Effects of Chitosan on the Uptake of Total Calcium, Magnesium and Sodium in Peach Seedlings

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Abstract. In this experiment, peach seedlings, as materials, were treated with various concentrations (0, 1, 2, 4 and 6 g/L) of chitosan. The content of total calcium, magnesium and sodium in roots, stems and leaves of peach seedlings were all measured. Overall, the chitosan treatments could increase the total calcium, magnesium and sodium content in roots and stems, especially at chitosan concentration of 2 g/L. In other words, spraying different concentrations chitosan solution could promote the accumulation of nutrient elements and the plants growth. However, the total calcium and sodium content in leaves of chitosan-treated seedlings were significantly lower than that in control seedlings. In soil, the water-soluble calcium content was higher and the water-soluble magnesium and sodium content were all the highest at 2 g/L chitosan concentration. Thus, to a certain extent, it’s good for spraying chitosan solution for the better growth and nutrient uptake of total calcium, magnesium and sodium in peach seedlings.

1. Introduction

Chitosan, a biopolymer, gets from chitin which is the most richest and renewable materials in the world [1]. When it comes to the chitin, it is widely existed in a crab or a shrimp and also is the primary component of fungal cell wall [2]. Chitosan has been applied in agriculture and recently used to promote the growth of plant [3-4]. There are previous studies revealing that the chitosan treatments can affect the growth and selected quality of sunflower sprouts or soybean sprouts [5-6]. In hyperlipidemic patients, chitosan supplementation can maintain the normal content of calcium and magnesium [7]. However, the report on the effect of spraying chitosan on the uptake of total calcium, magnesium and sodium in plant is few, so the purpose of this experiment was to explore that problem.

Peach is part of the genus peach of Rosaceae and also is a relatively primitive variety which has good drought resistance and grafting affinity contributed to other significant researches [8]. There are few studies about the effects of chitosan on elements of peach seedlings, thus, it is valuable to have a research for learning the effect of chitosan on the absorption of nutrients, such as total calcium, magnesium and sodium.

2. Materials and methods

2.1. Materials

Peach seeds were bought from a market where is in Chengdu, Sichuan, China and used as materials for experiment. Non-polluted soil was collected from the Chengdu campus of Sichuan Agricultural University. Meanwhile, the perlite and the Hoagland nutrient solution were bought online for germination experiment.
2.2. Experimental design

The experiment was conducted from April to July 2019 in the greenhouse at the Chengdu campus of Sichuan Agricultural University. Peach seeds were seeded into perlite and watered every 3 days, irrigated with Hoagland nutrient solution every 3 days after the seeds were sprouted. Four peach seedlings with identical growth potential were transplanted to a pot (15 cm height × 18 cm diameter) containing 3 kg prepared non-polluted soil, when the seedlings reached a height of 10 cm (or with about seven true leaves). At early growth stage, the soil moisture content was kept about 80% of field capacity. At 7 days after transplantation, the whole leaves of peach seedlings were sprayed with chitosan solutions (0, 1, 2, 4 and 6 g/L) until water droplets formed on the foliar surface and without dripping. Each treatment was set up repetition for three times.

The roots, stems and leaves of each peach seedling were separately harvested at one month after chitosan treatments, then washed with tap water and deionized water for three times. The various organs of peach seedlings were blanched at 110 °C for 15 min, dried at 75 °C for the constant weight, and then weighed. The dried tissue samples were finely ground for the determination of all kinds of nutrient elements content (such as total calcium, magnesium and sodium content). The total calcium and magnesium content were measured with EDTA titration and the total sodium content was determined by flame spectrophotometer [9]. Regarding the experimental soil, it was collected, dried and sifted for the measure of water-soluble calcium, magnesium and sodium content [10].

2.3. Statistical analyses

Statistical analyses were conducted to use statistical software of SPSS 17.0. The data were analyzed by one-way ANOVA with least significant difference at 5% confidence level.

3. Results and discussion

3.1. Total calcium content in peach seedlings

From table 1, the total calcium content in leaves of peach seedlings was higher than that in roots and stems. Among five treatments, the content in roots or stems increased with increasing chitosan concentration up to 2 g/L, but decreased if the chitosan concentration was greater than 2 g/L. At the chitosan concentration of 6 g/L, the content was the lowest in roots and the content of stems in chitosan-treated seedlings was all higher than that in control seedlings. The total calcium content in leaves gradually reduced with increasing chitosan concentration up to 6 g/L.

| Treatments (g/L) | Roots (mg/g) | Stems (mg/g) | Leaves (mg/g) |
|-----------------|--------------|--------------|---------------|
| 0               | 10.20±0.067c | 10.52±0.716b | 18.98±0.785a  |
| 1               | 10.70±0.240c | 10.57±0.157b | 18.41±0.100a  |
| 2               | 12.77±0.204a | 12.00±0.191a | 16.29±0.490b  |
| 4               | 11.59±0.145b | 11.82±0.070a | 15.56±0.102bc |
| 6               | 9.350±0.482d | 10.55±0.126b | 14.93±0.155c  |

Values are means (±SE) of 3 replicate pots. Different lowercase letters indicated significant differences among treatments at 0.05 levels.

3.2. Total magnesium content in peach seedlings

Relative to the control levels, the total magnesium content in stems and leaves of chitosan-treated peach seedlings was significantly increased (p < 0.05). In the wake of increasing chitosan concentration up to 2 g/L, the content in stems and leaves increased, but decreased at chitosan concentrations of 4 and 6 g/L. In terms of the total magnesium content in roots, it was the highest at chitosan concentration of 4 g/L but the lowest at 1 g/L.
Table 2. Total magnesium content in peach seedlings.

| Treatments (g/L) | Roots (mg/g) | Stems (mg/g) | Leaves (mg/g) |
|------------------|--------------|--------------|---------------|
| 0                | 1.778±0.103c | 1.783±0.027d | 2.109±0.153d |
| 1                | 1.764±0.095c | 2.781±0.118a | 4.186±0.213a |
| 2                | 2.734±0.091b | 2.914±0.112a | 4.203±0.143a |
| 4                | 3.520±0.084a | 2.513±0.033b | 3.798±0.028b |
| 6                | 2.587±0.069b | 2.231±0.097c | 2.789±0.021c |

Values are means (±SE) of 3 replicate pots. Different lowercase letters indicated significant differences among treatments at 0.05 levels.

3.3. Total sodium content in peach seedlings
Spraying different concentrations chitosan solutions could increase the total sodium content in roots and stems except for the chitosan concentration of 6 g/L. Especially at 2 g/L chitosan concentration, the content was the highest. With increasing chitosan concentrations, the total sodium content in leaves of peach seedlings reduced and decreased by 7.5% (p < 0.05), 6.4% (p < 0.05), 7.8% (p < 0.05) and 9.4% (p < 0.05), respectively. From table 3, the total sodium content in peach seedlings was the lowest at the chitosan concentration of 6 g/L.

Table 3. Total sodium content in peach seedlings.

| Treatments (g/L) | Roots (mg/g) | Stems (mg/g) | Leaves (mg/g) |
|------------------|--------------|--------------|---------------|
| 0                | 1.835±0.015b | 1.336±0.015c | 1.811±0.044a |
| 1                | 1.851±0.081b | 1.461±0.031b | 1.675±0.009b |
| 2                | 1.955±0.046a | 1.598±0.014a | 1.696±0.063b |
| 4                | 1.836±0.040b | 1.569±0.017a | 1.668±0.045b |
| 6                | 1.823±0.030b | 1.436±0.009b | 1.640±0.012b |

Values are means (±SE) of 3 replicate pots. Different lowercase letters indicated significant differences among treatments at 0.05 levels.

3.4. Water-soluble elements content in soil
In soil, the water-soluble calcium, magnesium and sodium content were different and the water-soluble calcium was higher than other two elements. The content of water-soluble calcium and sodium showed the opposite trend. The water-soluble calcium content was the highest at chitosan concentration of 6 g/L but the lowest at 2 g/L. The water-soluble sodium content was the opposite. Refer to the water-soluble magnesium in chitosan treatments, the water-soluble magnesium content in soil was all higher compared with the control, and the highest content was at chitosan concentration of 2 g/L.

4. Conclusions
Based on the analysis data, it illustrated the effects of chitosan on nutrient uptake in peach seedlings. The total calcium, magnesium and sodium contents were different in various organs of seedlings by spraying chitosan solution. Overall, the results showed that the content of total calcium, magnesium and sodium in roots and stems increased in chitosan-treated seedlings, compared to the control. But for total sodium content in roots and stems was the lowest at chitosan concentration of 6 g/L. Meanwhile, the total calcium and sodium content in leaves were all lower in chitosan-treated seedlings compared with the control seedlings. In soil, the water-soluble calcium content was higher and the water-soluble magnesium and sodium content were all just higher at 2 g/L chitosan concentration.
Table 4. Water-soluble elements content in soil.

| Treatments (g/L) | Water-soluble calcium (mg/kg) | Water-soluble magnesium (mg/kg) | Water-soluble sodium (mg/kg) |
|------------------|-------------------------------|--------------------------------|-----------------------------|
| 0                | 46.63±0.311b                  | 5.986±0.139e                   | 11.26±0.334bc               |
| 1                | 44.70±0.445c                  | 11.07±0.280b                   | 12.26±0.355b                |
| 2                | 42.92±0.566c                  | 20.04±0.411a                   | 13.93±0.051a                |
| 4                | 44.35±0.610c                  | 9.966±0.308c                   | 11.26±0.508bc               |
| 6                | 59.98±0.849a                  | 7.357±0.183d                   | 10.77±0.413c                |

Values are means (±SE) of 3 replicate pots. Different lowercase letters indicated significant differences among treatments at 0.05 levels.

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