

Study on iron uptake of peach seedlings

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Abstract. Hydroponic experiment was conducted to study the effect of peach seedlings (*Prunus davidiana*) grown in nutrient solution with different Iron (Fe) concentration. The results showed that Fe deficiency could inhibit growth of peach seedlings, the roots and shoots biomass of peach in Fe-free treatment was significant lower than that of other treatments, except for the peach seedlings treated with 60 mg/L Fe. The peach grown seedlings in nutrient solution with different Fe concentration, Fe content in roots increased significantly, in stems decreased significantly, in leaves increased significantly, except for the peach treated with 20 and 60 mg/L Fe, there was a marked drop in total Fe content in leaves compared with control. These results indicated that appropriate amount of Fe (Fe concentration was 20 mg/L) could favour the growth of peach seedlings; and excessive Fe (Fe concentration was 60 mg/L) could have deleterious effects on peach seedlings. In conclusion, Fe concentration was greater than 0 and less than 60 mg/L, which was suitable for peach growth, especially the peach seedlings treated with 20 mg/L Fe.

1 Introduction

Iron (Fe) is an essential nutrient element for plants affecting plant growth and development [1]. Fe deficiency chlorosis is a common abiotic stress affecting plants [2], under Fe deficiency exhibited serious chlorotic symptoms with yellowing leaves and lower chlorophyll content, photosynthetic rate decreases, along with a reduction in plant growth and fruit quality [3-4]. Particularly, chlorosis in fruit crops is becoming more and more serious in recent years, which has been reported in apple, pear, peach and so on [5-7]. Therefore, the research of Fe deficiency in plants has been paid extensive attention in academic circles.

Some studies have discussed chlorosis in peach [5-9], peach seedlings were more sensitive to Fe deficiency [9], Fe-deficiency may alter the barrier properties of the leaf surface of peach, which can significantly affect leaf water relations, solute permeability and pest and disease resistance [2]. In this study, hydroponic experiment was conducted to study the effect of peach (*Prunus davidiana*) grown and the model of Fe accumulation in nutrient solution with different Fe concentrations.

2 Materials and methods

2.1 Materials

The seeds of peach were purchased from a market in Chengdu, Sichuan, China.

2.2 Experimental design

The experiments were conducted with Hoagland solution under greenhouse conditions at the Chengdu campus of Sichuan Agricultural University from February to April 2019. After breaking dormancy, the plump seeds were surface-sterilized and sown, and then these seedlings were transferred to plastic nutrition bowls containing quartz sand. Subsequently, selecting the seedlings germinated robustly in good trim (about 10 cm high), replenished a ration of water and nutrient solution to seedlings on a regular basis. The nutrient solution is divided into Fe-containing and Fe-free, Fe concentration in the nutrient solution was set as follows: 2.5, 5, 10, 20, 30, 40 and 60 mg/L, the Fe-free nutrient solution was used as the control group. Each treatment repeated 3 times. The seedlings were experienced the treatments for one month, the roots, stem, and leaves of each plant were separately harvested, blanched at 110 °C for 15 min, dried at 75 °C until reaching a constant weight, and weighed. The dried vegetation was digested in HNO₃/HClO₄, the content of Fe was determined by spectrophotometric method using o-phenanthroline according to the methods described by Liu et al. [10].

2.3 Statistical analysis

Use Microsoft Excel 2010 and DPS 7.5 software for statistical analysis, data analysis by one-way ANOVA with least significant difference at 5% confidence level.

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Translocation factor = the Fe content of shoots/ the Fe content of roots [11].

3 Results and discussion

3.1 Biomass of peach seedlings

Table 1. Biomass of peach seedlings.

Iron concentration (mg/L)	Roots (g/plant)	Stems (g/plant)	Leaves (g/plant)	Shoots (g/plant)	Root/shoot ratio
0	0.171±0.003d	0.463±0.011d	0.747±0.009f	1.210±0.017f	0.619
2.5	0.199±0.004c	0.436±0.005e	0.934±0.019d	1.370±0.015e	0.467
5	0.213±0.006b	0.529±0.004c	1.229±0.014b	1.758±0.018c	0.430
10	0.225±0.009a	0.670±0.014b	1.471±0.016a	2.140±0.005a	0.455
20	0.211±0.005b	0.739±0.008a	1.224±0.019b	1.962±0.027b	0.604
30	0.197±0.003c	0.517±0.007c	1.098±0.023c	1.616±0.030d	0.471
40	0.193±0.009c	0.466±0.011d	0.894±0.019e	1.361±0.030e	0.522
60	0.173±0.006d	0.434±0.006e	0.718±0.015f	1.152±0.021g	0.604

Values are mean ± SD (n = 3). Different lowercase letters indicate significant differences based on one-way analysis of variance in DPS 7.5 followed by the least significant difference test ($p < 0.05$).

Different Fe concentration had different impact on the growth of peach seedlings (Table 1). The roots biomass was markedly higher under Fe treatments than that of control, except the Fe concentration was 60 mg/L. With the increase of Fe concentration, biomass accumulated to the root, when the Fe concentration was 10 mg/L, roots biomass was the highest. Under Fe-containing conditions, 5, 10, 20 and 30 mg/L Fe treatments caused a marked increase of stems biomass, by 14.25%, 44.71%, 59.61% and 11.66% respectively, compared with control, but no significant difference in 40 mg/L Fe treatment and dropped significantly in 2.5 and 60 mg/L Fe treatments were observed. Fe could enhance the leaves biomass accumulation, and leaves biomass got the highest in peach treated with 10 mg/L Fe. Similar to the biomass of roots and leaves, the biomass of shoots biomass was the highest when the Fe concentration was 10 mg/L, and 20 mg/L Fe treatments came next to it, which caused significant increases of shoots biomass by 76.86%, 62.15% respectively, compared with control.

3.2 Fe content in peach seedlings

Total Fe content was examined in roots, stems and leaves of peach seedlings (Table 2). With increasing concentration of Fe, the Fe content in roots remarkably increased, and showed a quick raise first and then decreased, the highest content of Fe in roots achieved 141.3 mg/kg when peach seedlings treated with 20 mg/L Fe. The Fe content in stems was is different from the Fe content in roots, which apparently decreased under Fe-containing conditions. And the lowest content of Fe in stems was 27.25 mg/kg, observed in 10 mg/L Fe treatments. The Fe content in the leaves of peach were increased significantly, except for the peach treated with 20 and 60 mg/L Fe compared with control. Under Fe-containing conditions, 10, 20 and 60 mg/L Fe treatments caused a significant decrease of the Fe content in shoots compared with control, while 2.5, 5, 30 and 40 mg/L Fe treatments significantly increased the Fe content in shoots. Under Fe-free conditions, translocation factor was the highest (5.629); when Fe concentration was 20 mg/L, translocation factor was the lowest (0.351).

Table 2. Fe content in peach seedlings.

Iron concentration (mg/L)	Roots (mg/kg)	Stems (mg/kg)	Leaves (mg/kg)	Shoots (mg/kg)	Translocation factor
0	14.15±0.464g	115.9±4.421a	57.15±1.897e	79.64±0.964d	5.629
2.5	40.96±1.313f	107.9±3.665b	73.97±2.442d	84.76±2.499bc	2.069
5	45.06±1.863f	35.08±1.767f	110.44±4.429b	87.77±2.760b	1.950
10	97.21±2.822d	27.25±1.755g	87.48±2.793c	68.65±2.018e	0.707
20	141.3±4.028a	53.26±0.870e	47.29±1.458f	49.54±0.605f	0.351
30	133.8±5.256b	70.11±2.405d	134.1±3.896a	113.6±1.882a	0.849
40	117.4±4.882c	82.85±4.191c	83.65±2.131c	83.37±1.028c	0.711
60	61.58±2.430e	55.25±1.020e	37.17±1.742g	43.98±1.081g	0.715

Values are mean ± SD (n = 3). Different lowercase letters indicate significant differences based on one-way analysis of variance in DPS 7.5 followed by the least significant difference test ($p < 0.05$).

4 Conclusions

Fe is involved in the synthesis of chlorophyll, under Fe deficiency exhibited serious chlorotic symptoms, and plant growth is restrained [12]. Most Fe stored in roots, remobilization of cell wall Fe in older leaves and roots has been evolved to increase the resistance to Fe deficiency [12]. In this study, Fe complete deficiency led to a higher TF (5.629), the ability of transferring Fe from roots to shoots of peach was improved. However, most Fe was transported from roots to stems, not leaves, so that led to the lowest total Fe content in roots (14.15 mg/kg), the highest total Fe content in stems (115.9 mg/kg) and lower total Fe content in leaves (57.15 mg/kg). Chlorophyll is positively correlated with leaf Fe status, lower total Fe content in leaves caused low chlorophyll content, plant growth was inhibited [13]. Fe deficiency could inhibit growth of peach seedlings, specific performances: the roots and shoots biomass of peach in Fe-free treatment was significant lower than that of other treatments, except for the peach treated with 60 mg/L Fe. Furthermore, Fe-free resulted in a higher shoot/root ratio, the shoots were inhibited more obviously than the roots.

And appropriate amount of Fe could favour the growth of plant, while excessive Fe retarded the growth of plant [14]. Under Fe-containing conditions, Fe content in roots as gradually decreased as the Fe increased, and in stems decreased significantly, in leaves increased significantly, except for the peach seedlings treated with 20 and 60 mg/L Fe, there was a marked drop in total Fe content in leaves compared to Fe-free treatments. Concurrently, the roots and shoots biomass of peach seedlings under Fe-containing conditions was significantly higher than that under Fe-free conditions, except for the peach seedlings treated with 60 mg/L Fe. These results indicated that appropriate amount of Fe (20 mg/L Fe) could favour the growth of peach; and excessive Fe (60 mg/L Fe) could have deleterious effects on peach seedlings.

Stated thus, it seemed that Fe concentrations were greater than 0 and less than 60 mg/L, which was suitable for peach seedlings growth, especially the peach seedlings treated with 20 mg/L Fe.

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