

Effects of Spraying Absciscic Acid on Photosynthetic Physiology of Lettuce Seedlings under Salt Stress

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Abstract. The glass lettuce was made as material, the effect of different concentrations (0, 1, 5, 10, 20 $\mu\text{mol}\cdot\text{L}^{-1}$) of exogenous absciscic acid on photosynthetic pigments and photosynthetic characteristics of lettuce seedlings under salt stress was studied. The results showed that when the concentration of absciscic acid was lower than 10 $\mu\text{mol}\cdot\text{L}^{-1}$, the chlorophyll content, carotenoid content, net photosynthetic rate, stomatal conductance, and transpiration rate in leaves of lettuce seedlings were all increased along with increasing of absciscic acid concentration. When the concentration of absciscic acid was higher than 10 $\mu\text{mol}\cdot\text{L}^{-1}$, all indicators decreased. But the opposite trend of intercellular carbon dioxide was presented. Therefore, spraying absciscic acid could increase the resistance of lettuce under salt stress, and the best absciscic acid concentration for lettuce against salt stress was 10 $\mu\text{mol}\cdot\text{L}^{-1}$.

1. Introduction

Salt damage has become one of the major factors in abiotic stresses that affects crop growth and yield [1]. At present, 20 percent soil in the world is already highly salinized [2], and according to the statistics of the UN Food and Agriculture Organization, it is estimated that 800 million hm^2 of soil will be affected by salt [3]. Lettuce (*Lactuca sativa* L.), also known as leaf vegetable, is a kind of one- and two-year-old herb crop of the compositae, which is named because it can be eaten raw. It contains many nutrients, such as protein, vitamins, sugars, and minerals. It is strongly resistant to cold and adaptable to the soil, and the light requirements during the growth period are not strict, which has become one of the important leaf vegetables [4]. Absciscic acid (ABA) is a plant endogenous hormone with a sesquiterpene structure that exists in plants, and has the effects of controlling plant growth and promoting senescence. With the deepening of research, it has been found that ABA plays an important role in the signal transduction of stress responses in plant drought, high salinity, and low temperature stress [5]. It is a stress-inducing factor of plants and is called “hormone of plants stress”. It can effectively increase the resistance of plants under biological and abiotic stress [6], such as improving anti-low temperature [7], drought resistance [8], salt resistance [9], disease resistance [10], heavy metal resistance [11], and so on.

2. Materials and Methods

2.1 Materials

The experiments were conducted at Sichuan Agricultural University (30°42'N, 103°51'E), Wenjiang,

China. The lettuce seeds namely 'glass lettuce' were purchased from Chengdu, China. Absciscic acid was purchased from Sigma-Aldrich (St. Louis, MO, USA). All chemicals used in experiments were of analytical grade.

2.2 Experimental Design

The plump lettuce seeds were chosen and sterilized with 1.2% sodium hypochlorite solution for 10 min, rinsed with deionized water three times, placed in a petri dish covered with wet filter paper, and placed in dark artificial climate incubator at 22 °C for germination. When the seeds piped, the germinated seeds were selected and sown them into the pots filled with the substrate. The size of the pots was 21 cm × 20 cm (diameter × height). The ratio of the substrate was vermiculite: perlite = 1:1, the pots were placed in a plastic greenhouse, and 1/2 Hoagland nutrient solution was poured every 2 days. After the second true leaf of lettuce was fully developed, the lettuce seedlings with the same growing trend were treated with salt stress with Hoagland nutrient solution containing 50 mmol·L⁻¹ NaCl, and were poured every 2 days, 20 ml each time, until the end of the experiment and daily replenished water depend on the weather. When the three true leaves of lettuce are fully spread, the four seedlings with the same growth were retained in per pot. Different concentration of abscisic acid solution with 0 (CK, fresh water treatment), 1, 5, 10, 10 μmol·L⁻¹ was sprayed on the leaves at 18:00 until leaf dripping, once every two days and for a total of 3 times. Each treatment was repeated 6 times for a total of 30 pots. The photosynthetic rate and photosynthetic pigment content of lettuce were determined 30 days after sprayed melatonin.

2.3 Statistic analyses

Statistical analyses were performed using SPSS 20.0 statistical software (IBM, Chicago, IL, USA). Data were analyzed by one-way ANOVA with least significant difference (LSD) at a 5% confidence level.

3. Results

3.1 Photosynthetic pigment content

Table 1 showed that the chlorophyll content and carotenoid content in lettuce leaf were significantly higher than those in control after treated with different concentrations of ABA. And the chlorophyll content in each treatment was increased by 2.24%, 58.46%, 67.66%, and 47.51% compared to control respectively. The total content of chlorophyll was increased by 6.11%, 61.14%, 76.33%, and 35.50% than control respectively, and the carotenoid content increased by 37.70%, 40.84%, 59.16%, and 2.10%, respectively. The contents of chlorophyll and carotenoids in lettuce leaves showed an upward trend in the range of 0-10 μmol·L⁻¹ ABA, while they decreased in the range of 10-20 μmol·L⁻¹.

Table 1. Photosynthetic pigment content of lettuce seedlings under salt stress.

Melatonin Concentration (μmol·L ⁻¹)	Chlorophyll a (mg·g ⁻¹ FW)	Chlorophyll b (mg·g ⁻¹ FW)	Total Chlorophyll (mg·g ⁻¹ FW)	Carotenoids (mg·g ⁻¹ FW)
0	0.402±0.044c	0.103±0.009c	0.507±0.054c	0.191±0.013b
1	0.411±0.016c	0.109±0.001c	0.538±0.015c	0.263±0.002a
5	0.637±0.018ab	0.170±0.016ab	0.817±0.024ab	0.269±0.005a
10	0.674±0.017a	0.178±0.001a	0.894±0.003a	0.304±0.003a
20	0.593±0.013b	0.144±0.003b	0.687±0.030b	0.195±0.007b

Note: there is a significant difference between 0.05 levels of different letters, the same as following tables.

3.2 Photosynthesis

Figure 1 below showed that Pn, Gs, and Tr of lettuce leaves exhibited an upward trend at different

concentrations after spraying with different concentrations of ABA, and they reached a maximum at $10 \mu\text{mol}\cdot\text{L}^{-1}$, which was significantly higher than that of the control. However, it was inhibited at $20 \mu\text{mol}\cdot\text{L}^{-1}$, which was significantly lower than that of control. In addition, with the increase of net photosynthetic rate, C_i decreased, which may be due to the limitation of stomatal factors related to the test material (lettuce) and its genotype. The above results showed that spraying leaves with a certain concentration of ABA could effectively increase the P_n , G_s , and Tr in salt-stressed lettuce leaves, and the low concentration of ABA has a promoting effect and the high concentration showed an inhibitory effect.

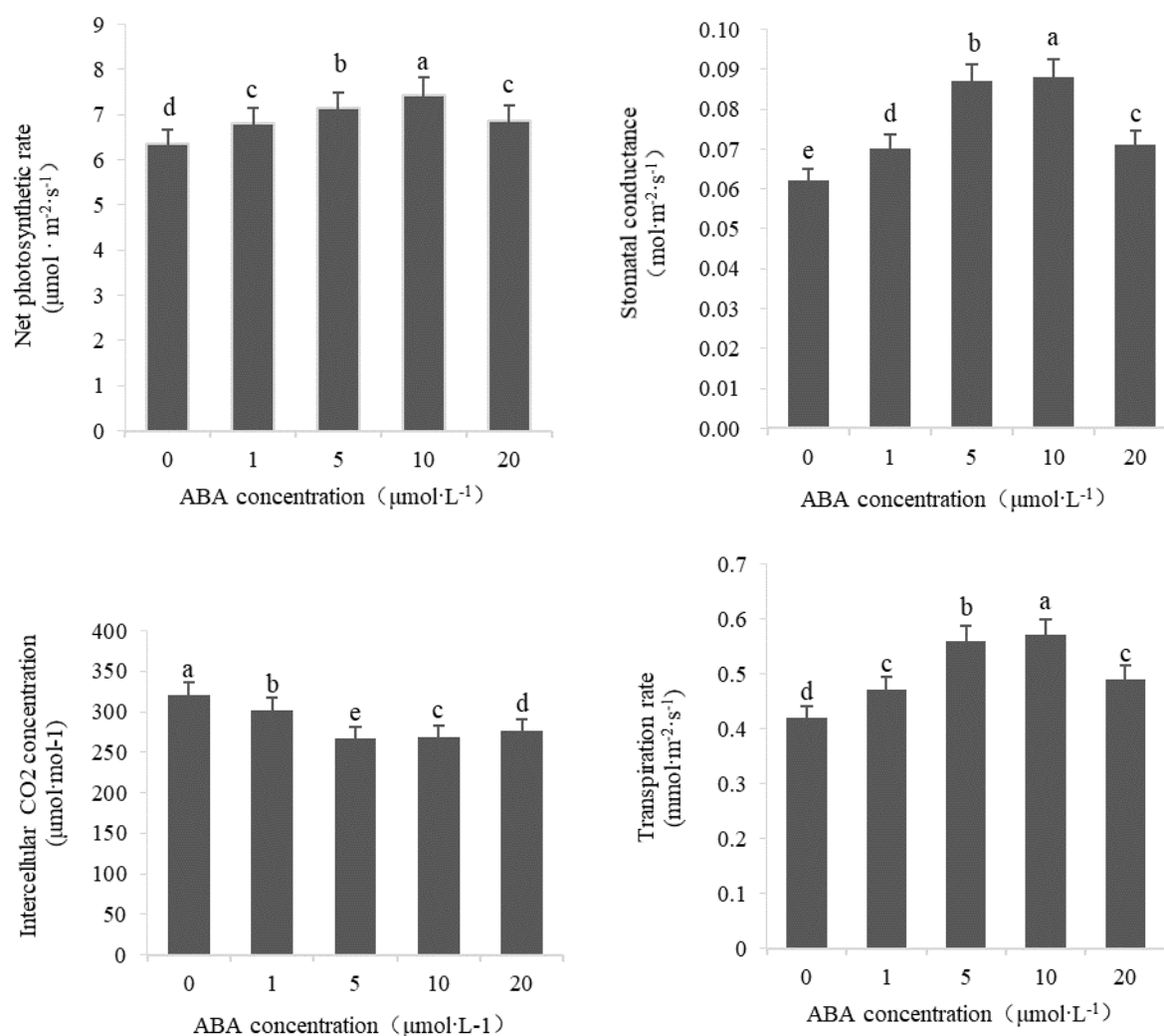


Figure 1. Photosynthesis of lettuce seedlings under salt stress.

4. Conclusions

Chlorophyll is the most important photosynthetic pigment of green leaf plants. It is extremely important for the absorption, transmission and transformation of light energy. Usually, the level of chlorophyll content is used to measure the strength of photosynthesis in leaves. Photosynthesis of plants is closely related to their growth and development. Photosynthesis can provide materials and energy to ensure the normal growth and development of plants. When plants are exposed to stress, their growth will be inhibited, and the photosynthetic rate may also be reduced. Studies have shown that salt stress can significantly reduce the P_n , G_s and Tr of lettuce plants, and increase C_i , which

indicates that the photosynthesis decline of lettuce under salt stress is mainly caused by non-stomatal factors, and exogenous growth regulators can increase the net photosynthetic rate of the lettuce. If the decrease of P_n is accompanied by the increase of C_i , it indicates that the decrease of photosynthetic rate is mainly due to the decrease of photosynthetic activity of mesophyll cells, which is caused by non-stomatal factors, and conversely, is mainly caused by stomatal factors. The results of this study show that spraying ABA on lettuce leaf under salt stress could increase the chlorophyll content and increase P_n , G_s and T_r , while decrease C_i of lettuce. The increase of G_s indicated that the light and substrate transportability of lettuce will increase after spraying ABA. The decrease of C_i indicated that exogenous ABA could enhance the photosynthetic activity of mesophyll cells under salt stress, enhance the photosynthetic rate, and make normal growth of lettuce plants under salt stress. In the range of $0\text{--}20\ \mu\text{mol}\cdot\text{L}^{-1}$, exogenous ABA could increase the content of photosynthetic pigments and enhance the photosynthetic pigment content in salt-stressed lettuce leaves, especially at $10\ \mu\text{mol}\cdot\text{L}^{-1}$.

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