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

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Abstract. Pot experiments were conducted to investigate the nitrogen (N) uptake of grape seedlings by intercropping and straw applying of *Pterocypsela laciniata*. The results showed that five treatments: the monoculture of grape, grape intercropping with *P. laciniata*, the root straw of *P. laciniata* applied, the stem straw of *P. laciniata* applied and the leaf straw of *P. laciniata* applied. All treatments significantly increased the content of total N in grape roots, leaves and shoots of grape seedlings. The straw applying significantly increased the content of total N in grape stems, and the stem straw of *P. laciniata* had the greatest effect on promoting N uptake of grape. When the stem straw of *P. laciniata* was applied, the soil alkali solution N content was increased by 9.93%. Therefore, applying stem straw of *P. laciniata* can not only promote N uptake by grape but also increase soil alkali solution N content.

1. Introduction

Nitrogen (N) is the most important component of plant structure [1] and has a lot to do with crop yield and quality. Application of N Fertilizer is an important measure to improve the yield and quality of Agricultural products. Since the eighties of last century, the application rate of N fertilizer has been increasing in China as a whole. However, the N use rate is low and large amount of N fertilizer loss [2]. Excessive N in the soil will cause a series of ecological and environmental problems through ammonia volatilization, leaching, runoff, nitrification, and denitrification [3-5]. China is carrying out the strategy of zero growth of fertilizer to alleviate agricultural pollution and promote the sustainable development of agriculture [6]. Therefore, it is of great practical significance to explore new measures of reducing fertilizer use and enhancing efficiency.

Intercropping has the function of increasing yield and improving quality [7]. There are many studies about intercropping promoting N uptake by crops. For instance, intercropping potato with oat can increase the N content of potato [8], intercropping oat with sunflower can significantly increase the amount of N absorbed by both of them [9], intercropping rice with water spinach can promote the uptake of N in rice and so on [10]. Straw resources in our country have a large yield but the utilization efficiency is low. With the development of rural economy and society, straw resource is gradually being replaced and straw resources gradually surplus. How to deal with the surplus straw becomes a big problem [11-12]. Crop straw is rich in N, phosphorus, potassium and many trace elements [13]. Studies have shown that straw could increase total N, biological N and dissolved N in soil by returning to field, and the effects depended on the type and amount of straw [14-15].



Grape is a famous fruit. Selenium is an indispensable element of the human body, and China is a selenium deficient country [16-17]. Application of selenium fertilizer in soil is a common method of producing se-rich grape. There are few reports on increasing the N content of se-rich grape plants through intercropping and straw returning.

2. Materials and Methods

2.1. Materials

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 which is 15 cm high and 18 cm in diameter, soaking uniformly by 10 mg/kg Se (in the form of Na₂SeO₃) solution for four weeks.

2.2. Experiment design

In January 2019, the *P. laciniata* seeds were placed in the climate chamber for culture. And 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 the soil which contained straw. All in all, this experiment consisted of five treatments: (1) grape seedlings monoculture (control), (2) grape seedlings intercropping with *P. laciniata* seedlings (IGP), (3) applying the leaf straw of *P. laciniata* in soil with grape seedlings (RSP), (4) applying the stem straw of *P. laciniata* in soil with grape seedlings (SSP), (5) applying the root straw of *P. laciniata* in soil with grape seedlings (LSP). 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 60 days, 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 soluble sugar content of root, stem, leaf and shoot [18].

2.3. Statistical analyses

Statistical analyses were performed using SPSS 17.0 (SPSS Inc., Chicago, IL, USA). Data were analyzed by one-way analysis of variance with least significant difference at the 5% confidence level.

3. Results

3.1. The content of total N in grape roots

Compared with control, the treatments of IGP, RSP, SSP and LSP all significantly increased the content of total N in grape roots (Figure 1). In the intercropping experiment, when intercropped with *P. laciniata* seedlings, the content of total N in grape roots increased by 9.75% ($p < 0.05$). In the straw applying experiment, applying the root, stem and leaf straw of *P. laciniata* increased the content of total N in grape roots by 31.93% ($p < 0.05$), 54.45% ($p < 0.05$) and 37.98% ($p < 0.05$), respectively. The treatments were ranked, from highest total N content in the roots of grape seedlings to lowest, as follows: SSP > LSP > RSP > IGP > control.

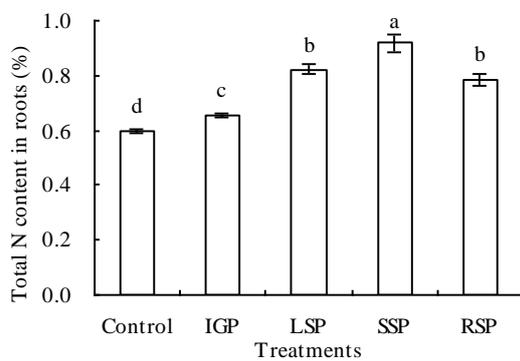


Figure 1. The content of total N in grape roots. Different lowercase letters indicated significant differences among treatments at 0.05 levels.

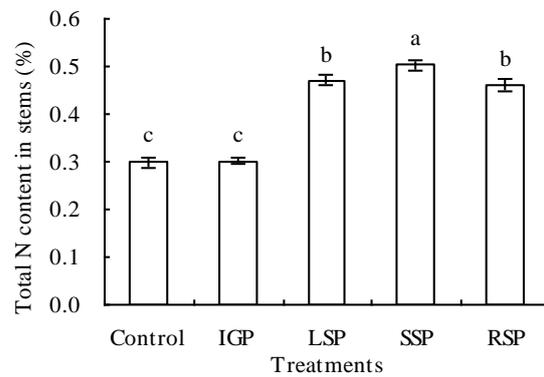


Figure 2. The content of total N in grape stems. Different lowercase letters indicated significant differences among treatments at 0.05 levels.

3.2. The content of total N in grape stems

There was no significant effect of intercropping with *P. laciniata* to increase the total N content in grape stems (Figure 2). However, Applying the root, stem and leaf straw of *P. laciniata* increased the total N content in grape stems by 54.70% ($p < 0.05$), 68.46% ($p < 0.05$) and 58.05% ($p < 0.05$). According to the effect to increase the total N content in stems, the treatments were ranked as follows: LSP > RSP > IGP > control.

3.3. The content of total N in grape leaves

SSP, LSP, RSP and IGP all significantly increased the total N content in grape leaves compared with control (Figure 3). In the intercropping experiment, the total N content in the leaves of grape increased by 22.63% ($p < 0.05$) compared with control. In the straw applying experiment, RSP, SSP and LSP increased the total N content in grape leaves by 24.87% ($p < 0.05$), 30.17% ($p < 0.05$) and 28.54% ($p < 0.05$), respectively. And there were no significant differences among SSP, LSP, RSP and IGP.

3.4. The content of total N in grape shoots

SSP, LSP, RSP and IGP all significantly increased the total N content in grape shoots compared with control (Figure 4). Compared with control, the total N content in the shoots of grape increased by 20.10% ($p < 0.05$) when intercropped with *P. laciniata*, and by 29.27% ($p < 0.05$), 34.80% ($p < 0.05$), 31.66% ($p < 0.05$) respectively when the root, stem and leaf straw of *P. laciniata* applied. The treatments were ranked, from highest total N content in the shoots of grape to lowest, as follows: SSP > LSP > RSP > IGP > control.

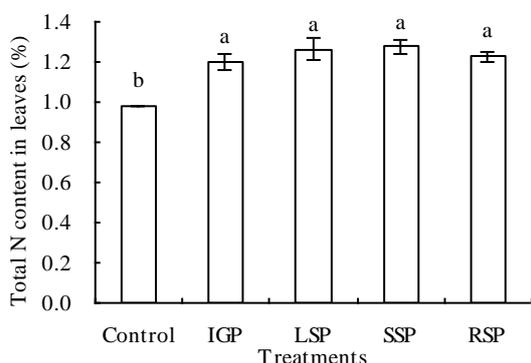


Figure 3. The content of total N in grape leaves. Different lowercase letters indicated significant differences among treatments at 0.05 levels.

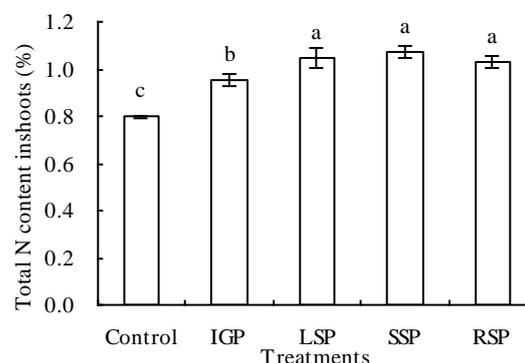


Figure 4. The content of total N in grape shoots. Different lowercase letters indicated significant differences among treatments at 0.05 levels.

3.5. The alkali solution N content in the soil

In the intercropping experiment, there was no significant effect of IGP on soil alkali solution N content compared with control (Figure 5). In the straw applying experiment, RSP, SSP and LSP increased the soil alkali solution N content by 2.33% ($p > 0.05$), 9.93% ($p < 0.05$) and 5.44% ($p > 0.05$) respectively compared with control (Figure 5). In all treatments, only SSP could significantly increase the soil alkali solution N content. The treatments were ranked, from highest alkali solution N content in the soil to lowest, as follows: SSP > LSP > RSP > IGP > control.

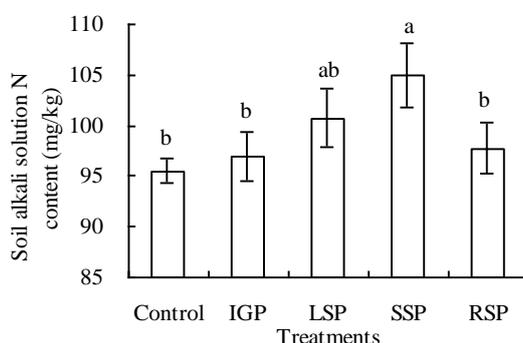


Figure 5. The alkali solution N content in the soil. Different lowercase letters indicated significant differences among treatments at 0.05 levels.

4. Conclusion

Intercropping *P. laciniata* with grape and applying the root, stem, leaf straw of *P. laciniata* can increase the N content in all parts of grape, among which the stem straw has the greatest effect. Besides, applying the stem straws of *P. laciniata* can significantly increase the alkali solution N content in the soil. Therefore, when soil was added selenium fertilizer, applying the stem straw of *P. laciniata* can promote the N uptake by grape greatly.

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