



Full Length Research Article

STUDY ON DAVIDIA INVOLUCRATA LEAF PHOTOSYNTHESIS DIURNAL VARIATION CHARACTERISTICS

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ABSTRACT

In order to understand the photosynthetic physiological characteristics of *Davidia involucrata*, using portable LI-6400 photosynthesis *Davidia involucrata* measured net photosynthetic rate (P_n), stomatal conductance (G_s), CO_2 concentration between cells (C_i) and transpiration rate (T_r). Results: *Davidia involucrata* leaf net photosynthetic rate (P_n) and diurnal variation of transpiration rate (T_r) diurnal variation showed a bimodal curve, "midday depression" phenomenon obviously; CO_2 concentration in stomatal conductance (G_s) diurnal and cell (C_i) diurnal variation of the overall trend is decrease, and both were significantly negatively correlated with net photosynthetic rate, but the intercellular CO_2 concentration (C_i) at 16:00 reached its lowest point and then showed a rising trend began.

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INTRODUCTION

Davidia a deciduous tree *Davidia involucrata* is China's unique single species genus and 10 million in Cenozoic tertiary left relict plant. In the quaternary glacial period, most parts of *Davidia involucrata* successively extinct, only in some areas of southern china survived, so became the plant kingdom today's "living fossil" (WeiQun *et al.*, 2002; Gang *et al.*, 2000). *Davidia involucrata* is the world famous ornamental plant, which is planted all over the world and belong to our country export species, with high economic value. It's also produced high quality wood joinery carving and luxury furniture. Because the flower shape resembles the pigeon fly by western botanists life called "Chinese dove tree". Because of the deforestation and the excavation of wild seedlings, the current number is small, the distribution scope is also reduced.

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If not to take protective measures, there is a danger of other broad-leaved tree species. It has listed as a protected species in the protection of rare and endangered species names of china and has very high academic status in plant phylogeny and the Geohistory change (LiGuo and JianMing, 1992). After 1869 years, the *Davidia involucrata* was found by Jean Armond David (1828-1900years) in SiChuan MuPing(BaoXing) and caused attention of botanists all over the world, but the study for *Davidia involucrata* Baill mainly concentrated in *Davidia involucrata* community, describe the population biology and ecology characteristic, cytology and tissue culture. On the contrary, there is less report news about physiological, biochemical, genetic, molecular, biology. Photosynthesis the most important physiological process in plants, which is one of the criteria for evaluating the first productivity of plants. This article observed the natural conditions under the light of *Davidia involucrata* leaf photosynthetic rate diurnal variation characteristics, in order to reveal the diurnal variations of photosynthetic characteristics of *Davidia involucrata* leaves under typical weather condition, general rule of *Davidia involucrata* growth and development, the effective protection of the germplasm resources and provide a theoretical basis.

MATERIALS AND METHODS

Test material

Selecting January 2014 acquisition in Mabian DaFengDing Nature Reserve Area of *Davidia involucrata* seed and sand reservoir in East Normal University in the nursery. In 2015 the germination of seedlings, seedling height is about 15-35cm, good growth, the growth uniformity, no pest damage. In the determination of, then choose three pieces of consistent growth of intact and healthy young leaves.

Test apparatus

Portable Photosynthesis Measuring Instrument of LI-6400 type

Determination and analysis method

Measurement of photosynthesis related indexes

May 2015, using the Portable Photosynthesis Measuring Instrument of LI-6400 type tester were planted under the condition of *Davidia involucrata* leaves the photosynthetic index. Choose index like Net Photosynthesis, P_n , $\mu\text{molCO}_2\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, Stomatal Conductance, G_s , $\text{molH}_2\text{O}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, Internal CO_2 concentration, C_i , $\mu\text{molCO}_2\cdot\text{mol}^{-1}$, Transpiration rate, T_r , $\text{mmolH}_2\text{O}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. Each leaf read data five times, remove the extreme ends, average nine datas of three leaves means the measured data and statistical analysis.

Analysis method

The original data were analyzed by EXCEL, and the correlation analysis was performed by SPSS11.5. The changes of photosynthetic characteristics were analyzed by EXCEL.

Results analysis

RESULTS

Diurnal variation of photosynthetic rate

Diurnal changes of P_n in leaves of *Davidia involucrata* as shown in the figure1, sunny day when the diurnal variation of P_n was a double peak curve, maximum value appeared at around 10:00, then P_n was potential, appeared the lowest value at 12:00 a.m. Then P_n rise slowly, until 14:00 o'clock appeared in the second peak, keep a short time after the peak of the fast downhill. The diurnal variation of net photosynthetic rate was decreased in the afternoon (With the midday depression phenomenon), and the photosynthetic rate was higher in the morning than in the afternoon.

The diurnal change of stomatal conductance of *Davidia involucrata*

It can be seen from the chart, figure 2, with the morning light is continuously enhanced, and the open porosity as the light changes, the stomatal conductance increased. It reached the first peak ($0.98 \text{ molH}_2\text{O}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) at 10:00 a.m.

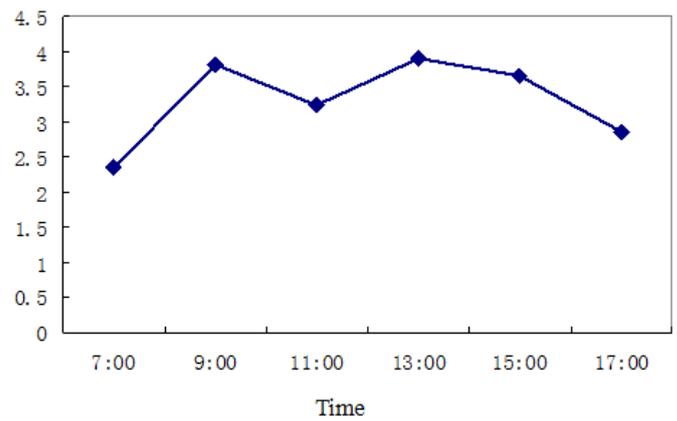


Figure 1. The diurnal change of P_n in leaves of *Davidia involucrata*

With the temperature rising, the vapor pressure gradient increased and leaf water potential and transpiration intensity the decrease of stomatal conductance decreased. It decreased to the lowest ($0.076 \text{ molH}_2\text{O}\cdot\text{m}^{-2}\cdot\text{s}^{-2}$) at 12:00 o'clock, The transpiration decreased, and the water content of mesophyll cells has been recovered in the afternoon, reached the second peak in a day ($0.08 \text{ molH}_2\text{O}\cdot\text{m}^{-2}\cdot\text{s}^{-2}$). Then with the light intensity decreased, stomatal conductance decreased continuously.

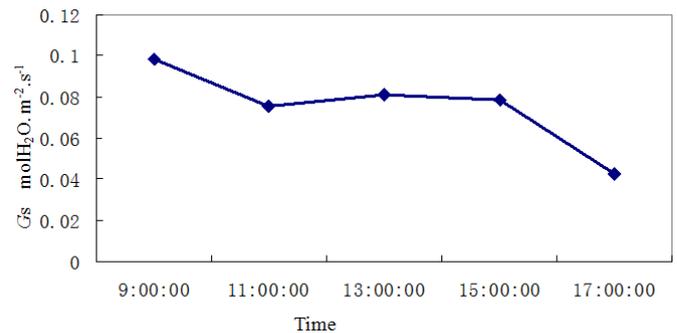


Figure 2. The diurnal change of stomatal conductance of *Davidia involucrata*

Diurnal change of intercellular CO_2 concentration

Intercellular CO_2 concentration is external CO_2 gas enter the process of mesophyll cells invidious kind of driving force and resistance and leaf photosynthesis and respiration to a final equilibrium results (Figure 3). The driving force is mainly reflected by the CO_2 concentration difference between the inside and outside. From the following diagram, the CO_2 in the cell was the highest in the morning. The rate of net photosynthetic rate was highest in the morning. When the net photosynthetic rate of high, the CO_2 concentration decreased, when the CO_2 concentration is too low, it will cause the CO_2 deficit, so that the net photosynthetic rate is difficult to further improve.

Transpiration rate change

Transpiration ensure water and nutrients absorbed by crops, regulate energy crop condition and stomatal opening. Transpiration rate is an important index to measure plant water.

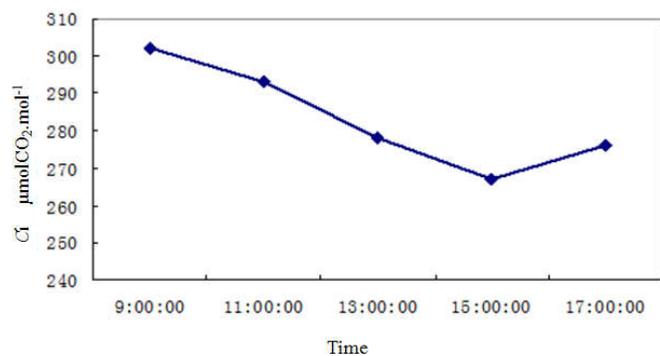


Figure 3. The diurnal change of intercellular CO₂ concentration

Revealing the diurnal variation of transpiration rate and looking affect plant transpiration rate of ecological factors, may provide an important basis for the *Davidia involucrata* reproductive technology (ZhiHua *et al.*, 1998). Transport minerals through plant transpiration, leaf temperature regulating, moisture and other supplies needed for photosynthesis, is closely related to the net photosynthetic rate of plants. Diurnal variation of plant transpiration rate are mainly two kinds of curve in the blade watered unimodal curve, in the lack of water is a bimodal curve. *Davidia involucrata* by the following figure shows leaf transpiration rate T_r diurnal variation of net photosynthetic rate and its diurnal variation of roughly the same (Figure 4). Transpiration rate and net photosynthetic rate were positively correlated. Transpiration rate of the day with the increase of net photosynthetic rate and photosynthetic active radiation and gradually increased after further enhanced with photosynthetically active radiation, transpiration rate decreased. In the afternoon minimum $1.57 \text{ mmolH}_2\text{O}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, 12: 00 - 14: 00 T_r values rise rapidly and then decline rapidly, T_r subsequently fell to the lowest value.

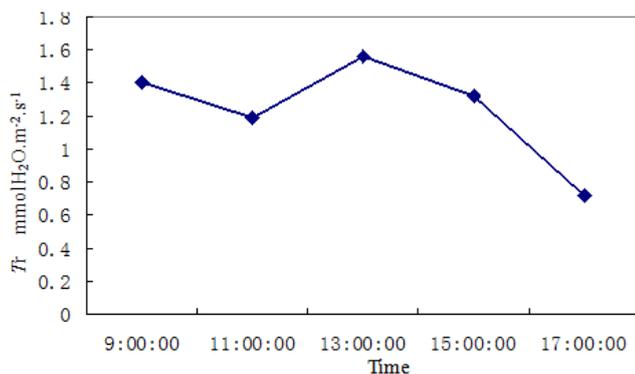


Figure 4. Transpiration rate change

Analysis

Analysis of the diurnal variation of transpiration rate

Intercellular CO₂ concentration on photosynthesis. Due to photosynthesis and stomatal conductance, thus affecting the stomatal conductance and transpiration. While the actual vapor pressure of the air play a direct role, through the saturation vapor pressure between the blade and the air, thus affecting transpiration, stomatal expanded contraction affect CO₂ and water vapor out.

Stomatal conductance is determined mainly by reference CO₂ concentrations, photosynthetic rates affected stomatal conductance and transpiration rate mainly depends on the humidity difference, stomatal conductance impact lightly.

Analysis of the diurnal variation of net photosynthetic rate

Diurnal variation of photosynthetic rate of plants is a very complicated process, because of the internal and external environment, the same kind of plants in different seasons of the diurnal variation of photosynthesis present different laws, different types of plants in the diurnal variation of the same season are not the same. Under the normal cultivation conditions, there is a pattern of plant photosynthesis diurnal variation. *Davidia involucrata* plant leaf net photosynthesis diurnal variation curves with the different of light intensity, vapor pressure deficit, air temperature showed "bimodal" type (Su ZhiXian and Zhang SuLan, 1999). The main causes of the lunch break that blade assimilates accumulation, the temperature is too high, spending strong, transpiration strong, severe dehydration blades, stomatal closure, the carbon dioxide concentration is too low. Net photosynthetic rate turned negative because of the photosynthetic rate is less than the rate of respiration, carbon dioxide is released than absorbed due. The second peak is higher than the first peak due to the plant after a night of compensating water, the release of carbon dioxide breathing at night, so that a high concentration around the blade. Although P_n recovery at afternoon, but still higher than the above-mentioned conditions are poor AM (LIAO JianXiong and WANG GenXuan, 1999).

Analysis of stomatal conductance of *Davidia involucrata*

Stomatal gas plant with the outside world and moisture exchange channels, stomatal opening and closing play an important role in the regulation of photosynthesis and transpiration rate. Wen-Ruey Lee, who had come to study "stomatal conductance with decreasing CO₂ concentration increases." (TaiQuan *et al.*, 1984). From 10: 00 to 11: 00 stomatal conductance began to decline, CO₂ concentration decreased synchronization between cells, P_n gradually decreased, their trends are consistent. It can be considered at this time, the change in PH mainly controlled by the stomatal movement. Hereafter stomatal conductance decrease is caused by rising concentrations of CO₂ between cells, rather than decrease, this phenomenon continued until sunset. Stomatal conductance is greatly affected by environmental factors, the appropriate light intensity and temperature is conducive to open pores, reduce stomatal resistance, stomatal conductance increases. Otherwise, reduced stomatal conductance, intercellular CO₂ concentration, photosynthesis. According to Farquhar and Sharkeyr 's views, intercellular CO₂ supply is not the direct cause of the decline P_n , P_n change this time mainly by non-stomatal control. Such as the diphosphate carboxylase (Rubisco) content and activity factors (Zhang Zhen Xian *et al.*, 1993).

Analysis of the intercellular CO₂ concentration changes

The relationship between Atmospheric CO₂ concentration and the P_n is more complex. According to correlation analysis, *Davidia involucrata* net photosynthetic rate and intracellular

CO₂ concentration have negative correlation in one day. The basic performance of *Pn* with increasing atmospheric CO₂ concentration gradually reduce, decrease with increasing *Pn*. Relative humidity lower diurnal variation noon, higher during the day changed slightly, notably the enhancement of photosynthetically active radiation and air temperature, relative humidity decline, correlation analysis showed that relative humidity and net photosynthetic rate of correlation is not significant (Wei CaiMiao, 1996). After enrichment night, atmospheric CO₂ concentration highest in the morning, at sunrise, with the photosynthesis of plants, CO₂ concentration by low, 16: 00 down to a trough value of about 265 $\mu\text{molCO}_2\cdot\text{mol}^{-1}$ (XiMing, 1995).

DISCUSSION

Plant photosynthetic rate and its influence has been the focus of research scientists. Diurnal variation of plant photosynthesis with the different climatic conditions, growing environment and growth period and showing a variety of changes in the law. Zheng Pi Yao (1992) divided the sunny *Pn* diurnal variation of plants into single peak, two peaks, serious type and flat type. On sunny day, *Pn* diurnal variation of *Davidia involucrata* was bimodal curve with a typical "siesta" feature. The results of what cause plant *Pn* produce "siesta" were very different. Since the pores are the important channel for CO₂ and water outing out of the blade, its opening size or extent of stomatal resistance has important influence to water status of plants and CO₂ assimilation. It's generally believed that stomatal opening decreases namely resistance increases, CO₂ enters the blade is blocked, CO₂ int lower, *Pn* decreased; while reducing stomatal resistance, Loss of water made transpiration rate fell. This kind of conclusion is based on the *Pn* and stomatal conductance degrees and their relevance to the main ecological factors. such as Zhang Zhihua (1993), Lu Binshe (1999), Miao Dequan (1991), Tao Jun (1999) and so on thought that ecological factors such as moisture deficit, low humidity and strong light, disease and other reasons caused stomatal conductance or stomatal resistance.

Then became the formation of a *Pn* "siesta" and volatility. Few found that the results is due to non-stomatal regulation factors (David Zhang, 1991; Huang Jungle, 1996). Study results showed that *Davidia involucrata* stomatal conductance leaf does have decreased significantly in midday, but with lower stomatal conductance, CO₂ concentrations was decreased. That indicating "siesta" formation is due to the decrease in stomatal conductance caused. From the diurnal variation of transpiration intensity bimodal curve, midday transpiration intensity is not reduced, dove *Pn* "siesta" formation and volatility is non-stomatal factors also have a certain relationship. Such as mesophyll resistance, leaf photosynthetic capacity, the specific further research is needed to determine the factors. *Davidia involucrata* leaf photosynthesis and transpiration showed different variation. Photosynthesis in plants is mainly their physiological metabolism.

Plant transpiration is not only their physiological activity, but also a greater impact by environmental conditions. Correlation analysis showed that: *Davidia involucrata* photosynthetic rate influenced by the transpiration rate, transpiration rate greatly influenced by stomatal conductance.

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