Effects of Exogenous Melatonin on Photosynthetic Characteristics of Eggplant Seedlings under Low Temperature and Weak Light Stress

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Abstract. Eggplant cultivar 'Changhong' was subjected to low temperature treatment of 15/10˚C (day/night) in the artificial climate chamber. The effects of exogenous melatonin (MT) on the photosynthetic of leaves under low temperature and weak light stress was investigated. The results showed that with the increasing of melatonin concentration, the net photosynthetic rate (Pn), stomatal conductance (Gs), transpiration rate(Tr), and light use efficiency (LUE) was enhanced first, and then decreased, the CO_2 concentration of intercellular (Ci) remained relatively stable, and water use efficiency(WUE) showed a downward trend. Thus, melatonin could siganificantly improve the photosynthetic capacity of eggplant under low temperature and weak light stress, and 200 μmol·L^{-1} was the best concentration.

Introduction

Eggplant (*Solanum melongean* L.) originated from the tropics of Southeast Asia, and it is extremely sensitive to low temperatures [1]. As the demand of anniversary supply about eggplant, low temperature and poor light has become main factor to suppress the early spring cultivation[2]. Especially it often encounter long term cold weather during the seedling stage, which would seriously affected the quality of seedlings, thereby affecting the yield and quality[3].

Melatonin (melatonin, MT) is the indole derivatives of tryptophan, it has very strong effects on antioxidation and elimination of free radicals[4]. In recent years, many studies have found that melatonin can effectively alleviate abiotic stress[5-6] harm to the plant, improve the resistance to low temperature and light, maintain higher chlorophyll content and enhance the photosynthetic efficiency of leaves, which has been confirmed in cucumber [7], tomato[8] and *Arabidopsis* [4]. But it has not been reported in eggplant. In this study, we used different concentrations of melatonin to spray eggplant seedlings for the purpose of screening the influence of melatonin on photosynthetic characteristics of eggplant under low temperature and weak light stress.

Materials and Methods

Materials. The experiments were conducted at Sichuan Agricultural University (30° 42′ N, 103° 51′ E), Wenjiang, China. The seeds of eggplant were harvested in 2014 and provided by Zhongdu Seed

Company (Chengdu, China). All chemicals used in experiments were of analytical grade. Melatonin 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 nursery substrate, the pot was ten centimeters in diameter and height. When the third leaf expanded, their leaves were sprayed with 0 (CK), 50, 100, 150, 200, 250 $\mu mol \cdot L^{-1}$ concentrations of melatonin solution until the blade dripping. Seedlings were sprayed with melatonin solution every other day, and three times in total. Each treatment consisted of 10 pots with one plant per pot. Two days after the last time for spraying the leaves, all seedlings were moved to the artificial climate chamber, the temperature was 15/10˚C(day/night), 12 hours each day and night, the light intensity was 100 l$\mu mol \cdot m^{-2} \cdot s^{-1}$, and keep the humidity at 70%. Positions of the pots were randomly changed daily to minimize positional effects. 6 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 CO_2 concentration 400 $\mu mol \cdot CO_2$ mol^{-1}, temperature 25˚C, light intensity 1200 μmol $m^{-2} \cdot s^{-1}$. The determination of photosynthetic parameters were net photosynthetic rate (Pn), transpiration rate (Tr), stomatal conductance (Gs) and 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[9].

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). Compared with CK, foliage spray of MT enhanced Pn of eggplant under low temperature significantly. With the increasing of melatonin concentration, Pn increased and then decreased. Pn of eggplant reached the highest at concentration of 200 $\mu mol \cdot L^{-1}$, and increased by 80.81% ($p < 0.05$). But the difference between 200 $\mu mol \cdot L^{-1}$ and 250 $\mu mol \cdot L^{-1}$ was not significant.

Stomatal Conductance (Gs). Stomatal conductance is one of the sensitive indicator when plants suffer environmental stress, low temperature will lead to the increase of stomatal resistance. Compared with CK, Gs have been improved after spraying MT, but the concentration of 50 $\mu mol \cdot L^{-1}$ only increased by 28.32%, with no significant difference with CK. And Gs was similar with Pn, it reached the highest at concentration of 200 $\mu mol \cdot L^{-1}$, and increased by 75.29%.

Transpiration Rate (Tr). Although MT can improve Tr of eggplant, but at low concentrations of MT, it was not significantly different wit CK. When the concentrations of MT at 150 $\mu mol \cdot L^{-1}$, Tr was significantly increased by 69.68%, and it also reached the highest at 200 $\mu mol \cdot L^{-1}$, about double of CK.

CO_2 Concentration of Intercellular (Ci). Compared with CK, 200 $\mu mol \cdot L^{-1}$of MT can increase the Ci by 6.61%, and the difference between all treatments didn't appear obviously on Ci, which illustrate that the impact of melatonin on Ci was not obvious.

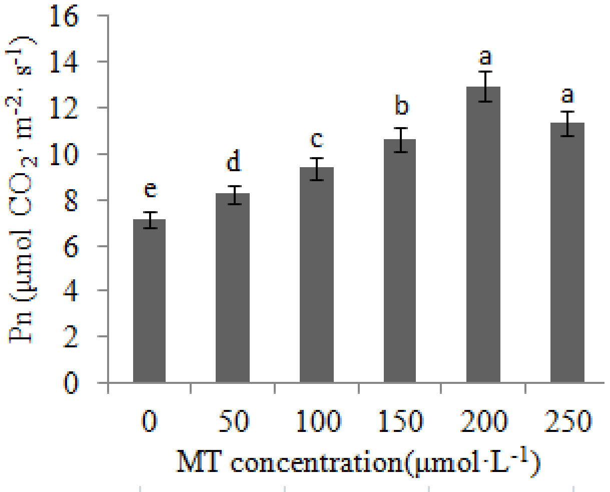

Fig. 1 Pn of MT sprayed eggplant

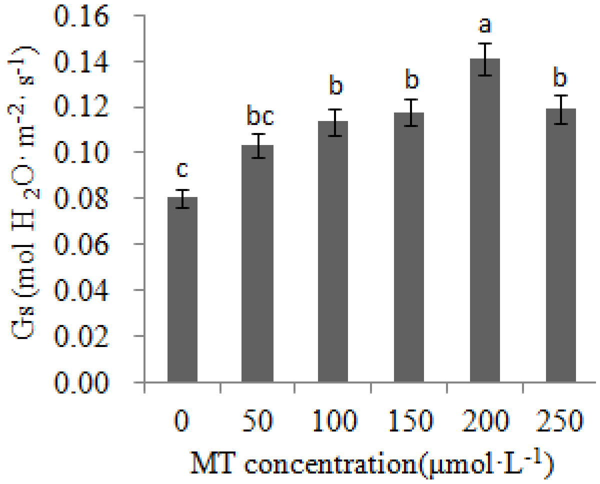

Fig. 2 Gs of MT sprayed eggplant

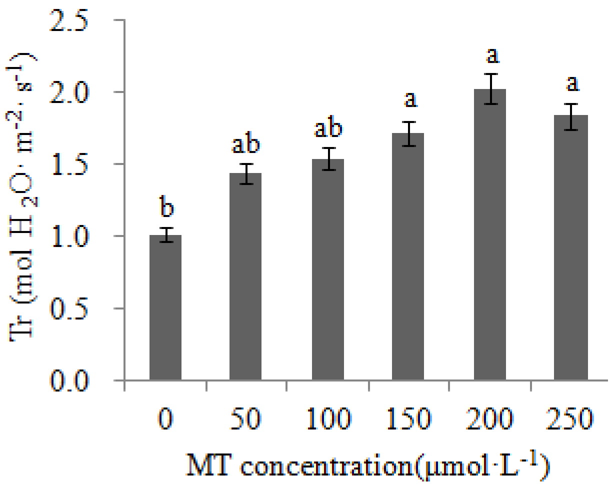

Fig. 3 Tr of MT sprayed eggplant

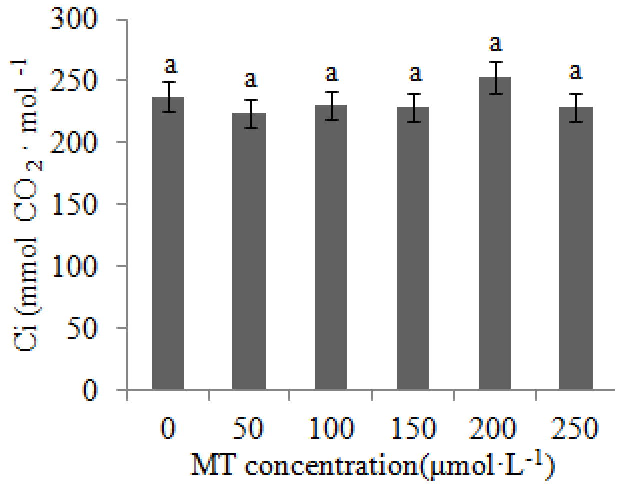

Fig. 4 Ci of MT sprayed eggplant

Water Use Efficiency (WUE). The Fig.5 shows that WUE of eggplant decreased by melatonin treatment under low temperature and weak light stress, and the difference was not significant before 200μmol·L^{-1}, but as the concentration continued to increase, the reduction of Ci was obvious, compared with CK, it was only 74.64% at the concentration of 250 μmol·L^{-1}.

Light Use Efficiency (LUE). Compared with CK, when the concentrations of MT were 50, 100, 150, 200and 250 μmol·L^{-1}, these treatments increased LUE of eggplant by 15.29% ($p > 0.05$), 31.13% ($p < 0.05$), 48.25% ($p > 0.05$) ,80.81% ($p > 0.05$)and58.35% ($p < 0.05$) respectively. It was as the same as Pn.

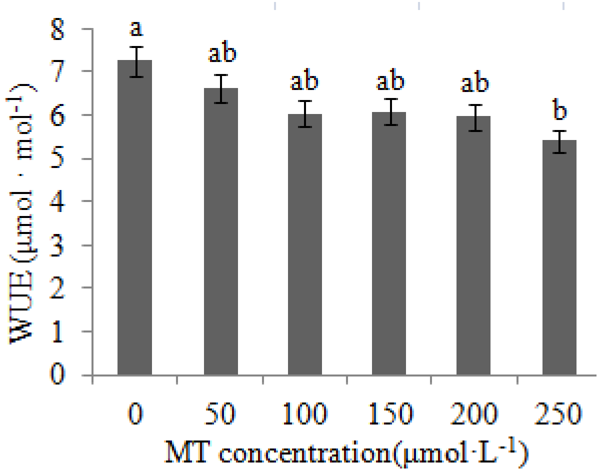

Fig. 5 WUE of MT sprayed eggplant

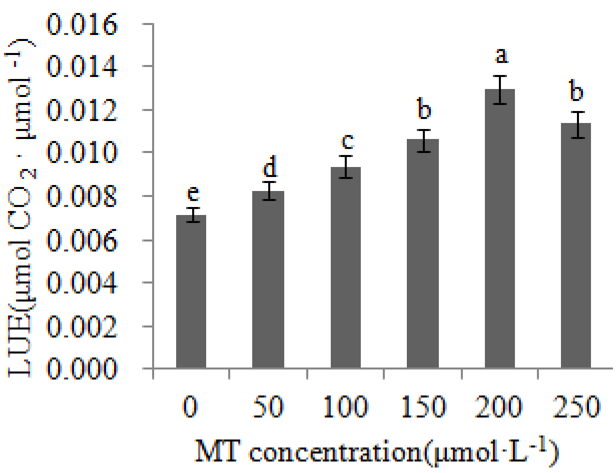

Fig. 6 LUE of MT sprayed eggplant

Conclusions

Melatonin can effectively improve the Pn, Gs, Tr, and LUE of eggplant seedlings, relieve the damage of chloroplast caused by low temperature and wake light stress. Especially, the comprehensive benefits was the best at concentration of 200 $\mu mol \cdot L^{-1}$, which was similar with the research of Gao[7]. Therefore, exogenous melatonin can maintain Pn at relatively high level, and ensure the high photosynthate transfer rate of whole eggplant seedling.

Acknowledgements

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