Effects of Exogenous Abscisic Acid on the Growth and Physiological Properties of Chinese Cabbage Seedlings under NaCl Stress

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Abstract. A pot experiment was conducted to study the effects of photosynthesis of Chinese cabbage under NaCl stress, and different concentrations of abscisic acid (ABA) solution about 1, 5, 10 and 20 μmol·L^{-1}was sprayed, control was sprayed water on leaves. The results showed that spraying ABA could improve the biomass of Chinese cabbage seedling , when the ABA concentration was 5 μmol·L^{-1}, the plant height, leaf area, fresh weight and dry weight were significantly higher than control ; Sprayed low concentration of ABA could increase the photosynthetic pigment content of cabbage seedlings. When the concentration of ABA was 5μmol·L^{-1}, the chlorophyll a, chlorophyll b and carotenoids was higher for 6.78% ($p < 0.05$), 25% ($p < 0.05$) and 10% ($p < 0.05$) respectively compared with the control. With the rising of ABA concentration, the activity of antioxidant enzyme increased at first and then decreased, and reached the highest at the concentration of ABA was 5 μmol·L^{-1}, but the MDA content was lowest. Thus, spraying ABA could improve the biomass, photosynthetic pigment content and antioxidant enzyme activity, reduce MDA content of Chinese cabbage seedling. Thereby , which alleviated damage of salt stress to Chinese cabbage seedling. In this experiment, the best ABA concentration was 5μmol·L^{-1}.

Introduction

Chinese cabbage is one of the highest per unit area yield of vegetables [1], is it convenient to storage durably, and is a mainly to solve the winter and spring supply vegetable species. The influence of soil salinization is a global agricultural production and ecological environment problems. Worldwide, almost a third of irrigated land under salt stress, and salinization area increased year by year [2].Saline soil is widely distributed, more types, and influented agricultural production to a low yield, but also an important soil resource in north of China [3-4]. Salt stress caused problems such as water shortage and ionic imbalance, serious impact on plant growth and development [5].

Plant hormone abscisic acid (ABA) played a crucial role in the plant response to adversity stress. And it is an important abiotic stress response of regulatory factors [6]. Under salt stress, plants endogenous ABA content increase significantly, and to stimulate the stomatal closure, change gene expression, accumulate osmotic regulation substances to enhance the ability of plant resistance to

stress [7-9]. This test used Chinese cabbage seedlings as materials to study effects of exogenous ABA on the growth and physiological characteristics of Chinese cabbage seedling under NaCl stress, hope to provide the reference for the cultivation of Chinese cabbage under salt stress.

Materials and Methods

Materials. The experiments were conducted at Sichuan Agricultural University (30° 42′ N, 103° 51′ E), Wenjiang, China. The seeds of Chinese cabbage named quick 35 were harvested in 2015 and purchased from Chengdu, China. All chemicals used in experiments were of analytical grade. ABA was purchased from Sigma-Aldrich (St. Louis, MO, USA).

Experimental Design. Seeds were sterilized in 10% sodium phosphate solution for 30 minutes, flushed five times in distilled water, and then placed on 9-cm-diameter Petri dishes with three layers of filter paper moistened with distilled water and germinated at 25˚C in darkness. Seeds were considered germinated when the seed coat was broken and a radicle was visible. After germination, seeds were planted in nutrition pot filled with vermiculite and perlite, the pot was ten centimeters in diameter and height.

Seedlings were irrigated with 20 mL Hoagland nutrient solution containing 50 μmol·L^{-1} NaCl every other day, until the experiment finished.

When the third leaf expanded, their leaves were sprayed with 0 (CK), 1, 5, 10, 20 μmol·L^{-1} concentrations of ABA solution until foliage and dorsal dripping. Seedlings were sprayed with ABA solution every other day, and three times in total. Each treatment consisted of 10 pots with one plant per pot. Positions of the pots were randomly changed daily to minimize positional effects. 30 days after treatment, measure growth index and physiological index.

Statistic analyses. Statistical analyses were performed using SPSS 13.0 statistical software (IBM, Chicago, IL, USA). Data were analyzed by one-way ANOVA with least significant difference (LSD) at a 5% confidence level.

Results and Discussion

Growth and biomass. As can be seen from Table 1, after sprayed ABA, with ABA concentration increased, plant height, leaf area, plant fresh weight and dry mass of Chinese cabbage seedlings are increased first and then decreased, and when ABA concentration was 5 μmol·L^{-1}, these targets reached highest, enhanced by 12.17% ($p < 0.05$), 23.07% ($p < 0.05$), 47.12% ($p < 0.05$) and 18.18% ($p < 0.05$), respectively, compared with CK. When the ABA concentration was 1 μmol·L^{-1}, the water content of cabbage seedlings is highest, and then, with the ABA concentration increased, it decreased slightly.

Table 1 Effects of ABA on the growth and biomass of Chinese cabbage under NaCl stress

ABA concentration /(μmol·L^{-1})	Plant height /(cm)	Leaf area /(cm^2)	Plant fresh mass /(g)	Plant dry mass /(g)	Water Content /(%)
0	8.22±0.21 c	135.59±1.35 b	2.95±0.41 c	0.55±0.02 b	81.26%
1	8.54±0.19 b	155.84±2.28 a	3.94±0.44 b	0.58±0.06 ab	85.39%
5	9.22±0.41 a	166.84±1.93 a	4.34±0.12 a	0.65±0.08 a	85.06%
10	8.85±0.32 ab	133.84±1.36 b	3.92±0.27 b	0.64±0.05 a	83.64%
20	8.32±0.35 bc	116.53±2.51 c	3.51±0.07 b	0.61±0.03 ab	82.50%

Note：Data followed different letters within column indicate significant difference of 0.05 level.

Photosynthetic pigment content. It was clearly observed that when the ABA concentration of 0~5 μmol·L^{-1}, the chlorophyll a, chlorophyll b and total chlorophyll content increased with ABA concentration increased, after sprayed ABA concentration of 5μmol·L^{-1}, all of them reached the peak, enhanced by 6.78% ($p < 0.05$), 25% ($p < 0.05$) and 9.86% ($p < 0.05$), respectively, compared with CK. And then, with ABA concentration increased, they declined. When the ABA concentration of 20 μmol·L^{-1}, chlorophyll a, chlorophyll b and total chlorophyll content were no significant differences with the control. The same as chlorophyll a, carotenoid content also reaches the maximum, when ABA concentration was 5 μmol·L^{-1}, the treatment enhanced by 10% ($p < 0.05$) compared with CK.

Table 2 Effects of ABA on the contents of photosynthetic pigments of Chinese cabbage under salt stress

ABA concentration /(μmol·L^{-1})	Chlorophyll a /(mg·g^{-1})	Chlorophyll b /(mg·g^{-1})	Chlorophyll a+b /(mg·g^{-1})	Carotenoid /(mg·g^{-1})
0	0.59±0.02 b	0.12±0.001 b	0.71±0.01 c	0.20±0.01 b
1	0.61±0.05 ab	0.14±0.005 a	0.75±0.02 ab	0.21±0.02 ab
5	0.63±0.01 a	0.15±0.004 a	0.78±0.05 a	0.22±0.05 a
10	0.59±0.01 b	0.14±0.001 a	0.73±0.01 b	0.21±0.01 ab
20	0.58±0.01 b	0.12±0.009 b	0.70±0.01 c	0.19±0.01 b

The enzymatic antioxidant system. The table 3 showed that the activity of SOD, POD, CAT of Chinese cabbage had same change trend. SOD, POD, CAT activity were increased as the concentration of ABA from 0 μmol·L^{-1} up to 5 μmol·L^{-1}.When the concentration of ABA was 5 μmol·L^{-1}, SOD, POD, CAT activity were increased by 20.75% ($p < 0.05$), 26.83% ($p < 0.05$) and 43.53% ($p < 0.05$), compared with CK, significantly, but all of them were no significant difference with the treatment of spraying 1 μmol·L^{-1} ABA. When the concentration of ABA were 10 and 20 μmol·L^{-1}, the activity of SOD were not significantly different with each other. Sprayed 20 μmol·L^{-1} ABA, POD and CAT activity higher than CK, but not significant.

MDA content. MDA is a product of the cell membrane lipid peroxide, the higher content of MDA indicated the more serious damage of cell membrane. Compared with CK, spraying exogenous ABA can reduce the MDA content in Chinese cabbage seedling leaves under NaCl stress (Table 3). Compared with CK, when the concentration of ABA were 1, 5, 10 and 20 μmol·L^{-1}, MDA content decreased by 7.44% ($p > 0.05$), 26.45% ($p < 0.05$), 18.29% ($p > 0.05$), 11.36% ($p > 0.05$), respectively. Except sprayed 5μmol·L^{-1} ABA, the MDA was significant higher than CK, other treatment were not.

Table 3 Effects of ABA on The enzymatic antioxidant system of Chinese cabbage under salt stress

ABA concentration /(μmol·L^{-1})	SOD activity /(U·g^{-1})	POD activity /(U·g^{-1})	CAT activity /(U·g^{-1})	MDA content /(nmol·g^{-1})
0	156.39±6.08 b	1908±28.28 b	21.34±0.42 c	9.68±0.81 b
1	166.73±7.91ab	2146±53.74 a	28.51±0.42 ab	8.96±0.23 ab
5	192.08±6.23 a	2420±58.66 a	30.63±0.54 a	7.12±0.95 a
10	172.37±14.87 b	2204±67.48 a	29.78±1.12 b	7.91±0.93 ab
20	165.97±0.01 b	2022±36.77 b	24.08±0.54 c	8.58±0.77 b

Conclusions

The Studies have shown that the plant cell membrane was damaged, which caused membrane

ester peroxide, at the same time, destroyed the photosynthetic system structure, eventually lead to significant losses under salt stress [10]. The results showed that spraying ABA could improve the biomass, photosynthetic pigment content and antioxidant enzyme activity, reduce MDA content of Chinese cabbage seedling under salt stress, and which was reached the most significant at ABA concentration was 5μmol·L^{-1}. The plant height increased by 12.17%, the total chlorophyll increased by 9.86%, SOD, POD, CAT activity were increased by 20.75% ($p < 0.05$), 26.83% ($p < 0.05$) and 43.53% ($p< 0.05$) compared with control respectively. Thus spraying ABA can enhance the resistance of Chinese cabbage seedling to salt stress through increasing the biomass and pigment content and antioxidant enzyme activity.

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