Effects of Chitosan on the Uptake of Total Iron, Manganese and Boron in Peach Seedlings

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Abstract. As materials for the study, peach seedlings were sprayed with various concentrations (0, 1, 2, 4 and 6 g/L) of chitosan for the sake of the uptake of total iron, manganese and boron content and a more particular knowledge of the growth of the seedlings. The results in experiment showed that the total manganese content accumulated more in peach seedlings compared with other two elements. The total manganese and boron content in roots and leaves of chitosan-treated seedlings could increase in general. In the wake of the chitosan concentration increased, the total iron content in roots and leaves of seedlings gradually decreased but increased in stems. When it comes to the absorption of nutrients by peach seedlings, there were existing synergism and antagonism in this experiment among iron, manganese and boron, which were good for the growth of peach seedlings.

1. Introduction

Biopolymer “Chitosan” has came from a natural substance, chitin, which is widely distributed in shrimp, crab and insect exoskeletons as well as in fungal and algal cell walls [1]. Chitosan has been getting more attention in recent years because of its excellent biocompatibility, biodegradability and bioactivity in agriculture [2-3]. Additionally, it plays an important role in plant protection [4]. The absorption of nutrients (such as iron, manganese and boron) by plants is helpful for their own growth, yield and quality and also defenses against awful conditions [5-6]. But there are few reports about the effects of chitosan on the uptake of nutrients, especially the nutrients of iron, manganese and boron in peach seedlings.

References to the peach, the genus peach of Rosaceae, due to the great salt, alkali and drought resistance and grafting affinity, it is widely applied in other significant researches as a material [7]. In this experiment, it was aimed to study the chitosan that how to affect the nutrients of iron, manganese and boron in peach seedlings.

2. Materials and methods

2.1. Materials

Peach seeds were bought from a market that in Chengdu, Sichuan, China used as materials for study. Non-polluted soil was collected from the Chengdu campus of Sichuan Agricultural University. Furthermore, the perlite and the Hoagland nutrient solution were used for germination experiment and purchased online.
2.2. Experimental design
At the Chengdu campus of Sichuan Agricultural University, the experiment was conducted from April to July 2019. Peach seeds were planted into perlite and watered every 3 days. Then when the seeds were all sprouted, they were irrigated with Hoagland nutrient solution every 3 days. This time, four peach seedlings with the same of growth potential were transplanted into a pot (15 cm height × 18 cm diameter) containing 3 kg prepared non-polluted soil if the seedlings reached a height of 10 cm. At seedlings growth stage, the soil moisture content was contained about 80% of field capacity. 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 after 7 days. Each treatment was set up repetition for three times.

After one month of spraying chitosan, the roots, stems and leaves of each peach seedling were separately harvested, then washed with tap water and deionized water for three times. The different 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 measurement of all kinds of nutrient elements content (such as iron, manganese and boron). The total iron and manganese content were determined with spectrophotometer method of sulfosalicylic acid and formaldehyde oxime spectrophotometer, respectively. The conventional spectrophotometer was used for the determination of the boron content [8].

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

3. Results and discussion
3.1. Total iron content in peach seedlings
The total iron content in stems of peach seedlings gradually increased with increasing the chitosan concentration up to 6 g/L. On the contrary, the content in roots and leaves of control seedlings was all higher than that in chitosan-treated seedlings. With the concentration increased, the content in roots and leaves significantly decreased. At 1, 2 and 4 g/L chitosan concentrations, the total iron content in roots had no significant difference (p > 0.05).

| Treatments (g/L) | Roots (g/g) | Stems (g/g) | Leaves (g/g) |
|-----------------|-------------|-------------|--------------|
| 0               | 56.09±1.689a| 24.91±0.088d| 68.78±1.628a |
| 1               | 48.01±1.348b| 26.71±0.167d| 64.91±1.883b |
| 2               | 46.58±1.505b| 34.45±1.055c| 61.81±1.568b |
| 4               | 45.53±1.879b| 43.55±1.050b| 50.25±0.995c |
| 6               | 36.53±1.332c| 49.73±1.071a| 44.49±0.992d |

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

3.2. Total manganese content in peach seedlings
From table 2, most of the total manganese content was concentrated in roots and stems and relatively less in leaves. With the chitosan concentration increased, the total manganese content in stems of peach seedlings was gradually reduced by 18.1% (p< 0.05), 19.9% (p< 0.05), 25.6% (p< 0.05) and 27.5% (p< 0.05), respectively. When increased chitosan concentration up to 2 g/L, the content in roots increased but subsequently reduced at the concentrations of 4 and 6 g/L. Compared to the control, the content in leaves of chitosan-treated seedlings was all higher.
Table 2. Total manganese content in peach seedlings.

| Treatments (g/L) | Roots (g/g) | Stems (g/g) | Leaves (g/g) |
|------------------|-------------|-------------|--------------|
| 0                | 291.4±3.069c | 325.2±2.503a | 76.95±2.284d |
| 1                | 373.8±6.316b | 319.3±5.323a | 86.40±3.671d |
| 2                | 450.5±6.273a | 260.4±3.535b | 159.1±5.220b |
| 4                | 242.0±2.619d | 241.8±2.044c | 175.9±5.885a |
| 6                | 192.9±5.084e | 235.9±6.472c | 137.9±3.503c |

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

3.3. Total boron content in peach seedlings

In the wake of increasing the chitosan concentration up to 4 g/L, the total boron content in roots of peach seedlings was always increased and it was a litter lower at concentration of 6 g/L compared with other chitosan treatments. Regarding the content in leaves, it was the highest at chitosan concentration of 2 g/L but the lowest at 6 g/L. The total boron content in stems of chitosan-treated seedlings was all significantly ($p < 0.05$) higher than that in control seedlings.

Table 3. Total boron content in peach seedlings.

| Treatments (g/L) | Roots (g/g) | Stems (g/g) | Leaves (g/g) |
|------------------|-------------|-------------|--------------|
| 0                | 84.03±1.513d | 58.96±2.239d | 231.2±4.094b |
| 1                | 189.5±4.848b | 91.53±1.365c | 332.5±11.41a |
| 2                | 114.6±3.998c | 127.5±4.189b | 150.2±5.911c |
| 4                | 226.0±5.182a | 135.2±1.133bc | 100.5±2.622d |
| 6                | 94.40±0.134d | 140.6±4.407a | 77.51±2.581e |

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

4. Conclusions

In chitosan-treated experiment, there was a difference absorbing nutrient elements in various organs of peach seedlings. Among the total iron, manganese and boron, more manganese elements accumulated in roots, stems and leaves compared with the other two elements. With the chitosan concentration increased, the total iron content in roots and leaves in control treatment was higher than that in chitosan-treated seedlings. On the contrary, the content of total manganese in roots and leaves was higher at chitosan concentrations of 2 and 4 g/L. Compared to the control, the chitosan treatments could increase the content of total boron in roots and leaves of peach seedlings. For the three elements in stems, the total iron and boron content enhanced by increasing the concentration of chitosan but decreased the total manganese content.

Acknowledgments

This work was financially supported by the Application Infrastructure Project of Science and Technology Department of Sichuan Province (2016JY0258).

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