

Comparison of Light Response in Ten Varieties of Iris Photosynthesis

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Abstract - An experiment was conducted to study the effect of 38 high temperature stress for ten varieties of Iris plants, by measuring the photosynthetic light response curve and photosynthetic physiological response including: i) the value of photosynthetic rate, ii) Intercellular CO₂ values, iii) stomata conductance values, iv) transpiration rate value. We then analyzed the indicators of changes in response to gradients of light radiation. The results show that the maximum value of Pn of Iris germanica ‘Gold boy’ is 14.87 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, There were 6 species of iris’ Pmax in the PAR from 1600 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$ to 3200 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$. The result also showed that there was a negative correlation between the Ci and Pn. From the results of the Tr-PAR, we find that the Tr value of the Iris germanica ‘Gold boy’ and Iris confusa are the highest and lowest in the ten species iris. The average value is 2.091 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$. The results of the Gs-PAR of ten iris showed that the Gs of most iris species do not increase or decrease distinctly along with the increase of PAR. The results also showed that Ci, Gs, Tr of the cultivated species of iris basically identical with the increase the PAR, but the original species of iris have more difference.

Keywords - Iris; Photosynthetic; Intercellular CO₂; stomatal conductance; transpiration

I. INTRODUCTION

Iris is the world's leading plant perennial flowers, it has very broad range of landscape applications. Although China is one of distribution center in the world of the Iris, and has the rich resources, however, new varieties of domesticated only a few. Nowadays, most of new cultivars of iris in China are imported from abroad, we are not fully aware of their adaptability and resistance. This will increase the risk of new varieties application. In addition, such as high temperature in summer, will occur more frequently with longer duration in many regions all over the world[1][2]. High temperature is one of the main environmental factors that restrict growth and development in plants[3][4]. Therefore, screening of heat-tolerant plant is very important[5][6]. However, it is sufficiently relevant between photosynthesis and temperature. This paper measured and compared the photosynthetic of 10 varieties of Iris at a temperature of 38C, furthermore we provides a theoretical basis for Iris promotion and application in central china.

II. MATERIALS AND METHODS

A. Situation of the Materials and Experimental Field

The pot experiment was conducted in a farm of Wuhan Scientific Research Institute of Forestry. Curtivars species of Iris germanica, Iris germanica ‘Blue Staccato’ s Gibeson’, Iris germanica ‘Tantara’, Iris germanica ‘black knight’, Iris germanica Gold boy’ and wild species of Iris confusa, Iris lactea, Iris sibirica, Iris ensata and Iris pseudacorus were selected for use in this study. Their Photosynthesis characteristic will be tested in 38 high temperatures. All varieties were propagation by division and planted to plastic pots (25 cm in height and 25 cm indiameter with 18 kg mixed-substrate). The substrate contained 2.5% of organic matter and 94.2, 23.5, and 80.

5mgkg⁻¹ of available N, P, and K. Part of the transplanting seedlings grew in glass greenhouse. The tested materials had uniform size and growth vigor, determination position located in the 1/3 of leaf length[3][4].

B. Photosynthesis determination method

At temperature of 38C from 9:00 to 11:00 am, sunny day, by using Yaxin-1102 portable photosynthetic analyzer, the maxmum net photosynthetic rate (Pmax), dark respiration rate(Rd), net photosynthetic rate(Pn) were measured[7]. We measured Photosynthetically active radiation, PAR from 0-3200 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, light gradient was 0, 100, $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, 200 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, 400 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, 600 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, 800 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, 1000 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, 1600 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, 2400 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, 3200 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, using open-circuit model. Carbon dioxide concentration, the temperature and the humidity of the air was in natural condition[8][9].

C. Data processing and analysis

The data was processed by DPS7.05 and Microsoft Excel2003, statistical analysis the relationship between net photosynthetic rate, Pn and impact factor.

III. RESULTS AND ANALYSIS

A. Light response curve of Pn

Pn directly reacted the capacity of plant photosynthetic. Light response curves of some Iris were showed in Figure 1. From the figure, when the light gradient between 0-3200 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, the Pn of Iris mostly shows a trend that is firstly rising and parallel to X axis. Only when the Pn of Iris pseudacorus and Iris germanica get the maximum value with the increase of PAR showed rapid decline. Especially the Pn of Iris pseudacorus is 9.21 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$ while light gradient is 1600 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$. After that, Pn rapidly

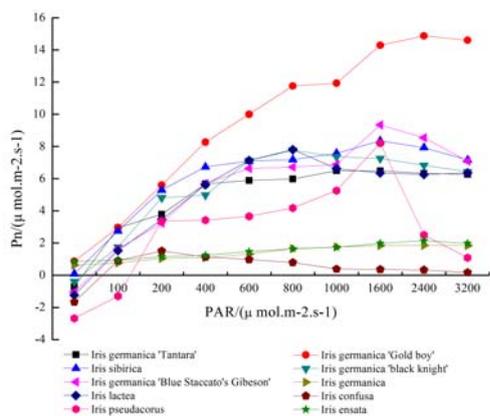


Figure 1. Pn-light response curves of ten species of *iris*

decline to 2.5 μmol. m-2. s-1 when the PAR is 2400 μmol. m-2. s-1. From the range of photosynthetic active radiation where the maximum value of Pn appeared, there are 6 varieties of *Iris*' PAR from 1600 to 2400 μmol. m-2. s-1. Pn of *Iris germanica* 'Gold boy' is the largest in 10 varieties, the value is 14.87 μmol. m-2. s-1. There are 3 varieties such as *Iris germanica* 'black knight', *Iris germanica* 'Tantara', *Iris lactea* which PAR are between 600-1000 μmol. m-2. s-1. Only the Pn of *Iris confusa* which maximum value appears when PAR is 200 μmol. m-2. s-1, moreover, the Pn is the smallest in 10 varieties, the value is only 1.51 μmol. m-2. s-1.

B. Light response curve of C_i

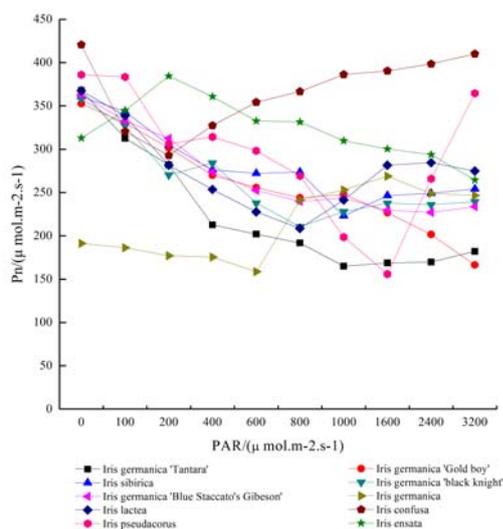


Figure 2. C_i -light response curves of ten species of ten species of *iris*

The response of *Iris* intercellular CO₂ and light radiation gradient were showed in Figure 2. From the Figure we know that the PAR of 10 *Iris* varieties were from 0 to 3200 μmol. m-2. s-1. Along with the increase of PAR, it

seems that C_i of *Iris* show a downward trend except *Iris germanica*. That is the C_i value when PAR is 0 always higher compare with the time which PAR is 3200 μmol. m-2. s-1. The change of C_i can be divided into three categories. The first, when PAR is between 0~500 μmol. m-2. s-1, C_i value of *Iris germanica* 'Tantara', *Iris germanica* 'Gold boy', *Iris germanica* 'Blue Staccato's Gibson', *Iris germanica* 'black knight', *Iris lactea*, *Iris sibirica* showing a sharp decline.

When the PAR > 500 μmol. m-2. s-1, C_i value of *Iris germanica* 'Gold boy' continued to decline while others presents the trend that slowly rising after decreased slowly. The second group is *Iris germanica*. C_i value of it showing a trend of slowly down when PAR is between 0-600 μmol. m-2. s-1, after that when the PAR is between 600-800 μmol. m-2. s-1, the C_i value began to rising. The third group is *Iris pseudacorus*. The C_i of it always present a downward trend when the PAR < 1600 μmol. m-2. s-1, however, when the PAR between 1600 -3200 μmol. m-2. s-1, it shows a rapid upward trend.

C. Light response curve of Tr

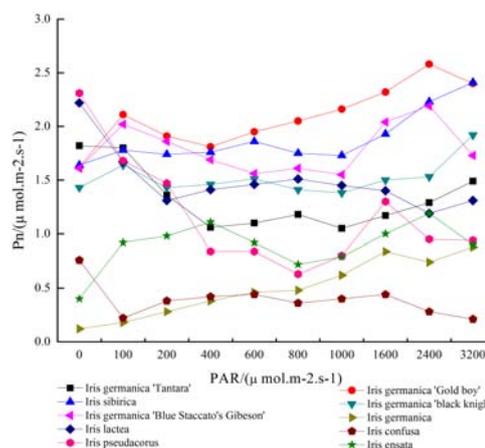


Figure 3. Tr -light response curves of ten species of *iris*

Figure 3. show that Tr of other 8 varieties present a gentle trend when PAR increase or decline except *Iris lactea* and *Iris pseudacorus*. There are also three categories. In the first group, the Tr value alternately rise and fall, the curve is smooth. *Iris germanica* 'Tantara', *Iris germanica* 'Gold boy', *Iris confusa*, *Iris sibirica* was included this group. In the second group, along with the increase of PAR, Tr value increase slowly, such as *Iris germanica*. In the third group, Tr value rapidly decline along with PAR increase when the PAR is between 0-200 μmol. m-2. s-1. While PAR > 200 μmol. m-2. s-1, Tr begin rise and fall of alternating, and has a small changes in amplitude. Including *Iris lactea*, *Iris pseudacorus*. The experimental results showed that Tr of *Iris germanica* 'Gold boy' is highest, the average value is 2.091 μmol. m-2. s-1, while Tr of *Iris confusa* is smallest, the average value is 0.391 μmol. m-2. s-1.

D. Light response curve of G_s

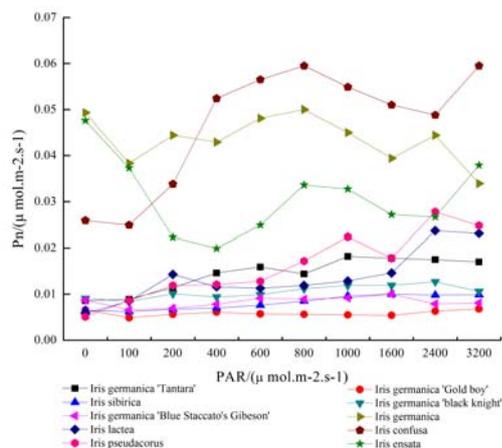


Figure 4. G_s -light response curves of ten species of *iris*

The figure 4. shows that G_s of 10 varieties form three kinds of curves with PAR increasing. G_s of the first group show a decrease-increase-decrease trend. There are 5 varieties *Iris* in this group include : *Iris germanica* 'Gold boy', *Iris germanica* 'black knight', *Iris germanica* 'Blue Staccato's Gibeson', *Iris germanica* and *Iris ensata*. The second group show an opposite trend compare with the first group. Include *Iris lactea*, *Iris pseudacorus*, *Iris confusa*. The third group present a rising trend along with the increase of PAR, include *Iris germanica* 'black knight' and *Iris sibirica*. From the figure we know that the G_s of *Iris sibirica* has a small rising amplitude while the *Iris germanica* 'Tantara' is opposite.

IV. CONCLUSIONS AND DISCUSSION

The light response curve of P_n shows that the maximum P_n value of *Iris* varieties with appears in PAR between 1600-2400 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, furthermore, with the increase of PAR, P_n present a tendency with firstly rising fast and gentle yearly. From the result of experiment, some introduction varieties such as *Iris germanica* 'Gold boy', *Iris germanica* 'black knight', *Iris germanica* 'Tantara' and *Iris germanica* 'Blue Staccato's Gibeson' have the similar biological characteristics and the light response curve, however, other *Iris* varieties have a greater different in their biological characteristics which have been showed in the light response curve of P_n . Furthermore, in this 10 *Iris* varieties, maximum P_n value of *Iris germanica* is 14. 87 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, on the other hand, the maximum P_n value of *Iris confusa* only 1. 51 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, which has a difference of 9. 84 times.

The higher of Intercellular CO_2 concentration, the smaller of differential concentration between stomatal internal and external. Stomata will absorb less CO_2 , correspondingly the P_r value is lower. From the analysis of 10 *Iris* varieties C_i -light curve and P_n -light curve we know that the results in agreement with the rules. From the result of T_r -light, there are 8 varieties which T_r value is between 1-

2. $5 \mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$, on the contrary 2 varieties which T_r value is below $1 \mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$. T_r value of the 8 varieties increase or decrease with PAR, but the change range is less. That is helpful to the plants make "transpiration pull", furthermore, it can promote and regulate the photosynthesis. The T_r value of *Iris confusa* always smaller, that means it can not make enough "transpiration pull" to promote photosynthesis.

The light response curve of G_s shows that G_s didn't increase or decrease distinctly along with the increase of PAR. From the results we also get the information that G_s value of *Iris lactea* and *Iris confusa* are closer, but other varieties of *iris* have more difference. The G_s value of cultivated species between 0. 0049-0. 02 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$ and the original species between 0. 005-0. 06 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$.

The photosynthesis ability can get from the P_n value. There was a positive correlation between photosynthesis ability and P_n value. Intercellular CO_2 is the reaction substrate for the photosynthesis. The photosynthesis rate was determined by the intercellular CO_2 . Stomata is the channel for the leaf get CO_2 . The consumption of CO_2 increase and the intercellular CO_2 decrease along with the increase of PAR and P_n . In order to get more CO_2 , the stomata will open big in some degree. The transpiration rate is influenced by PAR. Normally, the more PAR, the higher transpiration rate. This paper compared photosynthetic capacity of 10 *Iris* varieties from these 4 factors which closely related. Experimental data shows most *Iris* varieties are photophilic plant. There have 6 species *iris*'s maximum value of P_n mainly appear when PAR between 1600-2400 $\mu\text{mol. m}^{-2} \cdot \text{s}^{-1}$. The maximum and minimum value of average P_n and T_r have the same varieties which are *Iris germanica* 'Gold boy' and *Iris confusa*. On the other hand, comprehensive compare the photosynthetic characteristics of 10 *Iris* varieties, the experiment result shows that P_n , C_i , T_r value of *Iris germanica* 'Gold boy' is highest, G_s is lowest. Therefore we can draw a conclusion that the *Iris germanica* 'Gold boy' is the best. This is more consistent with the actual planting.

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REFERENCES

- [1] ZHANG Ying-Hua, YANG You-Ming *et al.*. Effect of High Temperature on Photosynthetic Capability and Antioxidant Enzyme Activity of Flag Leaf and Non-leaf Organs in Wheat. *ACTA AGRONOMICA SINICA* 2015, 41(1): 136 - 144
- [2] SUN Jin-wu, LIU Jun-xiang, CHEN San-you, LI De-ming *et al.*. Light response of photosynthesis of different *Broussonetia papyrifera*. *Grassland and Turf*. 2010, Vol. 30, No. 3 47-52
- [3] Du Lin, Li Yongcun, Mu Huaizhi, Zhang Tianyong, Liu Feifei, Huang Haiiao. Photosynthetic Characteristics of Tetraploid and Diploid *Betula platyphylla*. *Journal of Northeast Forestry University*. 2011 Vol. 39 (2) NO. 2 1-4

- [4] WU YY, LIU C Q, LI PP, et al. Photosynthetic characteristic involved in adaptability to Karst soil and alien invasion of paper mulberry(*Broussonetia papyrifera*(L. Vent.)) in comparison with mulberry(*Morus alba* L.). *PHOTOSYNTHETICA*, 2009, 47(1):155-160
- [5] GONG Hong-juan , YE Kai-yu . Photosynthetic characteristic comparison of ‘Hongyang’ kiwifruit grafted the four different rootstocks. *Journal of Southem Agriculture* 2014. 45(10) : 1825–1830
- [6] JIANG Fuwei, JIANG Hong, LI Wei, et al. Photosynthetic and physiological characteristics of three angiosperms of different evolutionary ages under acid rain *Chin J PLANT Ecol*, 2009, 3(1):125-133
- [7] HERRICK J D, THOMAS R B. Effects of CO₂ enrichment on the photosynthetic light response of sun and shade leaves of canopy sweetgum trees(*Liquidambar styraciflua*) in a forest ecosystem. *Tree Physiol*, 1999, 19:779-786
- [8] JIANG Wen-wei, CHEN Ya-qiong, HUANG Jian-rong, SUN Lei. Photosynthetic characteristics with four cultivars of *Aster novae-angliae*. *Journal of Zhejiang Forestry College*. 2010, 27(6):865-871
- [9] DAI Weiran, REN Jian, BI Yufen . Effect of drought stress on light-response curves of centipedegrass. *Acta Partaculturae Sinica*. 2010 Vol. 19 No. 3 251-254