

# Effects of Exogenous Abscisic Acid on Photosynthetic Characteristics 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  $\mu\text{mol}\cdot\text{L}^{-1}$  was sprayed, control was sprayed water on leaves. The results showed that spraying ABA could improve net photosynthetic rate (Pn), stomatal conductance (Gs), water use efficiency (WUE), light use efficiency (LUE), transpiration rate (Tr) and  $\text{CO}_2$  concentration of intercellular (Ci) of Chinese cabbage under NaCl stress, thereby enhanced the photosynthetic capacity. Therefore, spraying exogenous ABA can improve the resistance of NaCl stress of Chinese cabbage, and the ABA concentration of 10  $\mu\text{mol}\cdot\text{L}^{-1}$  worked best.

## Introduction

Chinese cabbage (*Brassica rapa* ssp. *pekinensis*) is Brassica vegetables, rich in minerals and vitamins, plays an important role in greenhouse production [1]. Due to the big fat flood irrigation during protected cultivation of vegetables, soil salinity with a lot of water evaporates upward movement gathered to the soil surface, the soil widespread secondary salinization, thereby affecting the facility cabbage production quality and yield [2-3].

Abscisic acid (ABA) is a kind of plant endogenous hormones with sesquiterpene structure, which can regulate plant adaptation to environmental stress [4-5]. Numerous studies have shown that exogenous abscisic acid can effectively alleviate the damage caused by stress (high temperature [6], chilling [7], drought [8] and salt [9] etc.) to maintain normal metabolism. Xiao's study showed that exogenous ABA can significantly improve the photosynthesis of sweet potato seedlings under NaCl stress, and improve the salt tolerance of sweet potato [10].

Currently ABA on plant stress resistance and its application in agriculture has received increasing attention [4]. But the research of ABA on photosynthesis in Chinese cabbage under NaCl stress is rare. Therefore, this study investigated the effect of exogenous abscisic acid on photosynthetic characteristics of Chinese cabbage seedlings under NaCl stress, in the hope of providing a reference about Chinese cabbage cultivation in the salinized land.

## 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 2014 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  $\mu\text{mol}\cdot\text{L}^{-1}$  NaCl every other day, until the experiment finished.

When the third leaf expanded, their leaves were sprayed with 0 (control), 1, 5, 10, 20  $\mu\text{mol}\cdot\text{L}^{-1}$  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, the photosynthesis of each plant was determined by using LI-6400 portable photosynthesis meter (LI-COR Inc., USA). The photosynthetic parameters of the photosynthesis meter were manual control  $\text{CO}_2$  concentration  $400 \mu\text{mol}\cdot\text{CO}_2 \text{ mol}^{-1}$ , temperature  $25^\circ\text{C}$ , light intensity  $1000 \mu\text{mol m}^{-2}\cdot\text{s}^{-1}$ . The determination of photosynthetic parameters were net photosynthetic rate (Pn), transpiration rate (Tr), stomatal conductance (Gs) and  $\text{CO}_2$  concentration of intercellular (Ci), and each treatment was repeated three times. Water use efficiency (WUE) = net photosynthetic rate (Pn) / transpiration rate (Tr), Light use efficiency (LUE) = net photosynthetic rate (Pn) / light intensity[11].

**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

**Net Photosynthetic Rate (Pn).** Sprayed ABA increased the net photosynthetic rate of leaves of cabbage seedlings under NaCl stress (Fig. 1). When the concentrations of ABA were 5, 10 and 20  $\mu\text{mol}\cdot\text{L}^{-1}$ , these treatments enhanced Pn by 26.22% ( $P>0.05$ ), 56.59% ( $P<0.05$ ), 65.50% ( $P<0.05$ ) and 42.53% ( $P<0.05$ ) respectively, compared with control.

**Transpiration Rate (Tr).** After sprayed ABA, each treatment were significantly higher than control. With spraying ABA concentration increased, the Tr of chinese cabbage seedlings increased before decreasing, and reached a maximum, which was 133.66% of the control, when the ABA concentration of  $10\mu\text{mol}\cdot\text{L}^{-1}$ .

**Water Use Efficiency (WUE).** As you can see from Fig. 3, it was not significant effects on WUE of Chinese cabbage seedlings to sprayed the ABA of  $1\mu\text{mol}\cdot\text{L}^{-1}$ . But the high concentration of ABA promoted WUE significantly. When sprayed concentration of ABA were 5, 10 and 20  $\mu\text{mol}\cdot\text{L}^{-1}$ , the WUE was increased by 20.83% ( $P<0.05$ ), 23.82% ( $P<0.05$ ) and 17.18% ( $P<0.05$ ) respectively compared with control.

**Light Use Efficiency (LUE).** The same as Tr, with the increasing of ABA concentration, the LUE of Chinese cabbage rose rapidly at beginning, and then declined slightly. After sprayde the concentration of  $10\mu\text{mol}\cdot\text{L}^{-1}$ , LUE reached a peak, though enhanced by 65.50% ( $P<0.05$ ) compared with control, no significant with the treatments of spraying 5 and 20  $\mu\text{mol}\cdot\text{L}^{-1}$ .

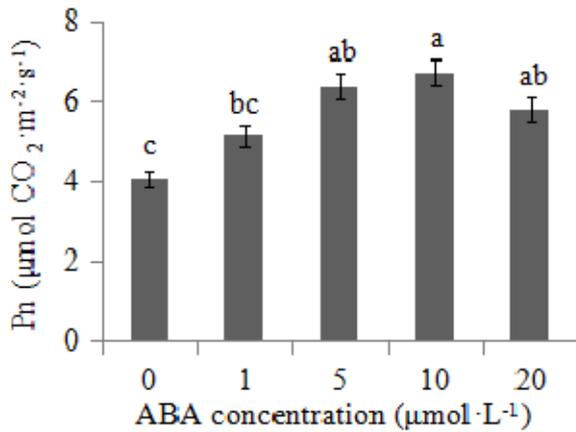


Fig. 1 Pn of ABA sprayed Chinese cabbage

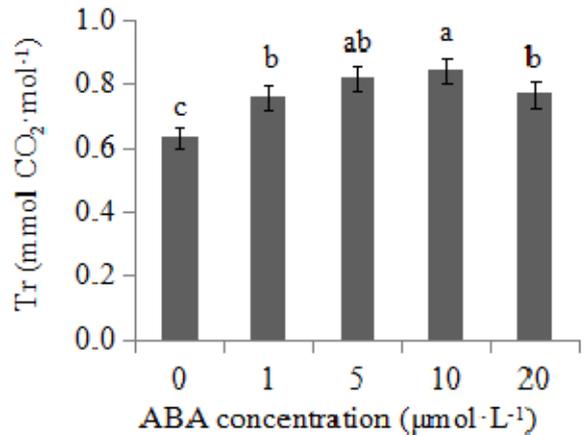


Fig. 2 Tr of ABA sprayed Chinese cabbage

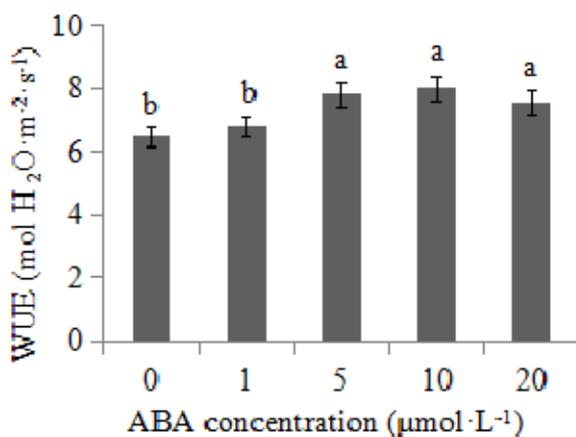


Fig. 3 WUE of ABA sprayed Chinese cabbage

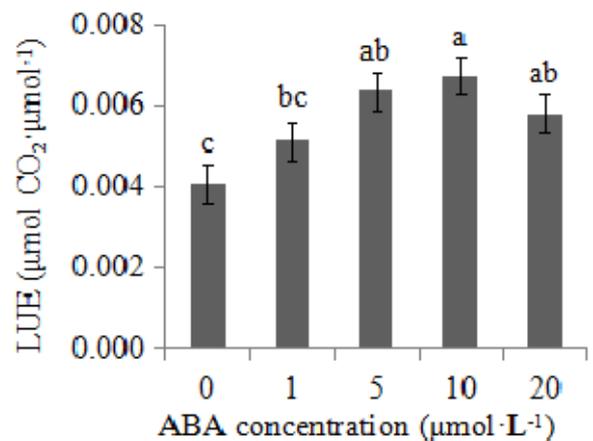


Fig. 4 LUE of ABA sprayed Chinese cabbage

**Stomatal Conductance (Gs).** It was clearly observed that spraying ABA significantly improved the Gs of Chinese cabbage. There were not significant difference on Gs of the treatments of spraying ABA concentration of 1,5,10  $\mu\text{mol} \cdot \text{L}^{-1}$ , and compared with control, which inanced Gs by 205.71% 226.67% and 241.89% respectively.

**CO<sub>2</sub> Concentration of Intercellular (Ci).** Ci of each treatment ABA was significantly higher than the control, but not significant difference among them.

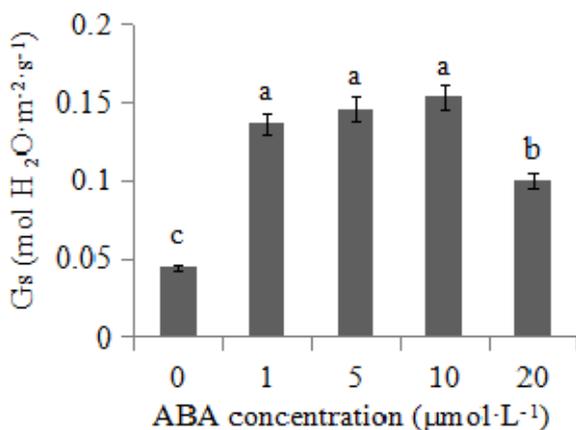


Fig. 5 Gs of ABA sprayed Chinese cabbage

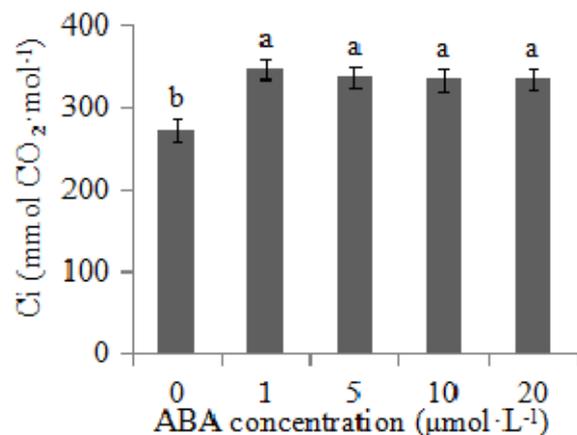


Fig. 6 Ci of ABA sprayed Chinese cabbage

## Conclusions

Numerous studies show that ABA can improve plant antioxidant activity, alleviate membrane lipid peroxidation and protect the optical system, thereby increasing the ability of plants to salt stress [12,13]. The results showed that: after sprayed ABA, the Pn, Gs, WUE, LUE, Tr and Ci of Chinese cabbage seedlings were improved, and with the concentration of ABA increasing, all results are reduced after the first increase, and peaked on ABA concentration was  $10 \mu\text{mol}\cdot\text{L}^{-1}$ , except Ci.

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