. Earth & Environ. Sci., 199: 042025.
[8] Bao. J.F. (2006) Plant Physiology Experiment Guide. Higher Education Press, Beijing, China.