



Studies on Photosynthetic and Fluorescence Characteristics of Five Beichuan Magnolia Strains

¹Meng Zhang, ²Yunjie Gu, ¹Xiaoxu Qin, ¹Xia Chen, ²Guoqin Zhuang and ²Xiaoqing Li

¹College of life Science and Engineering, Southwest University of Science and Technology, 621010 Mianyang, Sichuan, China

²Sichuan Forestry Academy, 610081 Chengdu, Sichuan, China

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Corresponding Author:

Meng Zhang

College of life science and Engineering, Southwest University of Science and Technology, 621010 Mianyang, Sichuan, China

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Abstract: The photosynthesis and fluorescence parameters of Beichuan magnolia were studied to providing theoretical foundation for high yield and good quality variety breeding. Five strains of Beichuan magnolia cultivated in Linfeng Village Beichuan County were detected by using the Li-6400XT and PAM-2500 in a sunny day. The results show that there are significant differences in photosynthetic and fluorescence characteristics between the five strains of Beichuan magnolia. The photosynthetic rate of No. 1-3 are higher than that of No. 4 and 5. For the PSII, the No. 1 is broadly higher than that of the others. The No. 1 is thought to be a better suitable for wider living site after comparative analyzing both the photosynthetic and fluorescence parameters.

INTRODUCTION

Magnoliae (Xin-Yi in Chinese), the dried flower buds of *Magnolia sprengeri* Pamp. is officially listed in the Chinese Pharmacopoeia and one of the most popular traditional Chinese medicines^[1]. It has been widely used in traditional oriental medicine against symptoms such as acute or chronic rhinitis, allergic rhinitis and other rhinitis^[2]. *Magnoliae* is also widely used as a spice, especially in cosmetic, food and cigarette^[3]. Additionally, it is known to be a rich source of lignans^[4] which have attracted considerable interest because of their complex structures and notable physiological effects. It is necessary to pay more attention to the exploitation and protection of *Magnoliae* plants.

As one of magnolia production in the main production areas in Sichuan, Beichuan magnolia (*Magnolia sprengeri* Pamp.) the main varieties are *Magnolia sprengeri* Pamp. Because of its commodity

medicinal volatile oil content is often short of the law of the People's Republic of China Pharmacopoeia (1995) of 1.0%, the Magnolia is unsalable and has become an important factor affecting the development of its industrialization. Since, 2004, Sichuan Forestry Academy carried out the Beichuan magnolia selective breeding work by using abundant resource. Five high yield and good quality of magnolia strains have been selected to study the photosynthetic characteristics. The research on photosynthesis and chlorophyll fluorescence parameters of strains would provided the scientific basis for the application of high yield and good quality.

MATERIALS AND METHODS

Plant material and testing situation: The 35-years-old Beichuan magnolia strains from No. 1-5 plants in Linfeng Village, Beichuan County were studied. Beichuan has a humid subtropical climate, 1700 m above sea level,

annual average temperature 15.4°C, annual sunshine hours 1050 h, 1100 mm annual rainfall and annual frost-free season 240 days.

Detecting of photosynthetic characteristics: Consistent tree height, DBH and crown basic of Beichuan magnolia strains from No. 1-5 plants were selected to detect photosynthetic characteristics. Choosing the canopy in the lower branches grew well to determine its net Photosynthetic rate (Pn), intercellular CO₂ Concentration (Ci), stomatal conductance (Gs) and Transpiration rate (Tr) from the 3rd top mature leaf marker with Li-6400XT portable photosynthetic apparatus in active photosynthesis 9:00-11:00 am. Light intensity was set 300 mol/m²/sec¹. Three mature leaves were selected from each strains and each leaf repeated 5 times less on average.

Detecting fluorescence characteristics: The same leaf was selected on sunny morning 9:00-11:00, June 20, 2013 which was marked blade fully dark adaptation for 20 min. The kinetic parameters of chlorophyll fluorescence induction, the original light energy conversion efficiency of PSII (Fv/Fm) and photochemical quenching coefficient of qP, Non-Photochemical Quenching (NPQ) equivalence were monitored using the PAM-2500 (WALZ company, Germany) portable pulse modulation chlorophyll fluorescence spectrometer. Each department selection 3 strains each repeated 5 times.

Data analysis: All data were handled by statistical methods using DPSv7.05 and Sigmaplot 11.0 mapping.

RESULTS

Comparison of net photosynthetic rate: Net photosynthetic rate is one of the most important parameters in the plant photosynthetic characteristics and it reflects the assimilation ability of CO₂. Seen from Fig. 1a, there is a significant difference between Beichuan magnolia strains on the net photosynthetic rate. Among these parameters, the value of N0.2 (8.78) was the greatest, followed by the No. 3 (8.01 mol/CO₂/m²/sec¹) but no significant difference was found between this two strains. Difference between No. 1-5 has statistically significant. Net photosynthetic rate for other strains was as follows: No. 1, 4, 5. There were significant difference between the three strains.

Comparison of stomatal conductance: Stomata controls gas and moisture exchanges between the plant and the external atmosphere. They play an important role in plant photosynthesis and transpiration. Seen from Fig. 1b, there was significant difference between Beichuan magnolia strains on the stomatal conductance. Among these

parameters, the value of N0. 3 (0.14 mol H₂O/m²/sec¹) was the greatest has statistically significant with other four strains. Followed by the No. 2 (0.11 mol H₂O/m²/sec¹) and No. 5 (0.10 mol H₂O/m²/sec¹) but no significant difference was found between this two strains. The smallest is No. 4 (0.05 mol H₂O/m²/sec¹). Thus, Beichuan magnolia No. 4 had lower water consumption ability and the photosynthetic efficiency which could be seen this feature from the Pn value.

Comparison of transpiration rate: The transpiration is plant's one kind of intrinsic capillarity, it can pull out upwardly the moisture content from the root, causes moisture content arriving at trees an end. Transpiration, the crux for the bio-activity of plants is essential for the physiological process of plants. The difference of transpiration rate between Beichuan magnolia strains has been shown in Fig. 1c, Among these parameters, the value of No. 3 (2.23 mmol H₂O/m²/sec¹) was the greatest, followed by the No. 2 (1.98 mmol H₂O/m²/sec¹), there is no significant difference between the No. 2 and 3 The minimum is No. 4 with the value 0.84 mmol H₂O/m²/sec¹.

Comparison of intercellular CO₂ concentration: Significant differences of the intercellular CO₂ concentration were found between five strains. Seen from Fig. 1d, the value of No. 5 (295.9 mol CO₂ mol⁻¹) was the greatest had statistically significant with other four strains. Followed by the No. 3 (269.9 mol CO₂ mol⁻¹) and the minimum was No. 1.

Comparison of the non photochemical quenching: Non Photochemical Quenching (NPQ) reflects the PSII antenna pigment absorption of light energy that cannot be used for electron transfer and part of escaping light energy in the form of heat. NPQ is a kind of plant protection mechanism and has certain protective effect on photosynthetic mechanism. Seen from Fig. 2a, the NPQ value of No. 3 (1.41) was largest and has statistically significant with other four strains. Followed by No. 1 and the value was 1.12. The value of No. 2, 4 and 5 was 0.43, 0.56 and 0.41, respectively there was no significant difference. It suggested that PSII actual photochemical efficiency of No. 5 and 2 were higher but their light protection were so weak that they were easily damaged by strong light. The PSII actual photochemical efficiency of No. 3 was low but it had strong light protection. The PSII actual photochemical efficiency of No. 1 was in the middle but light protection still strong. The light protection of No. 4 was weak.

Comparison of maximum photochemical quantum yield (Fv/Fm) of PSII: Fv/Fm was measured by the leaf dark adaptation after 20 min which reflected the biggest

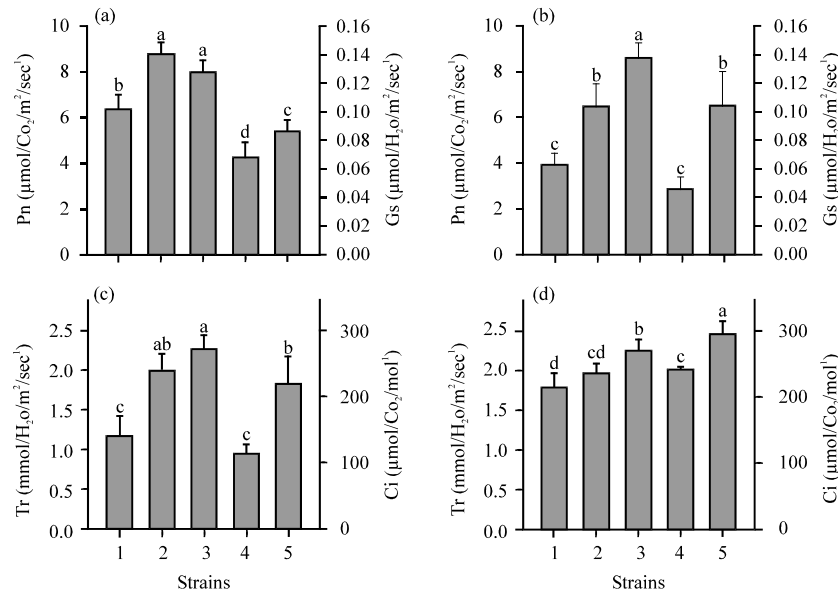


Fig. 1(a-d): The photosynthetic indexes of five Beichuan magnolia strains 1-5 is No. 1-5 (Error bars represent the mean Standard Error (SE) and data in the figure are (average±SE). Lowercase letters mean significant difference (p<0.05), same as below)

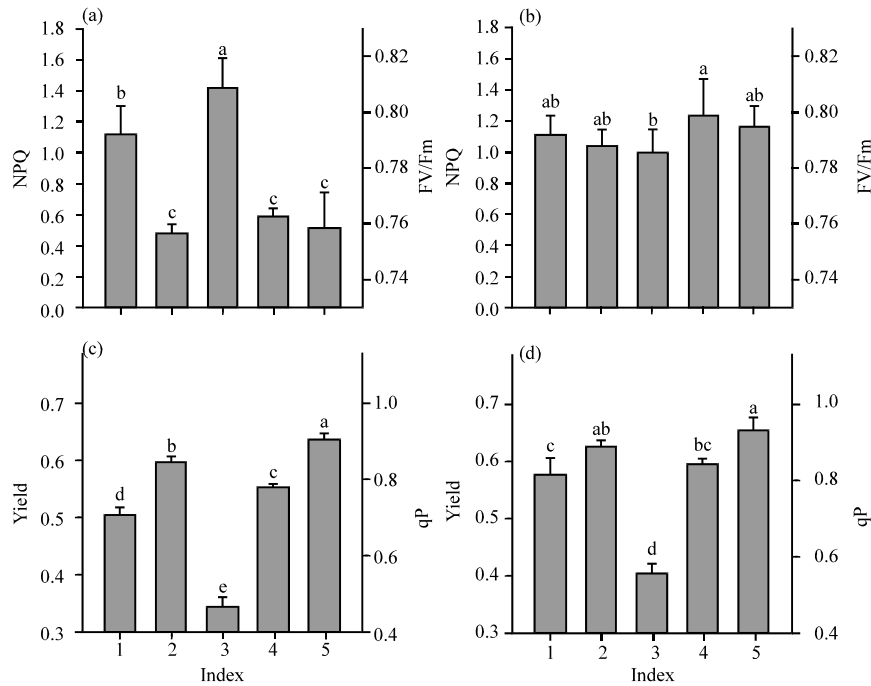


Fig. 2(a-d): The fluorescence indexes of five Beichuan magnolia strains

light energy conversion efficiency of PSII reaction center. The variation of Fv/Fm is tiny under no stress condition not affected by species and growth condition. But Fv/Fm is markedly reduced under stress condition. Seen from Fig. 2b, Fv/Fm value of No. 4 (0.8) was largest

among five strains which had significant difference with No. 3 and no significant difference with No. 1, 4 and 5.

Actual photochemical quantum yield (Yield) of PSII: Actual quantum yield can partly reflect the

photochemistry activity of PSII which also reflects the original light energy capture efficiency of PSII reaction center under partially closed. Seen from Fig. 2c, actual photochemical quantum yield of PSII to the five strains was in order of No. 5>2>4>1>3.

Comparison of photochemical quenching: The qP value reflects the PSII electron acceptor original QA and redox state of PSII development center and the higher its value, the greater its activity of PSII high electron transfer. The qP value of No. 5 (0.91) was the largest followed by No. 2 (0.87) no significant difference was found between this two strains. The qP value of No. 3 (0.51) was the smallest which had significant difference with other strains.

DISCUSSION

In this study, the results showed that the correlation among transpiration rate, stomata conductance and intercellular CO₂ concentration was positive which had the same study results with Dawson etc that stomata controlled gas and moisture exchanges between the plant and the external atmosphere. The environmental conditions and blade's adaptation to the environment can decide plant survival and growth. Plants can adapt to changes of external light environment by change the photosynthetic capacity of leaves.

The differences of chlorophyll fluorescence parameters between different crop varieties were mainly caused by its genotype difference and the determination of chlorophyll fluorescence analysis system could be used as an important index of selection and identification of varieties^[5]. Fv/Fm values are often used to measure the original light energy conversion efficiency and the ability to use light energy of plant leaves PSII. The value of Fv/Fm is high, leaves will absorb the light energy into chemical energy effectively in order to improve the photosynthetic electron transport rate, forming more ATP and NADPH for photosynthetic carbon assimilation to provide adequate energy and reducing power. The abiotic stress condition, the Fv/Fm value of higher plants is between 0.75-0.85^[6] and with stress strengthening, the Fv/Fm value should be markedly reduced. The Fv/Fm value of five Beichuan magnolia strains was around 0.79 which showed that the plant was in the stress in this study.

High photochemical efficiency is the precondition of specular and accumulation in the select breeding of good varieties but the protection mechanism of strong sunlight should not be ignored. The PSII photochemical efficiency of No. 1 was moderate and protection of glare sunlight was strong in this study. High and low photosynthesis efficiency of plant is not the simple sum of PSI and PSII

photosynthetic efficiency but the comprehensive effect of two optical system efficient coordination. Five Beichuan magnolia strains in this study were still in the normal growth conditions and the natural conditions are not under duress. Different methods should be used to have a comprehensive evaluation of strains on breed selection, to make selection more meaningful.

CONCLUSION

In this study, different Beichuan magnolia showed marked variation of Gs, Tr and Ci and also show a larger difference on the net photosynthetic efficiency. It indicates that the adapting ability to the environment of different strains vary widely. The No. 2 and 3 show higher net photosynthetic efficiency, followed the No. 1. Comparative analysis the photosynthetic and fluorescence parameters of five Beichuan magnolia strains, the No. 1 is considered the relatively excellent strain in Beichuan Lin Feng Village magnolia base.

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