

Effects of Different Iron Concentrations on Physiology of *Prunus davidiana* Seedlings

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Abstract. In order to study the changes of the photosynthetic pigment content, antioxidant enzyme activity and osmotic adjuster content, the *Prunus davidiana* seedlings were cultured into Hoagland nutrient solution which added various concentrations of iron solution. Then the results showed that photosynthetic pigment content and antioxidant enzyme activity were all higher in iron-treated *P. davidiana* seedlings, compared with that in control seedlings. When increased iron concentration up to 10 mg/L, the chlorophyll a, chlorophyll b and the total chlorophyll content gradually rose, but decreased at iron concentrations of 20, 30, 40 and 60 mg/L. Irrigating iron concentration of 60 mg/L was the best way to increase the activity of superoxide dismutase (SOD), peroxidase (POD) and catalase (CAT), and malondialdehyde (MDA) content. But for chlorophyll a/b ratio, it was the highest in no-iron seedlings. Moreover, the soluble protein content was the highest at iron concentration of 30 mg/L, but the lowest at 10 mg/L. Thus, the study concluded that irrigating iron solution could improve the growth and resistance to adverse circumstances of *P. davidiana* seedlings.

1 Introduction

Iron is an essential nutrient for plants and also affects individual's life span and the whole public health [1-2]. Iron deficiency causes a series of physiological changes. The leaves of plants develop yellow and the growth gets worse or interveinal chlorosis without iron, because this nutrient is indispensable in the electron transport chains of respiration and photosynthesis [3-4]. A previous study has shown that various concentrations iron solution effects of the photosynthesis and antioxidant system in pea seedlings [5]. Application of nano-iron oxide in the prevention and controls of iron deficiency yellowing disease in plants and that means promoting the antioxidant enzyme (POD, CAT and SOD) activity and photosynthetic pigment contents (chlorophyll a, chlorophyll b, carotenoid and total chlorophyll) [6].

Prunus davidiana, always as a good rootstock for stone fruit trees such as plums, cherries, apricots and other kinds of peaches, belongs to the genus peach of Rosaceae and has good drought resistance, salt and alkali resistance, good grafting affinity and so on [7-8]. Studies about the effects of iron on *P. davidiana* seedlings are not a lot and it's valuable to conduct a research for application of iron in fruit trees.

2 Materials and methods

2.1 Materials

This study selected *P. davidiana* seeds as materials to cultivate with perlite to explore the antioxidant enzyme activity and photosynthetic pigment contents in *P. davidiana* seedlings by irrigating iron solution. The nutrient solution for experiment was Hoagland which was bought online.

2.2 Experimental design

In February 2019, the material, *P. davidiana* seeds, was planted into perlite in climate chamber to culture. When the seedlings all reached a height of 10 cm, nine uniformly growing *P. davidiana* seedlings were transplanted into a tray for water planting and irrigated with Hoagland nutrient solution every 3 days. It was time to pour in some different concentrations of iron solution (0, 2.5, 5, 10, 20, 30, 40 and 60 mg/L) and blending with Hoagland nutrient solution after 7 days. There was each treatment repeating three times.

After one month with iron treatments, the mature leaves from the top of *P. davidiana* seedlings were collected for the assay of photosynthetic pigment of chlorophyll a, chlorophyll b, carotenoid and total chlorophyll, and the antioxidant enzyme activity of peroxidase (POD), catalase (CAT) and superoxide dismutase (SOD), the soluble protein content and the malondialdehyde (MDA) content as described by Hao et al [9]. By measuring the above date, studying the effects of iron solutions on physiological status of *P. davidiana* seedlings and knowing more the characteristics of iron in fruit trees.

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2.3 Statistical analyses

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

Table 1. Photosynthetic pigment content in *P. davidiana* seedlings.

Treatments (mg/L)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Carotenoid (mg/g)	Total chlorophyll (mg/g)	Chlorophyll a/b
0	1.224±0.031e	0.240±0.005g	4.549±0.055f	1.463±0.030e	5.111±0.193a
2.5	2.204±0.107b	0.500±0.007c	8.791±0.175c	2.704±0.111b	4.412±0.187b
5	2.219±0.092ab	0.460±0.010d	9.181±0.239b	2.679±0.088b	4.827±0.263a
10	2.397±0.032a	0.606±0.028a	8.998±0.262bc	3.003±0.053a	3.963±0.154c
20	2.376±0.038a	0.582±0.013b	9.815±0.185a	2.957±0.032a	4.087±0.136c
30	2.287±0.087ab	0.600±0.018ab	9.552±0.062a	2.887±0.070a	3.820±0.261c
40	2.027±0.029c	0.420±0.007e	8.446±0.160d	2.446±0.022c	4.832±0.150a
60	1.915±0.026d	0.400±0.011f	8.047±0.092e	2.310±0.015d	4.851±0.200a

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

From Table 1, the photosynthetic pigment content had an obvious dissimilarity ($p < 0.05$) between control and iron-treated *P. davidiana* seedlings and the chlorophyll a, chlorophyll b, carotenoid and the total chlorophyll content in treated *P. davidiana* seedlings were all significantly higher than that in control seedlings. When increased iron concentration up to 10 mg/L, the chlorophyll a, chlorophyll b and the total chlorophyll content gradually rose, but decreased at iron concentrations of 20, 30, 40 and 60 mg/L. For the content of carotenoid, it was the highest at iron concentration of 20 mg/L. The chlorophyll a/b ratio was all lower in treated seedlings compared to control seedlings. Also, the content of chlorophyll a, total chlorophyll and chlorophyll a/b ratio had no significant difference ($p > 0.05$) at concentrations of iron solution 10, 20 and 30 mg/L.

3 Results and discussion

3.1 The photosynthetic pigment content in *P. davidiana* seedlings

3.2 Antioxidant enzyme activity and osmotic adjuster content of *P. davidiana* seedlings

Irrigating different concentrations of iron solution increased the activity of POD, CAT and SOD and it was the highest at iron concentration of 60 mg/L (Table 2). Compared with treated *P. davidiana* seedlings, the POD, CAT and SOD activity were all significantly lower ($p < 0.05$) in control seedlings. At iron concentration of 30 mg/L, the soluble protein content in *P. davidiana* seedlings was the highest, but the lowest at 10 mg/L. Irrigating the iron concentration of 60 mg/L was the best way to increase the MDA content, but it was the lowest when the application of iron concentration of 5 mg/L. Compared to the seedlings with no iron solution, the growth and resistance to environment in treated *P. davidiana* seedlings would be better.

Table 2. Antioxidant enzyme activity and osmotic adjuster content of *P. davidiana* seedlings.

Treatments (mg/L)	POD activity (U/(g/min))	CAT activity (mg/g/min)	SOD activity (U/g)	Soluble protein content (mg/g)	MDA content (μmol/kg)
0	85.39±0.949g	2.725±0.107d	198.6±6.086d	28.33±0.235e	31.81±0.230e
2.5	376.9±9.250d	6.046±0.089a	212.0±9.938a	34.01±0.846d	53.19±1.846b
5	220.9±10.74f	5.770±0.060b	182.6±5.586b	27.56±0.869e	29.53±1.346f
10	209.9±7.387f	5.431±0.125c	159.5±3.754c	25.38±0.877f	30.28±1.282f
20	253.8±11.65e	5.669±0.174b	169.1±4.506b	41.40±1.186b	35.54±1.031d
30	409.3±18.48c	5.824±0.199ab	254.8±11.80ab	47.56±1.018a	29.68±1.400f
40	594.1±18.40b	6.037±0.131a	254.7±10.07a	36.22±1.353c	46.86±0.415c
60	786.9±23.31a	6.068±0.053a	312.2±9.285a	27.88±0.955e	54.96±0.974a

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

4 Conclusions

This research was conducted to learn the effects of photosynthetic pigment, antioxidant enzyme activity and osmotic adjuster on *P. davidiana* seedlings by irrigating different concentrations of iron solution. Through data analysis, it showed that the chlorophyll a, chlorophyll b, carotenoid and the total chlorophyll content in treated *P. davidiana* seedlings were all significantly higher than that in control seedlings. The chlorophyll a/b ratio in control seedlings was the lowest. Also, the activity of POD, CAT and SOD and the MDA content in iron-treated *P. davidiana* seedlings were all higher than that in control seedlings. By and large, the photosynthetic pigment and antioxidant enzyme activity in iron-treated *P. davidiana* seedlings were higher than that in control seedlings, so irrigating iron solution was good for the growth and resistance of *P. davidiana* seedlings.

Acknowledgments

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

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